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An International Multidisciplinary Monthly e-Magazine

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(15 JULY 1903- 2 OCT 1975)

EDUCATION DEVELOPMENT DAY

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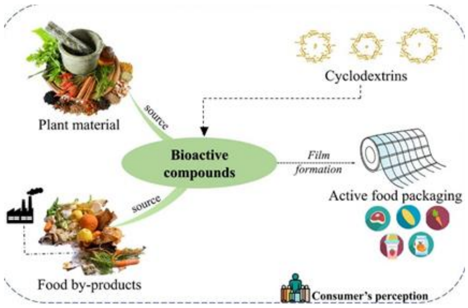
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From the Desk of Editor-in-chief

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I would like to introduce the launch of **"AgriGate - An International Multidisciplinary Monthly e-Magazine Volume 04 Issue No. 06 – June 2024"** with immense pleasure. Ourteam is privileged to dedicate this issue to former chief Minister of Tamil Nadu**.** With the view to eliminate illiteracy in Tamil Nadu, the School Education Department has announced that July 15, the birth anniversary of former Chief Minister K Kamarajar will be observed as "**Education Development Day**" in the Tamil Nadu State. We also dedicate this issue to Agricultural youth. The World Youth Skills Day is celebrated on 15 July to raise awareness about the importance of technical, vocational education & training and the development of other skills relevant to both local and global economies.

The main objective of the magazine is to provide a publishing platform to young researchers and scientists as well as an information hub for the enthusiast, progressive farmer and also common readers. We envisage providing an online platform that appreciates illuminating articles on various topics related to agriculture and allied sciences monthly that will appraise and update the students, farming community and the whole society at large on the updates in agriculture.

Last but not the least, I wholeheartedly thank the editorial team, authors as well as anonymous reviewers for contributing to the release of this issue.

Our team welcomes your constructive feedback and suggestions to improve delivering fruitful content to hungry minds.

Dr R Shiv Ramakrishnan
Editor-in-chief
AgriGate Magazine

AgriGate- An International Multidisciplinary e-Magazine

Volume: 04 Issue No: 07

AGRI TOURISM-AN INNOVATION TO EARN AN EXTRA INCOME FROM FARM ACTIVITIES-A CASE OF TOURISM CENTERS IN MAHARASHTRA, INDIA

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Abstract

This study was conducted by using case study research method and it is restricted to two Agri Tourism Centers only. Both the cases are from Pune District of Maharashtra State of India. First case called as Mauli Krushi Paryatan Kendra operated by Mr. Janardhan Thopte and the second case is Mayur Krushi Paryatan Kendra operated by Mr. Maruti Govind Ukirde. In this study the issues related to operate the Agri-Tourism centers are discussed in depth. Mainly focused on scope to operate Agri Tourism, challenges, implications and sustainability were discussed. As a case study method of investigation main focus was to get the first hand information form the Agri-Tourism Operators mainly on types of services provided such as stay facilities, ethnic food, activities undertaken at the centers, to know the rural culture and sustainability of the Agri-Tourism centers to get an extra income out of the farm activities and look beyond as entrepreneurship. Regarding the first case i.e. Mauli Krushi Paryatan Kendra started by Mr Thopte in the year 2009 on 8 acres of land without taking financial aid. Mr Thopte engaged 8 people to work for tourism and farming activities and out of tourism activities he is able to get net income of Rs.1,30,000 in a year whereas the income from agriculture is only Rs.50,000. The second case called as Mayur Krushi Prayatan Kendra owned by Mr Ukirde started on 6 acres of land since 2006 and his net income from tourism activities is Rs.1.00 lakh only in nine months

from June to December as summer is very hot in this area due to very low rainfall**.** In both the cases major constraint is a marketing and to get the popularity of their centers among the urban visitors**.** Both the Agri Tourism operators taking help form the Agro Tourism Development Corporation ***(***ATDC***)*** and Maharashtra State Agri and Rural Tourism Co-Operative Federation Ltd ***(***MART***)*** for advertising the centers**.**

Keywords: Agri-Tourism, Service Providers, Scope, Subsidiary Income, Tourists

Introduction

Agri-Tourism is a concept and leisurely activities in the rural setup for sustainable livelihood for the rural people / farmers as subsidiary income source. Agri-Tourism helps a person to understand and appreciate the land and the people who live on it. The work environment of cities and life style / urbanization is also an important factor which forces the urban people to go out and get rid from their routine busy life schedule to relax from the work stress and peace of mind. People from urban areas and children will get exposed in the Agri-Tourism center with the rural life and they can enjoy the natural environment in these centers. Agri-Tourism is a way of travel to farm visit and usually offers the opportunity to help with on-site farming. It is a purposeful visit with a producer of agricultural commodities or land-based products and services with multiple activities. Agri-Tourism is not only to stay in a village and enjoy the village based food but this is an opportunity to be close to where the 75% of Indians live. One of the best things about staying on a farm is that guests can contribute to the place through their involvement. Agri-Tourism is an idea to make tourists to feel life like a villager, right from milking the cow, ploughing the field, bathing in an open well to climbing a tree, plucking fruits, flowers, vegetables and several other agricultural practices and activities. Agri-Tourism is defined as travel, which combines agricultural or rural settings with products of agricultural operations all within a tourism experience. Agri-Tourism can be defined as “A range of activities, services and amenities provided by farmers and rural IIMK Part XII–Tourism Other Sectors IIML Conference on Tourism in India – Challenges Ahead, 15-17 May 2008, IIMK 515 people to attract tourist to their area in order to generate extra income for their businesses”. (Gannon,1988 in Klaze, 1994).

Commercialization in every field and the high standard of living forced the farmers to utilization every inch of land not only to produce the higher yields but also to utilize their waste land or unproductive lands for Agri-Tourism activities as subsidiary business for sustainable livelihood. Agri-Tourism has given a chance to the rural farmers to share their work with the masses. It is also an opportunity to the guests to buy agricultural and horticultural produce grown on the farm. Many children grow up without knowing the actual facts of the rural life. Agri-Tourism, therefore, gives an opportunity to the children from urban/ city areas to learn something from the rural people about their life, hardship of their day today agriculture based activities.

The concept, Agri-Tourism was formally launched at Agri-Tourism Development Corporation, Baramati, Maharashtra on May 01, 2004. The concept of Agri-Tourism envisages involvement of private sector, the farmers / Agri-Tourism Service Providers based on Public Private Partnership (PPP). The Agri-Aourism Service Providers act as guides as well to hosts for the tourists. The Agri-Tourism Center needs to have cleanliness, hygiene environment and surroundings with modern facilities for safety and comfort of the tourists. The preference is given to farms which have agricultural land attached to the center. The Agri-Tourism Service Provider is needs to provide home cooked food, stay facilities at the center and to show the agricultural practices to visitors such as cultivation of flowers, harvesting of agricultural crops or fruits, bee keeping, dairying and several other agricultural operations etc. and introduction about the village, life of villagers their culture, societal norms and the way of life through various participatory practices. The tourists can enjoy the natural environment, fresh air and atmosphere at the center. The tourist should get an exposure about the local community, their life style which means attending a Panchyat meeting, exposure of local traditional songs, traditionally celebrated festivals, dances, art, crafts, etc.

Maharashtra stands third in India for population and area. It lies on the west coast of India with a 720 km long cost-line along the green Konkan region. Western Ghats and Sahyadri mountain ranges have several hill stations and water bodies with semi-evergreen and deciduous forests. There are several tourist centers in Maharashtra which are the supporting natural environment for the Agri-Tourism Centers in the state. Almost 43 per cent of population lives in urban areas in Maharashtra. Even the outside from the state and countries the tourists are visiting in the state. The well-developed infrastructure such as connectivity to the roads, communication facilities, connectivity to the air ports and well spread network of trains are some of the advantages to reap the potential tourists at these centers is added advantage.

Based on these facts and contributing to the development of Agri-Tourism Centers in Maharashtra, some of the Agri-Tourism Centers operated by the individual farmers selected for the study and to know the practical impact among the farmers and scope to capture attention of the urban / foreign tourists to visit these centers which will be helpful to the farmers for better livelihood and it is a great experience to the tourists to get exposed with the rural life, this enforced to the investigators to take up this study to know the personal profile of the Agri-Tourism Service Provider & salient features of the selected Agri-Tourism Centers.

METHODOLOGY

The researcher critically and logically reviewed the experience of agricultural transformation by complementing with agro based tourism as case studies from the state of Maharashtra, India. Other multiple sources were also used by the researcher for data collection as it was also defined by Robert K. Yin that the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used (Yin, 1984, p. 23). The primary data was collected from the selected Agri-Tourism Centers and the owners of agro-tourism operators were interviewed personally with in depth discussions.

The present investigation was conducted by using case study research method during the year 2012-13. Maharashtra State was purposively selected as a Home State for the investigator and he is also well versed with the local language (*Marathi*) which was helped him to build the rapport with the Agri-Tourism Service Providers and get the first-hand information for document the word of mouth experiences of the Agri-Tourism Service Providers. Investigator has visited two Agri-Tourism Centers selected randomly to document as case studies. The vast network, scope and potential of Agri-Tourism Centers in Maharashtra specially in Pune district in support of Agriculture Tourism Development Corporation (ATDC, Pune) which is the main organization promoting this activity for achieving income, employment and economic stability in rural areas. Based on these special features and wide network of Agri-Tourism Centers in Pune and nearby areas the Pune District was selected by the investigator for the study purposively. The study is limited to two Agri-Tourism Centers from Pune district of Maharashtra.

RESULTS AND DISCUSSION

Case-1. MAULI KRUSHI PARYATAN KENDRA

The Mauli Krushi paryatan Kendra was established by Mr Janrdhan Thopte in the year 2009 at Chincholi Morachi a small village in Pune District of Maharashtra. Morachi Chincholi or

(मोराची चिंचोली), by name itself means a village of tamarind trees (Marathi: चिंच chincha) and town of dancing peacocks (Marathi: मोर moar) all around. It is situated near Pune-Ahmednagar Highway about 55 km from Pune. Even today one can find a lot of peafowls in the village. This area comes under totally dryland belt and rocky soils with very low rainfall.

According to Mr Thopte he has completed his high school level education only. Due to low and erratic rainfall with un-economical agricultural production forced him towards the innovative concept of Agri Tourism. After going through the several channels and hiccups involved in establishing the Agri Tourism Center in spite of having good network of ATDC in Maharashtra he has established his own Agri Tourism Center without borrowing loan from any bank in the year 2009 named as Mauli (Meaning-Mother) Krushi Paryatan Kendra on his 8 acres of land. He has engaged 8 workers for Agri Tourism and farming activities. They will work for at-least 8 hours a day, on wages ranging from Rs.100-150 per day. According to Mr Janardhan, his annual earnings from Tourism activities are Rs.3,50,000. and expenses are Rs.2,20,000. The net earnings are Rs.1,30,000/- per annum whereas, the income from farming activity is only Rs.50,000/- per annum. Mr Thopte says that his 80 per cent income comes from Agri Tourism activity whereas only 20 per cent revenue was generated through the farming activity.

.
Investigato with Mr. Janardhan Thopte at Morachi Chincholi Village, Pune

During discussion Mr Janardhan and investigator went around the farm and he said that there are no rains since last 8 years in this region and if there is a rain than also it is very low. There are two open wells in his farm out of which one is totally dried and one tube well is there for irrigation purpose. There is also a watershed pond constructed under the scheme Farm Ponds on Demand operated by Govt of Maharashtra for which subsidy facility is also there for farmers. The pond was constructed in the year 2010 with the cost of Rs.82,200. The size of pond is 30 X 30 X 3 meters which is a good source for harvesting water during rainy season and it is also use to fill the water by using tube well and open well water to avoid the shortage of electricity for irrigation purpose. There is a drip irrigation system is also installed in his farm for irrigating orchards and vegetable crops. He has also introduced Gappi fishes in the farm pond to reduce the mosquito breeding as these fishes eats the eggs laid by the mosquitoes.

The entire 8 acres of land is under cultivation with Mango, Custard apple, Guava, Sweet lime, Orange, Kagzi lime, Jack Fruit and he has also planted one or two saplings of Apple as an experiment. All types of vegetables are grown in his farm and pick and harvest facility is also provided for the tourists as they can by the fresh vegetable as well as fruits available in the farm. Mr Janardhan is a very innovative farmer uses organic farming practices also uses mulching sheets under the fruit orchards and vegetables to avoid the heavy moisture loss during the summer season. Mixed farming systems opted by Mr Janardhan to avoid losses as one crop fails the other crop can be harvested which is an innovative idea of advanced farming practices. The open space between two rows of orchard is also utilized for cultivation of vegetable crops in this center for getting an extra income and also helpful to reduce the weeds.

Farm pond constructed under the scheme Farm Pond on Demand implemented vy Govt. of Maharashtra

Table 1: Personal profile of the Agri-Tourism Service Provider

Criteria	Features
Name of the Agri-Tourism Center with address	Mauli Krushi Paryatan Village: MorachiChincholi, Tahsil: Shirur, District Pune-412218 Mobile: 9960663530
Year of establishment	2009
Name of the owner	Mr. Janardhan Thopte
Age	38 Years
Education	SSC
Landholding	08 Acres
Land under Agri-Tourism	08 Acres
Approval	ATDC & MART

The special features of Mauli Krushi Parayatan are one-day stay with home based pure vegetarian ethnic food, tractor ride, bullock cart ride, pick-n-harvest facility, information about variety of orchards, vegetables, medicinal plants and their usages and site visit of entire village by bullock cart**.**

Case-2. Mayur Krushi Paryatan Kendra

Mayur Krushi Paryatan Kendra is started by Mr. Maruti Govind Ukirde at Village: Chincholi Morachi in the year 2012 newly established in this area and in the process of getting the approval from ATDC and MART. According to Mr Maruti he has established this center on 6 acres of land which is only 9 months old. All the 4 family members are engaged in the Agri Tourism as well as farm activities involved for 8 hours in a day. As explained by Mr Maruti, actual season as Agri Tourism activity starts from June and ends with February (around 9 months) due to hot summer in this area of dry region during March to May there will be no visitors. The main income source for the family is from Tourism activity which is Rs.1.0 lakh as this center is in its budding stage and it is a hope that in future they will get good business in the years to come out of the tourism activities as they are working in ATDC and MART for obtaining approval. Since the inception of this center for a period 9 months around 500 tourists have visited and after getting approval the number of visitors will be more and there is chance to increase the annual income from tourism activities as well they are also receiving 3-5 lakhs of income from agricultural activities by selling the farm produce.

Researcher with Mr Maruti Ukirde and Mr Janrdhan Thopte

Since this center is not approved by the ATDC and MART for which Mr Maruti is trying and as soon as the inspection process is completed by the officials from ATDC, the center will get approval and it is helpful for us advertising and marketing.

At this center all the 6 acres of land is under cultivation of fruit orchards such as Pomegranate, Mango, Sapota, Sweet lime, Oranges and some of the vegetables are also cultivated. All the modern package of practices followed by Mr Maruti for cultivation of orchards and vegatable crops as his daughter completed her diploma in agriculture. Mr Maruti's son is working in Indian Army service and also helping the parents to develop this center as modern as possible in the years to come.

Watershed farm pond at Mayur Krushi Paryatan Kendra

The fruits grown at this centers are available for the tourists to pick and harvest mode on payment basis, they will also enjoy with the freshly harvested fruits and also be an excitement of harvest. There is an open well at this center, one tube well and also a farm pond for irrigation of all fruit and vegetable crops.

At this center one can experience to go so close to nature, rural life, animals, birds and agricultural activities and best quality ethnic food on cheapest rate and try to live life for one or two days in the purely pollution free environment. Tourists will be glad at this center by watching animals, birds and peacocks. This area is a very silent and good for even meditation, hillocks is also the beauty of this area. One can also find some love birds, cows, buffalo, ducks, rabbits, backyard poultry birds at this center. Food is also prepared here on Chulha in a desi style with Jowar and Bajra Roties with few curies and Chutinies.

Peahens at Mayur Krushi Paryatan

Stay facility for tourists at Mayur Krushi Paryatan Kendra

Visitors will experience about village culture, rural setup, their lifestyle, how farmers are producing grains, vegetables, milk etc. How people live together and how they share their pains and gains. You can also find the domestic animals at this center which are useful to farmer how they ride Bullock Cart, how they plough the land, how biogas (gobargas) unit functions, how people using domestic fuels, how the national birds (peacocks) are safe in this village and live in drought conditions. There is an awareness among the villagers not use the pesticides in their fields for safeguard of peacocks.

This center is full-fledged with several facilities such as accommodation best quality ethnic food and safety norms. Regarding the facilities, one can enjoy with the Bullock Cart ride and tractor ride around the farm. Watch the peacocks in morning and evenings during their feeding time. The food is served in the desi style of veg and non-veg. children can go for outside activities such as traditional games like gotya (marbles) gilli danda, kabbadi, flying kites etc.

The best time to see peacocks is morning hours and evening hours (6.00 am – 9.00 am & 5.00 - 7.30 pm) one can see beautiful peacocks with opened feathers. According to Mr Maruti, the peacock dances to attract peahen and breeding takes place only once in a year, peahens lay 5-6 eggs and it takes 30-32 days to hatch. Many times, lack of rains peahen not getting safe place to lay eggs and some wild birds and animals damage their eggs and chicks, due to that the population of peacocks decreasing day by day and it is worry some for our village. In oral conversion Mr Maruti expressed his feeling as when I was young I found my village full of fruit gardens and tamarind trees but due to drought condition people losing their gardens, cattle and interest in farming. It is hurting to me and it is responsibility of every citizen of India to safe guard the climate and nature ultimately helps to save the planet.

The average charges for the visitors are as follows for the tourists who wish to visit the center.

Item	Rate (Rs.) / Specification
Breakfast	100 for adult & child
Lunch	Adult-275 for non-veg 300: Child-175
Night meal	Adult-275; Child-175 & for non-veg food is Rs.300/-
Room charge	500 per day with adequate water & best quality linen

Table 2: Personal profile of the Agri-Tourism Service Provider

Criteria	Features
Name of the Agri-Tourism Center with address	Mayur Krushi Paryatan Village: Morachi Chincholi, Tahsil: Shirur, District Pune-412218 Mobile: 7875992279, 9226223364
Year of establishment	2012
Name of the owner	Mr. UkirdeMarutiGovind
Age	58 Years
Education	Primary level
Landholding	6 acres
Land under Agri-Tourism	6 acres
Approval	Not yet approved by any Institution

Special features at Mayur Krushi Paryatan are traditional welcome to every tourist, bullock cart ride around the village, stay facility for 1 day + day and night, visit to farm and information about cultivation of Mango, Guava, Sapota and Pomegranate, facilities such as pick and harvest of fruits, vegetable and flowers etc., on payment basis. Homemade food is served to tourists. Water shed pond is also one of the attraction at this center. Rabbits, backyard poultry bird, love birds, peacocks and ducks are also major attractions of this center.

Conclusion

While conclusions drawn from the case study inevitably require some caveats, our research highlights how Subsidiary Income Evolution can be seen as a simple and, hence, systems thinking provides a preliminary understanding of how this evolve. In doing so, we provide insights into this framework may be useful to others in order to explore and exploit opportunities with significant ambiguity.

In both the cases it was observed that one can buy the fresh vegetables, fruits and flowers, simultaneously tourist can enjoy the harvesting of all type of produce available at the farm. Tourist can know about the cultivation practices opted by the at these centers and they will also get the first hand information about the various crops. Tourists will take part in various activities such as bullock cart and tractor rides, play with domestic animals, experiencing rural games and folk dances. Tourist can also enjoy by watching the water harvesting farm ponds, local tree plantation and various facilities provided by these centers. Similar Study was also conducted by Gopal, Varma and Gopinathan (2008). Similar study was also conducted by Hamilpurkar (2012).

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A BIRD'S EYE VIEW ABOUT CARBON CREDIT AND CARBON TRADING

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Introduction

Carbon credits and carbon trading are key components of emissions trading schemes (ETS) aimed at reducing greenhouse gas emissions.

I. Carbon Credits:

Carbon credits represent a key mechanism in efforts to combat climate change by incentivizing emission reductions and promoting sustainable practices. By definition a carbon credit represents "a unit of greenhouse gas emissions reduced, avoided or removed from the atmosphere. It is a tradable instrument that represents the right to emit one metric ton of carbon dioxide equivalent (CO2e) or its equivalent in other greenhouse gases". Carbon credits are typically generated through projects or activities that result in emission reductions or removals. These projects can include renewable energy projects (e.g., wind farms, solar power plants), energy efficiency improvements, afforestation and reforestation projects, methane capture from landfills or agriculture and industrial process improvements. Carbon credits must undergo certification by recognized standards bodies or registries to ensure their legitimacy and credibility. Common certification standards include the Clean Development Mechanism (CDM), Verified Carbon Standard (VCS), Gold Standard and Climate Action Reserve (CAR).

Types of Carbon Credits:

1. Voluntary Carbon Credits: Voluntary carbon credits are a mechanism used by individuals, companies, or organizations to mitigate their carbon footprint voluntarily as part of their corporate social responsibility (CSR) initiatives or sustainability goals. The concept revolves around the idea of compensating for the emissions produced by various activities by investing in projects that reduce or remove an equivalent amount of greenhouse gases from the atmosphere. It typically works as follows,

a. **Assessment of Carbon Footprint**: Individuals or entities calculate their carbon footprint, which is the total amount of greenhouse gases, usually measured in carbon dioxide equivalents (CO2e), emitted directly or indirectly as a result of their activities.

b. **Purchase of Carbon Credits**: Once the carbon footprint is assessed, individuals or entities can purchase carbon credits equivalent to the amount of emissions they want to offset. Each credit represents the removal or reduction of one ton of CO2e from the atmosphere.

c. **Investment in Carbon Reduction Projects**: The funds generated from the sale of carbon credits are typically invested in projects that aim to reduce greenhouse gas emissions or remove carbon dioxide from the atmosphere. These projects can include renewable energy projects, afforestation or reforestation initiatives, methane capture projects, or energy efficiency programs, among others.

d. **Verification and Certification**: Carbon reduction projects undergo rigorous verification and certification processes to ensure that they meet established standards and deliver the promised emission reductions. This verification is often done by third-party organizations to provide transparency and credibility to the carbon credit market.

e. **Retirement of Carbon Credits**: Once the emission reductions are verified and certified, the carbon credits are retired, meaning they cannot be traded or used again. This ensures that the emission reductions are not double-counted and that the purchaser can legitimately claim to have offset their carbon footprint.

2. Compliance Carbon Credits: Compliance carbon credits, also known as regulatory carbon credits, are a key component of emissions trading schemes established by governments or regulatory bodies to limit greenhouse gas emissions. Compliance carbon markets are established under government-led emissions trading schemes, such as the European Union Emissions Trading System (EU-ETS) or regional cap-and-trade programs. Unlike voluntary carbon credits, which are purchased voluntarily by individuals or organizations, compliance carbon credits are often required by law or regulation for entities that exceed a certain threshold of emissions. It work within emissions trading schemes as follows,

a. **Cap and trade system**: In a cap-and-trade system, a regulatory body sets a cap on the total amount of greenhouse gas emissions allowed within a certain jurisdiction or sector. This cap is typically reduced over time to achieve emissions reduction targets.
b. **Allocation of allowances**: Under the cap-and-trade system, the regulatory body allocates a certain number of emissions allowances to covered entities. These allowances represent the right to emit a specified amount of greenhouse gases, usually measured in tons of CO_2e.
c. **Trading of allowances**: Covered entities can buy and sell emissions allowances among themselves in a regulated market. Entities that can reduce emissions more cost-effectively than others may sell their excess allowances, while entities facing higher abatement costs may purchase additional allowances to comply with the emission limits.
d. **Compliance carbon credits**: In addition to emissions allowances, some emissions trading schemes allow covered entities to use compliance carbon credits to meet their regulatory obligations. These credits are generated from approved emission reduction projects, such as renewable energy projects, energy efficiency initiatives, or carbon capture and storage projects. Each compliance carbon credit typically represents one ton of CO_2e that has been reduced or removed from the atmosphere.
e. **Verification and certification**: Like voluntary carbon credits, compliance carbon credits undergo rigorous verification and certification processes to ensure that the emission reductions are real, additional, measurable and permanent. Third-party verification is often required to ensure the integrity of the credits.
f. **Penalties for non-compliance**: Covered entities that exceed their allocated allowances and fail to surrender sufficient compliance carbon credits to offset their excess emissions may face penalties or fines imposed by the regulatory body.

Trading and Market Mechanisms: Once certified, carbon credits can be bought, sold, or traded on carbon markets. Buyers purchase carbon credits to offset their own emissions or to comply with regulatory requirements, while sellers, such as project developers or carbon brokers, sell carbon credits to generate revenue and finance emission reduction projects. Carbon markets facilitate price discovery for carbon credits based on supply and demand dynamics.

Role in Climate Mitigation: Carbon credits play a crucial role in incentivizing emission reductions, promoting investment in low-carbon technologies and projects, and contributing to global efforts to mitigate climate change. By providing financial incentives for emission reductions, carbon credits help drive the transition to a more sustainable and low-carbon economy.

Merits and demerits of carbon credit:

Carbon credits offer a means to incentivize emission reductions and promote sustainable practices, but they also have limitations and drawbacks. Here's a breakdown of their merits and demerits:

Merits:

1. Carbon credits provide financial incentives for businesses, organizations and individuals to invest in emission reduction projects and adopt sustainable practices. By monetizing emissions reductions, carbon credits encourage entities to take concrete action to mitigate climate change.
2. Carbon credits support the development and deployment of low-carbon technologies and projects by providing a source of funding. This can accelerate the transition to a more sustainable and low-carbon economy by stimulating innovation and investment in renewable energy, energy efficiency, and other clean technologies.
3. Carbon credits enable cross-border cooperation on climate mitigation efforts by allowing entities in one country to invest in emission reduction projects in other countries. This promotes global solidarity in addressing climate change and helps distribute the costs and benefits of emissions reductions more equitably.
4. Carbon credits can contribute to sustainable development goals by financing projects that deliver co-benefits beyond emissions reductions, such as poverty alleviation, biodiversity conservation, community development, and improved public health. This aligns climate action with broader social, economic and environmental objectives.
5. Carbon credits can complement regulatory measures by providing flexibility and cost-effectiveness in achieving emissions reduction targets. They offer an additional tool for policymakers to incentivize emission reductions while allowing businesses to choose the most cost-effective compliance strategies.

Demerits

1. Some critics argue that carbon credits may enable "green washing" by allowing entities to offset their emissions through the purchase of credits without making meaningful reductions

in their own emissions. This raises questions about the integrity and additionality of emission reduction projects.

2. Carbon trading markets are susceptible to volatility and speculation, which can lead to price fluctuations and market manipulation. Lack of transparency and oversight in some markets may increase the risk of fraud, manipulation and abuse, undermining the credibility and effectiveness of carbon credit programs.
3. Carbon credit programs often focus on specific sectors, regions or gases, which may result in limited coverage and effectiveness in addressing broader climate change challenges. Coverage gaps and inconsistencies in carbon credit standards and regulations can also undermine the integrity and coherence of carbon markets.
4. Participation in carbon credit programs can be complex and administratively burdensome for businesses, particularly small and medium-sized enterprises (SMEs) with limited resources and expertise. Compliance costs, administrative requirements and transaction costs may deter participation and innovation.
5. In some cases, emission reduction efforts financed by carbon credits may be offset by rebound effects or leakage, where emissions are displaced or increased elsewhere as a result of project activities. This can undermine the overall effectiveness of carbon credit projects and raise questions about their environmental integrity.

II. Carbon Trading

Carbon trading, also known as emissions trading, is a market-based approach to controlling greenhouse gas emissions. It involves the buying and selling of permits or credits that represent the right to emit a certain amount of greenhouse gases. It is a market-based approach to controlling greenhouse gas emissions. It involves the buying and selling of carbon credits or allowances, which represent the right to emit a certain amount of greenhouse gases. The working nature of carbon trading is as follows,

a. **Cap and trade systems**: The most common form of carbon trading is cap-and-trade systems, where a regulatory authority (such as a government or regional authority) sets a cap on total emissions from covered entities, such as power plants, factories and industrial facilities. These entities are allocated or required to purchase a certain number of carbon allowances, each representing a specified amount of emissions.

b. **Emission reduction obligations**: Entities that emit less than their allocated allowances can sell their excess allowances to other entities that exceed their emissions limit. This creates a market for buying and selling emissions allowances, incentivizing emission reductions and providing flexibility for businesses to comply with regulatory requirements.

c. **Price discovery**: Carbon trading markets facilitate price discovery for carbon credits and allowances based on supply and demand dynamics. The price of carbon credits can fluctuate based on factors such as market conditions, regulatory changes, technological advancements and climate policies.

d. **Compliance and voluntary markets**: Carbon trading can occur in both compliance markets, where entities are legally obligated to reduce emissions or purchase allowances to comply with regulations and voluntary markets, where entities voluntarily purchase carbon credits to offset their emissions and demonstrate environmental responsibility.

e. **Regulation and oversight**: Carbon trading markets are typically regulated and overseen by government agencies or regulatory bodies responsible for administering emissions trading programs. These agencies set the rules, standards, and requirements for participation in the market, monitor compliance, and enforce penalties for non-compliance.

Merits and demerits of carbon trading

Let's delve into the merits and demerits of carbon trading

Merits

1. Carbon trading employs a market-based mechanism to regulate greenhouse gas emissions, allowing the forces of supply and demand to determine the price of emissions allowances. This market-driven approach promotes cost-effectiveness and efficiency in achieving emission reduction targets.
2. Carbon trading provides flexibility for businesses to choose the most cost-effective strategies for reducing emissions, whether through internal reductions, investments in cleaner technologies, or purchasing emissions allowances. This flexibility encourages innovation and allows businesses to adapt to changing market conditions and regulatory requirements.
3. By creating a financial value for emissions reductions, carbon trading incentivizes businesses to invest in emission reduction projects and adopt cleaner technologies. The ability to buy and sell emissions allowances provides a financial incentive for businesses to reduce their carbon footprint and improve environmental performance.

4. Carbon trading facilitates international cooperation on climate change mitigation by allowing countries to trade emissions allowances and credits across borders. This promotes global solidarity in addressing climate change and enables countries to achieve emissions reduction targets more cost-effectively by leveraging opportunities for emission reductions in other regions.
5. For entities that reduce emissions below their allocated allowances, carbon trading can provide an additional revenue stream through the sale of excess allowances. This revenue can be reinvested in further emission reduction efforts, sustainability initiatives, or other business activities.

Demerits

1. Carbon trading markets can be subject to volatility and speculation, leading to fluctuations in the price of emissions allowances. This volatility can create uncertainty for businesses and investors and may undermine the effectiveness of carbon trading as a long-term tool for emissions reduction.
2. Participating in carbon trading requires businesses to navigate complex regulatory frameworks, reporting requirements and compliance obligations. This administrative burden can be particularly challenging for small and medium-sized enterprises (SMEs) with restricted resources and expertise.
3. Carbon trading markets are vulnerable to manipulation and abuse, including fraud, market manipulation and insider trading. Lack of transparency and oversight in some markets can increase the risk of malpractice, undermining the integrity and credibility of carbon trading programs.
4. There are concerns about the additionally of emission reduction projects financed through carbon trading. Some projects may not represent real, additional emissions reductions beyond what would have occurred anyway, raising questions about the environmental integrity and effectiveness of carbon credits.
5. Carbon trading may have distributional impacts, with costs and benefits distributed unevenly among different stakeholders. There is a risk that vulnerable communities and marginalized groups may bear a disproportionate burden of the costs of emissions reductions, while others reap the benefits of carbon trading.

Conclusion

In general, carbon credits and carbon trading play a crucial role in incentivizing emission reductions, promoting investment in low-carbon technologies and projects and contributing to global efforts to mitigate climate change. They provide a mechanism for businesses, governments and individuals to take action on climate change and transition to a more sustainable and low-carbon economy.

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THE REMARKABLE *LATHYRUS* HAS THE POTENTIAL TO REVOLUTIONIZE AGRICULTURE BY OVERCOMING SIGNIFICANT CHALLENGES

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Introduction

The global human population has reached 8 billion people, and according to the latest projections by the United Nations, the world's population could grow to around 8.5 billion by 2030 and 9.7 billion by 2050. It is predicted that population and income growth will double the global demand for food by 2050, leading to increased competition for crops as sources of bioenergy, fiber, and for other industrial purposes. Conversely, there is a growing demand for higher quantity, quality, and diverse food due to the increasing population, average income, and awareness of health and globalization. However, meeting this demand poses a serious challenge as we frequently witness droughts, floods, heat and cold waves, as well as incidences of pest and disease epidemics, resulting in agricultural productivity losses. Abiotic factors account for more than 50% of these losses, while arable land is decreasing due to urbanization and industrialization. Climate change has potentially decreased agricultural productivity by 10-25% and is forecasted to cause further losses within the next 50 years. These threats are likely to become even more significant under climate change and the pressures of an ever-growing human population.

The urgent need to enhance crop resilience and yield to ensure future food security, as well as the increasing demand for environmentally friendly agricultural practices, create a favorable context for new cropping systems that include grain and forage legumes, also known as pulses. Pulses have a broad genetic diversity, making them adaptable to future climate scenarios. They can grow in poor soils and withstand drought, and their inclusion in multiple cropping systems promotes sustainable farming practices. The highly resilient Lathyrus species (Fabaceae) can play an important role in these immense agricultural challenges. Lathyrus genus includes 160 species, some of which are important for food, fodder, and ornamental crops. Most *Lathyrus* sp. are mesophytes found in open woodlands, forest margins, and roadside verges. There are also littoral, alpine, and drought-tolerant varieties. The genus includes both annual and perennial species, many of which have a climbing habit using simple or branched tendrils. L. sativus (grass pea) is particularly crucial as a food crop and has been used as animal feed since around 6000 BC. Grass peas can help address significant agricultural challenges. Achieving necessary productivity gains will depend on more sustainable management of renewable soil and water resources and more efficient utilization of genetic diversity.

Lathyrus demonstrates robust agricultural crop resilience to stress

Lathyrus is a nutrient-dense food crop with reduced water demands. These characteristics make Lathyrus an important player in addressing global malnutrition. Additionally, it is an environmentally friendly and sustainable source of various nutritional and health-beneficial components. As an annual cool-season grain legume crop, grass pea requires relatively low input compared to major crops, making it a model crop for sustainable agriculture and a viable alternative for diversifying cropping systems in marginal lands. This highly climate-resilient and economically important annual feed and food grain legume is of growing interest in the Mediterranean region, especially in Asian and African developing countries. Grass peas are robust under adverse conditions, particularly water deficit and waterlogging stresses, salinity, and temperature extremes, due to their content of β-Oxalyldiaminopropionic acid (β-ODAP), a naturally occurring amino acid derivative.

These underutilized yet hardy crops are well-suited for adapting to fragile agro-ecosystems owing to their ability to thrive under extreme conditions. Notably, these plants have advantageous traits, including high nutritional value, nitrogen fixation capacity, tolerance to temperature extremes, and moderate waterlogging. In comparison to other legumes, grass peas exhibit distinct morphological and physiological features that confer drought tolerance, such as narrow leaves, winged stem margins, and a deep, extensive root system. Clearly, grass peas hold significant promise as a crucial plant species in dryland systems. The renewed interest in grass peas can be attributed to their utility as animal feed and fodder. This resurgence aligns with the expansion of cereal-based cropping systems, which currently dominate extensive agricultural land globally. Notably, this crop demonstrates resilience against major diseases and insect pests, except for sporadic occurrences under specific environmental conditions. **Lathyrus is the key to resilience and high nutrition value, surpassing all other crops**!

"This crop has high nutritional value and is easy to cultivate, making it an excellent choice for sustainable agriculture. It has outstanding nitrogen fixation and the ability to withstand both biotic and abiotic stress, making it well-suited for zero/no tillage cultivation." Supporting improved health and capable of withstanding the impacts of climate change. Significant strides in its enhancement through conventional breeding and more recent genomics techniques have been highlighted in numerous studies. Grass peas can serve a variety of purposes, including animal feed and fodder, as well as human consumption, due to their seed and mature leaf protein content of 18–34% and 17%, respectively. These values exceed those of field pea (*Pisum sativum* subsp. arvense (L.) Asch) (23%), faba bean (*Vicia faba*) (24%), or lupine (*Lupinus albus*) (32%). While animal feed from grass pea usually consists of ground or split grain or flour and is primarily used to feed lactating cattle or other draft animals, human diets include boiled Lathyrus grains, which are either consumed whole or processed into split dal. Furthermore, grass pea is highly suitable for human consumption due to its 58% polyunsaturated fatty acid content (Grela et al. 2010). As a nutrient-dense food/feed crop with high drought tolerance and minimal input requirements for cultivation, grass pea provides food and nutrition security for many low-income communities.

Grass pea, like other underutilized legumes, holds immense potential for compounds that can contribute to human health. For instance, it is the only known dietary source of L-homoarginine. Therefore, as a nutraceutical, grass pea exemplifies the potential for "functional food". The robustness of grass pea, combined with its inherent ability to biologically fix atmospheric nitrogen through its rhizobia-containing roots—a feature shared with otherlegumes—makes it an appealing crop for cultivation under adverse agricultural conditions.

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BIOPESTICIDES: PIONEERING SUSTAINABLE SOLUTIONS FOR MODERN AGRICULTURE

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Abstract

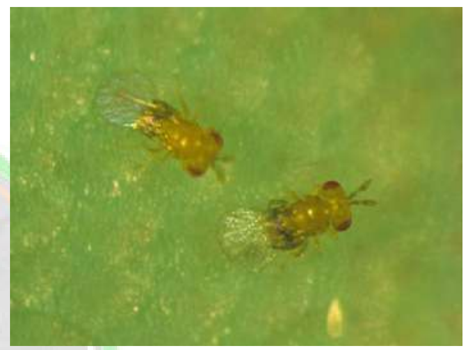
In the natural world, competition, predation, and parasitism are common occurrences. It has been discovered that various living organisms can be utilized in agriculture to safeguard crops against insect pests, fungal and viral diseases, nematodes, weeds, and mollusks, all of which threaten crop health. A wide range of pest species can now be managed using many commercially available biopesticide products, which contain active agents such as bacteria, fungi, viruses, and beneficial insects. An insecticide that includes *Bacillus thuringiensis* accounts for over 90% of all biopesticide sales. While global agrochemical sales are either stagnant or declining, biopesticide sales are increasing at an annual rate of 10-25%. Biopesticides are precise in their action and do not leave toxic residues. These biological agents can effectively eliminate agricultural pests, enhancing crop productivity and maintaining environmental balance when used correctly.

Introduction

The market for biological pesticides is growing, gradually overtaking conventional pesticides in market share. The biopesticide sector is rapidly developing, driven by biotechnological advancements. Organic farming and integrated pest management systems are major forces propelling the market growth of biopesticides. Organic farmers favor these alternatives for their "green" attributes. To enhance pest control effectiveness, both conventional methods and biopesticides should be used in combination. Biopesticides, which include living organisms such as plants, bacteria, nematodes, fungi, and viruses, or their derivatives, are used to manage pest populations. The primary advantages of biopesticides are their reduced environmental impact and lower public health risks. They also offer more targeted control of specific pests, minimizing risks to non-target organisms. Additionally, pests are less likely to develop resistance to biopesticides compared to conventional pesticides (Boyd and Hoodle 2007). However, while conventional pesticides can provide immediate action, biopesticides may take longer to become effective after application. Integrated pest control systems can reduce the reliance on chemical pesticides, thereby mitigating the negative aspects associated with both chemicals and biopesticides, while harnessing the benefits of each approach.

Biopesticides

Biopesticides are typically administered in liquid forms, water-dispersible formulations, water-soluble pellets, or powders. The choice of formulation depends on ease of application, farmer preferences, and the available dispensing equipment. Liquid-based formulations constitute the largest portion of the market (approximately 60%), followed by granules, with powders being the least common option.



Predators, Parasitoids and Nematodes

Parasitoids

Trichogramma are small wasps from the family Trichogrammatidae, known for their role as egg parasitoids targeting lepidopteran pests. Widely used in agriculture, they lay eggs inside host insect eggs, where larvae hatch and consume contents, preventing pest development. Effective against over 200 insect species, Trichogramma supports integrated pest management by reducing pest populations before they harm crops. These are mainly from Hymenoptera and Diptera. On the basis of stages of the host attacked the parasites are correspondingly called Egg parasite, larval parasites and pupal parasites. It is always the larval stage of the parasite that damages the host. The adult parasite finds the suitable host and lays eggs on or in or near the host. When eggs are laid near the host or on the host they emerged larvae find the way in to the host body in endoparasitic group. If it is ectoparasitic in nature it sticks to the host body and gets the food from host for the development. Its environmental safety,

minimal residue, and low resistance development compared to chemical pesticides make it a sustainable choice (Gillespie *et al*., 2006). Released manually or with equipment, timely application optimizes its impact, promoting biodiversity and safeguarding crop yields.

Predators

Green lacewings like *Chrysopa carnea* and *Chrysopa rufilabris* are abundant in crop fields. Their eggs typically hatch within a few days, and the larvae feed on young whiteflies, mites, aphids, small worms, and thrips. After about 5 days, the lacewing larvae hatch, continuing the cycle. Lacewing eggs for sale often include a food supply and rice hulls.

Lady beetles are prominent and beneficial predatory insects. They lay eggs that develop into small larvae within 7 days. After three to four weeks, the larvae enter the pupal stage, and within another week, they emerge as young adults ready to prey on insects. Ladybugs consume small worms, aphids, and a variety of insect eggs.

Syrphid flies, also called flower flies or hover flies, are able to prey on small, soft-bodied insects during their larval stage. They are particularly beneficial early in the growing season when temperatures are cooler and other predators are less active, effectively controlling aphid infestations.

Nematodes

Heterorhabditis bacteriophora, an entomopathogenic nematode, is utilized to control beetle larvae in the soil. These nematodes are adept at navigating through soil to find a suitable host. Upon penetrating the larval body through its cuticle, Heterorhabditis releases a symbiotic bacterium (Photorhabdus) that rapidly reproduces and fatally infects the host within 24 to 72 hours. Newly hatched juvenile nematodes then seek out additional hosts. *H. bacteriophora* is primarily deployed to combat root weevils and has significant potential benefits for horticulture and ornamental crops.

Bacterial

***Bacillus thuringiensis* (*Bt*)**

Many lepidopteran pests, including the American bollworm, Heliothis and Earias species, as well as Spodoptera and Plutella, are susceptible to *Bt*. Various commercial crops utilize *Bt*, such as rice, castor, cotton, cauliflower, tomato, and cabbage. When ingested by insect larvae, *Bt* releases an endotoxin that binds to the intestinal lining of the midgut, creating pores that disrupt ion balance and ultimately lead to paralysis. This results in insect mortality within a few days. There are approximately 500 to 600 different strains of B. thuringiensis, known to be effective against 525 insects from diverse families. The introduction of B. thuringiensis has rendered several crops resistant to lepidopteran pests (such as skippers, moths, and butterflies) as well as coleopteran pests (including weevils and beetles). Compared to chemical pesticides, *Bt*-based insecticides are less likely to harm non-target insects (Zaia *et al*., 2006).

Viral

a. **Nucleopolyhedrosis virus (NPV)**, a baculovirus, infects a variety of lepidopteran insects found on crops like tomato, cotton, maize, sunflower, vegetables, chickpea, groundnut, and sorghum. Once ingested, infectious virus particles begin to disrupt the insect internally, developing within the nuclei of the host. NPV selectively targets specific pests while posing no harm to non-target insects, making it suitable for integrated pest management strategies to enhance the effectiveness of other biological control agents. Nearly 300 isolates of NPV have been identified, primarily affecting Diptera (5%), Hymenoptera (6%), and Lepidoptera (88%).

b. **Granulosis virus (GV)** has been documented in approximately 65 isolates exclusively affecting Lepidoptera. GVs are typically more specific to their hosts compared to NPVs and are transmitted through eggs or orally. Under optimal conditions, virus particles can remain viable for years due to their protein barriers. When larvae become infected with GVs, the protein coat dissolves in the insect gut, enabling viral DNA to enter digestive cells and initiate infection. This leads to the insect's deterioration and eventual death due to its inability to digest properly (Zannou *et al.*, 2007).

Fungal

Beauveria bassiana primarily targets foliar-feeding pests through biocontrol, causing a disease known as white muscardine. When *B. bassiana* spores come into contact with an insect's outer layer, they germinate and invade the host's body. Inside the insect, the fungus produces toxins and depletes nutrients, eventually leading to the insect's death. Unlike bacterial and viral pathogens that require ingestion by the host, fungal pathogens like B. *bassiana* infect the host directly. After the insect dies, the fungus reverts to its original white mold form, producing millions of new spores. *B. bassiana* spores can kill aphids within 3 to 5 days at a temperature of 22.22°C, with the speed of action influenced by temperature fluctuations. This fungus is effective against a range of pests including whiteflies, aphids, thrips, psyllids, weevils, and mealybugs (Zilahi *et al*., 2002).

Conclusion

In today's agriculture, biopesticides play a crucial role as sustainable alternatives to conventional chemical pesticides. They encompass a diverse range of biological agents such as bacteria, fungi, viruses, and beneficial insects that effectively manage pests while minimizing environmental impact. Unlike chemical pesticides, biopesticides are often more targeted, reducing harm to non-target organisms and leaving minimal residues. This targeted approach not only enhances crop health and productivity but also promotes ecological balance by preserving beneficial insects and wildlife. The increasing demand for biopesticides reflects their efficacy and safety, driving innovation in biotechnological advancements. Organic farming and integrated pest management systems further bolster their adoption, emphasizing their role in reducing reliance on synthetic chemicals. Biopesticides contribute to sustainable agriculture practices by supporting soil health, biodiversity, and long-term crop resilience. As biopesticide research continues to expand, optimizing formulations and application methods, their integration into agricultural practices holds promise for meeting global food production challenges while minimizing adverse effects on human health and the environment. Embracing biopesticides represents a forward-thinking approach in agriculture, aligning economic viability with environmental stewardship for future generations.

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HARNESSING THE POWER OF RICE STRAW: A PROMISING BIOFUEL FEEDSTOCK

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Introduction

Rice plays a vital role in achieving Zero Hunger as it is a staple food for many countries worldwide. Over the years, there has been a tremendous increase in rice production, and it is projected to rise by 28% in 2050 due to the growing world population (Zhu et al., 2019). According to the Food and Agriculture Organization (FAO, 2022), the Asian region contributes approximately 90.5% of the total global production.

Rice straw, an agricultural byproduct obtained after harvesting the rice grain, constitutes approximately 40 to 60% of the rice plant's total weight [Logeswaran et al., 2020]. Comprising 43% cellulose, 25% hemicellulose, and 12% lignin, rice straw is classified as lignocellulosic biomass [Vivek et al., 2019]. The rapid advancement of rice farming techniques and technologies, such as intensified rice-cropping systems and the adoption of combined harvesters has resulted in an escalation in the amount of straw left behind in the fields. The growing demand for rice and its subsequent increase in production has led to a rise in the production of rice straw. Now a day's the concentration on second generation biofuel is getting more attention due to constrains in original biofuel. Agricultural waste is an appealing feedstock for an alternative bioenergy source.

The increasing concern regarding global environmental issues, such as climate change and fossil fuel depletion, has prompted the exploration of alternative energy sources. Many countries worldwide have set targets to reduce greenhouse gas (GHG) emissions intensity per unit of GDP by 2030, compared to 2005. Therefore, it is crucial to investigate more sustainable energy sources in order to meet the growing energy demand [Han et al., 2022]. Consequently, renewable energy has emerged as a viable option to decrease reliance on fossil fuels and contribute to the mitigation of GHG emissions [Harun et al., 2018]. Among the various renewable energy sources, biomass stands out as one of the most sustainable and cost-effective options. In comparison to fossil fuels, biomass offers a more sustainable alternative fuel and has the potential to be converted into biomethane gas, which can potentially replace natural gas.

Government policies

Recent government policies aim to minimize or eliminate the use of fossil or non-renewable resources in manufacturing systems while maximizing their reuse within the same system. Moreover, the utilization of agricultural residue in energy production can help mitigate gaseous emissions such as CO_2, SO_2, and NO_3. Rice husk, rice straw, and sugarcane bagasse, among other agricultural residues, have been widely employed worldwide to generate renewable energy. Rice straw, which accounts for nearly half of the weight of the paddy plant, is particularly noteworthy as an important agricultural waste for bioenergy utilization [Logeswaran *et al.*, 2020].

Rice straw

Rice straw holds potential for various agricultural applications, such as improving soil quality through carbonization and composting, generating bioenergy, and producing industrial products like bio-fibre and silica. However, not all of these options are economically viable as the costs associated with rice straw materials, including transportation expenses, remain higher compared to those of traditional feed stocks or existing feed stocks.

Open field burning is a widely employed method in many countries including India for various purposes, such as mitigating high labour expenses associated with manual straw collection, addressing difficulties in soil incorporation caused by frequent crop rotations, insufficient time for decomposition, and other related factors. In light of the unprofitability of manual rice straw collection for farmers, the incorporation of rice straw into intensive systems with multiple cropping cycles per year poses significant challenges due to the slow decomposition rate of rice straw. Consequently, the practice of burning rice straw in open fields has seen a rapid increase, leading to detrimental environmental effects such as greenhouse gas (GHG) emissions and suspended particulate matter

Inadequate management of straw integration can result in reduced production efficiency and increased greenhouse gas emissions. After adding straw to the soil, it is essential to consider proper strategies for managing greenhouse gas emissions. The slow decomposition rate of rice straw is a primary reason why some farmers hesitate to incorporate it into the soil, especially in intensive cropping systems with a 3-week interval. Recent research from IRRI indicates that integrating rice straw into the soil can lead to emissions of 3500 to 4500 kg CO_2-eq ha1, which is 1.5 to 2.0 times higher compared to removing the straw (Romasanta et al., 2017). Removing straw from rice fields can help prevent open-field burning and significantly reduce greenhouse gas emissions in the rice production cycle.

Off-field management of rice straw

Off-field management of rice straw is divided into agricultural uses, energy production, and applications within the industrial/manufacturing sector. Numerous rice-producing nations leverage rice straw for agricultural functions, including the creation of biochar, bedding materials, mushroom growth medium, compost, and animal feed. Furthermore, rice straw finds utility in industrial contexts, notably in the fabrication of roof insulation materials and particleboards made from rice straw. Amidst a growing global focus on diminishing dependence on fossil fuels, the interest towards harnessing rice straw biomass for bioenergy has escalated. China is at the forefront of converting rice straw into bioenergy, with 53.6% of its rice straw output routed towards rural energy solutions.

In rice straw, cellulose is made up of D-glucose subunits connected by glycosidic linkages and can be categorized as either crystalline or amorphous. Hemicellulose contains pentose, hexose, uronic acids, and other compounds . Hemicellulose plays a crucial role in holding together lignin and cellulose molecules, providing tensile strength. Lignin, on the other hand, protects the mosaic structure of monolignol compounds such as p-coumaryl, coniferyl, and sinapyl (Harun et al., 2022).

Numerous studies have been conducted by different scientists throughout the world to explore the potential of utilizing rice straw as a bioenergy resource. Despite the promising potential of rice straw for bioenergy production, there are concerns regarding its environmental impact throughout the entire production process and application. It is crucial to conduct studies on the environmental performance of rice straw utilization to identify the most environmentally friendly technologies and practices. Additionally, investigating the sources of emissions is important to pinpoint the environmental hotspots in the process. Therefore, improvements can be made, particularly in terms of the materials used as inputs.

Rice plants that have undergone genetic engineering can produce more bioethanol with lower costs and more energy from biomass. For instance, a research discovered that the lignocellulose porosity and accessibility were enhanced in a rice mutant (cesa7) with decreased cellulose crystallinity and polymerization. Additionally, this mutant produced bioethanol with about 96% of its hexose yields coming from biomass saccharification, which was nearly complete. According to a different study, transgenic rice lines treated with hot water and alkali chemicals nearly completely underwent enzymatic saccharification, yielding more than 20% of their biomass as bioethanol.

Conclusion

Plant genetic engineering tools have made significant advancements in recent years. One of the most groundbreaking technologies is genome editing, which allows for highly efficient and precise modification of specific DNA sites (Yin et al., 2017). Currently, the clustered regularly interspaced palindromic repeat (CRISPR)/CRISPR-associated 9 (Cas9) system is widely recognized as a highly effective and easily accessible platform for genome editing. Hence by applying CRISPR-associated 9 (Cas9) system) in future and modification of scarification efficiency of the rice straw may serve as an very good alternative for fossil fuel in future.

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USER FRIENDLY ERGONOMIC BATHROOM CUM WATER CLOSET DESIGNS FOR ELDERLY

Article ID: AG-VO4-I07-06

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Introduction

The old age is an integral part of human life. It is the precious time spent by an individual with and around the environment, where it gives the feeling that one has entered to the childhood again. Elderly or old age consists of ages nearing or surpassing the average life span of human beings. The boundary of old age cannot be defined exactly because it does not have the same meaning in all societies. The 'National Policy on Older Persons' (1999) adopted by Government of India defines 'senior citizen' or 'elderly' as a person who is of age 60 years or above. Although retirement from accustomed work is usually at the age of 60 years, general vitality and interest may continue at the moderate pace for some more years. The first five years may be considered young old, the second five years as old-old and the years thereafter as oldest-old.

Home is the one where we spend our valuable time with family hence the special features with regard to interior should be taken into consideration especially for the elderly people. In the urban areas due to space problems the physical aspects present in housing accommodation may not be in good condition, hence housing may be less comfortable for the aged people. So suitable considerations should be taken while planning keeping the elderly generation in mind. There is a strong relationship between ergonomics, interior and old age people. As the age increases there will be increase in physical, physiological, body pain and psychological health problems. Hence for these health problems they need a proper medication and also a good environment around them. The physical design of housing interior plays a major role in influencing the quality of life of all elderly residents. Sheehan (1992) stated that the physical design of housing interiors plays a major role in influencing the quality of life of all elderly residents. In order to continue the design criteria and recommendation for housing for elderly persons, one must first be aware of the functional needs of the residents. One must consider that ageing is a process, and the functional levels of each individual will generally decrease at different rates. Hence, during in old age the structural facilities of home should be given more importance than the functional facilities, but now a day the functional design is given more importance. Apart from the structural design housing should fulfill the needs of safety, comfortability and privacy. The utilization of space, positioning of building materials, flooring and number of doors windows and their dimensions should be taken into consideration and should be planned keeping the elderly people in mind. Poor functional design may cause injuries and accidents due to falls. In order to achieve a good interior design, it should be planned carefully.

Features and advantages of user friendly ergonomic bathroom cum water closet designs for elderly

Problems	**Solutions/Remedies**	**Advantages**
Slippery flooring	• Provision of non-skid flooring in bathing region and use of non-skid mat at sink and water closet region	• To avoid falls/ accidents
Lack of grab bars	• Provision of grab bars at both sides of water closets and shower chair.	• For body balancing and supporting
Difficulty in using Indian toilet	• Provision of grab bars at both sides of water closet at two different levels *i.e.* squatting elbow height and shoulder height level. • Use of adjustable chair • Provision of wall hung commode.	• Controls the posture while sitting down and getting up while toileting. • Convenient for sitting and getting up easily and independently while toileting. • To eliminate squatting posture while toileting. • Convenient for elderly with leg and knee pain and for disabled.
Problems related to	• Provision of solar hot water	• Avoids

water facility	facility. • Regular maintenance of plumbing system	• the bathroom hazards related to gas geyser and boiler. • Helps in avoidance of water supply problems • Eases the operation of taps/faucets.
Insufficient lighting/ventilation and problems related to electrical switches	• Provision of ventilators and exhaust fan. • Use of high voltage bulbs • Bigger size electrical switches at the entrance of bathroom and water closets.	• Avoids bathroom hazards and helps in air movement and avoid suffocation. • Clear visibility
Absence of hand faucet/shower/waterjet	• Provision of hand faucet and waterjet facility in water closet • Provision of hand showers in bathroom	• For easy wash after toileting • Avoids the excessive hand movements. • Convenient and comfortable to use.
Insufficient or improper storage facility	• Provision of sufficient storage facility at comfortable reaches	• Avoids excessive movements • Easy to find and reach the accessories
Lack of shower chair	• Provision of height adjustable shower chair at bathing region	• Comfortable and easy bathing • The height of shower chair can be adjusted as per the convenience.
Need for bathroom cum water closet and preferably attached to bedroom	• Bathing and toileting regions are mounted on a single piece of model.	• Convenient and comfortable to use • User friendly design
Adequate size and easy allowance of movements	• The floor plan is in accordance with the standard dimensions given by Model Building Bye-Laws (2016) • Free from obstacles and sharp edges	• Avoids the space problems • Less expensive and user friendly • Avoids bathroom hazards due to obstacles and sharp edges

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A CASE STUDY ON EROSION AND CHANGE DETECTION IN CHAR LAND OF MAJULI

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Introduction

The issue of erosion and change detection in the char lands of Majuli is a critical environmental and socio-economic concern. Majuli, located in the Brahmaputra River in Assam, India, is the largest river island in the world and is known for its unique cultural heritage and biodiversity. However, the island faces severe erosion due to the shifting course of the Brahmaputra River, exacerbated by climate change and human activities. Majuli Island, home of about 1.3 million people is endangered because of the erratic behavior of the river. In this study, an attempt has been made to observe the trends of erosion in Majuli island using satellite data of 1976 to 2024. Image processing of digital data has been done in QGIS software. Supervised for delineation of river from land and then change detection analysis has been done to find out changes in river course from 1976 to 2024. Erosion and deposition maps of the area have been prepared and the erosion of island is measured.

The observation has revealed a dramatic change in reduction of land area of the Majuli Island. Subansiri is the largest tributary of Barhmaputa and water yield to the Brahmaputa of the is 0.076 cumec/km^2 (Goswami, 1998). The Brahmaputra is a classic example of a braided river consisting of a network of interlacing channels with unstable bars and islands As the flow begins to rise with the onset of the monsoon, most of the islands are submerged and the river then flows in more or less single channel. The most striking feature is the continuous shift of the thalweg (deep channel) from one location to another within the bankline, its movement being high in the rising stage (May to August), most erratic during the falling stage (September to October) and minimal in the low flow stages (Goswami, 1998). The mechanism of braiding may be attributed as the affect of excessive sediment load, large and variable flow, erosion-prone banks and the rapid aggradation of the channel (Goswami, 1991, Leopold *et.al*, 1964). The extreme braided nature of the Brahmaputra coupled with silt and sand strata of the banks is the main cause of erosion. Erosion in this area was not much before the 1950 earthquake of magnitude 8.6 Richter scale but became active thereafter and attained serious dimension after the 1954 flood. In 1987, Majuli suffered the most severe flood having lost 50,000 cattle and crop (Centre for Natural Disaster Management, Assam Administrative Staff College, Jawaharnagar, Khanapara). Porcupines are being used to control erosion only at a few places, but it has not been found to be effective. The aim of this present study is to evaluate the migration of the rivers Brahmaputra.

Methodology

Erosion of the island is a continuous process since historical times and posses a significant concern. The present approach have been made to study the erosion-deposition processes with the help of data resource generated from the Survey of India (SOI) toposheets and Landsat- 8 satellite imagery spanning the period from 1976 to 2024 to investigate spatial changes over available period of time.

Fig.1. – Map showing the location of study area.

Such information is considered valuable in providing information for a period of more than 40 years, which is often beyond the scope of empirical observation. Ground truth observations were made to prepare the interpretation key and Garmin Global Positioning System (GPS) was used to locate the latitude, longitude and altitude of the study sites. Geomorphic attributes of the flood plain, morphology of the channel and banks, and erosion/deposition activities have been evaluated from the toposheets, imageries and after proper field checking were used for interpretative use of the present study

Result and Discussion

Migration of Brahmaputra:

a) 1976 to 2024: During the period of 1976 to 1998 a significant change was observed in the migration of bank line of river Brahmaputra. The migration of bank lines during this period is presented in Fig.2. Heavy erosion of the island was caused by Brahmaputra river during this period as the river migrates towards north at most of the places. The river channel had migrated for a distance of about 6.49 km near Mayadebi, 5.24 km near Manikmukh kuamargaon, 1.73 km at Bengena Ati and 4.24 kms near Khorapargaon (Dutta *et al.*, 2010). This results in erosion of Majuli Island and thereby decreasing the total area. The next stretch of 65 km mainly showed migration towards the north. The river migrated towards north about 1.53 km near Khorapargaon, 1.14 km near Bengena Ati, 1.53 km near Rajgurubari and 2.5 km near Ujani Gejargaon. In between, the river had migrated towards south at Khoraholgaon and Kapahchali for about a distance of 1.25 kms and 1.8 kms respectively with reference to the 1998 position of the river bank line.

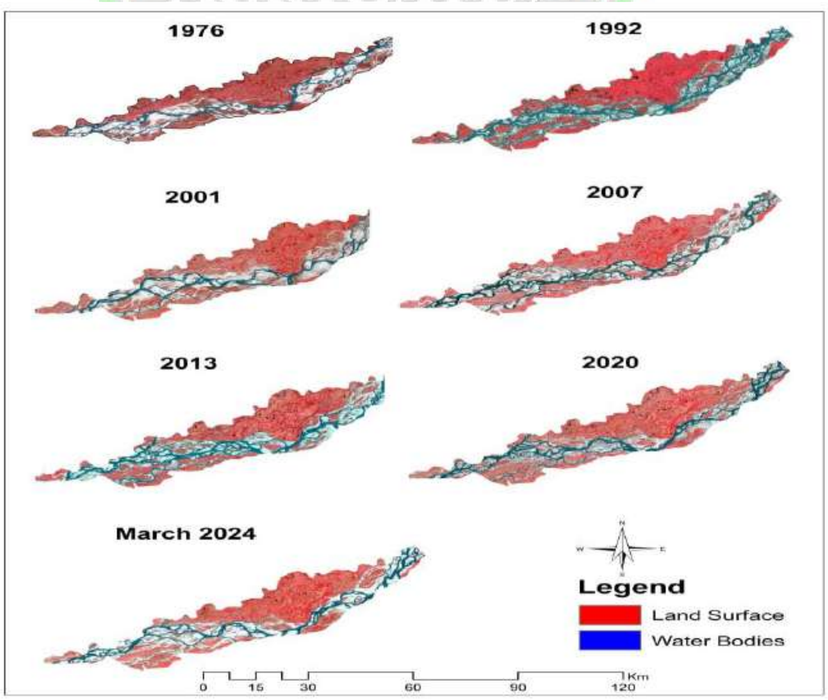

Fig 2. FCC of Majuli from 1976 to 2024

Analysis on total observation covering the period from 1976 to 2023, it was clearly visible that the river Brahmaputra has migrated for a maximum distance of about 6 km towards north near Mayadebi and Khorapargaon areas. However, near Bengena Ati and Ujani Gejeragaon the bank line was migrated towards north of a distance of about 2.87km and 5.1 km respectively (Dutta *et al.*, 2010). From the present investigation it can clearly be attributed that there have been a continuous shift in the bank line of the Brahmaputra River channel indicating significant erosion affect at many places of the Majuli Island.

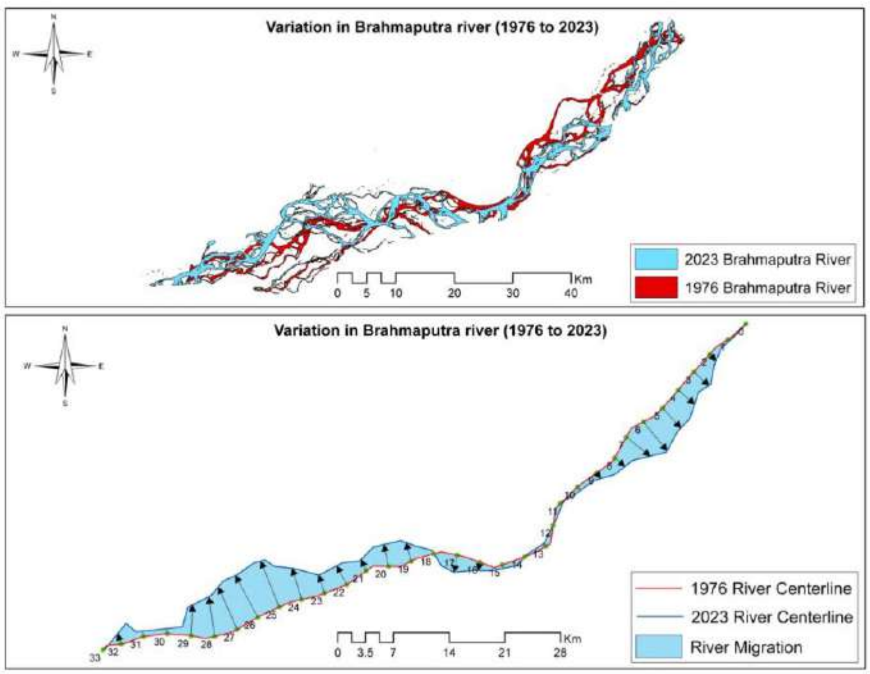

Fig 3. Variation in Brahmaputra river from 1976 to 2023

Erosion/Deposition activities around Majuli Island :

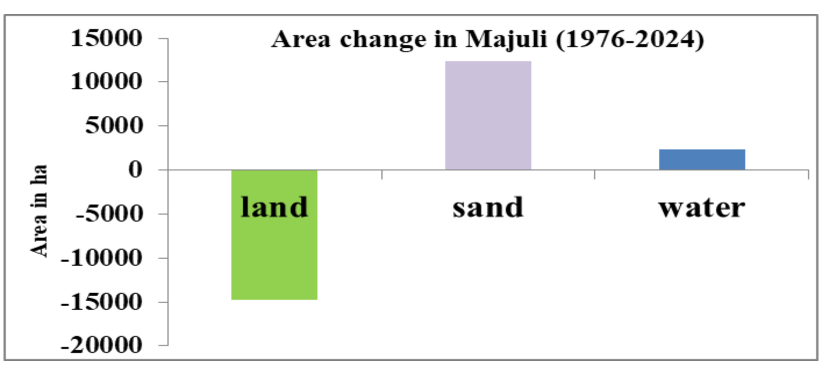

Fig 3. Change of land area to sand and water

The activity of erosion deposition processes around Majuli Island with reference to the Subansiri (North) and Brahmaputra (South) Rivers have been evaluated. In the light of generated information an interpretative discussion have been attempted in the preceeding sections.

Ground truth Verification

Fig- 5. Visit in Char land of Majuli

Fig- 6. Observation by Binocular from Ferry

Fig-7. Conversation with Padmashree Jadav Payang

Fig -8. Erosion Control Structure i.e. Porcopine

Fig- 9. Visit highly eroded area at Majuli

Fig- 10. Garmin Global Positioning System

The stretch up to 20km from the western end of Majuli Island suffered erosion with maximum at Bohumari and Nunibari of about 8.83 km2 and 10.77 km2 respectively. Thereafter, there was deposition of about 6.07 km2 at Major Chapori and 12.26 km2 at Kumolia gaon. The average annual erosion and deposition are given by the total area of erosion and deposition divided by the period of years. It gives the amount of erosion or deposition in each year. The rate of average annual erosion and deposition per unit length is given by average annual erosion or deposition divided by the stretch in kilometers. Spanning the period over to 2008 the study attributed that the total average annual erosion and deposition covering the entire period were 8.76 km2 /yr and

1.87 km2 /yr respectively. Comparatively higher erosion potential was confined to the south bank of Majuli Island than the north bank. The south bank of Majuli Island showed a higher rate of average annual erosion per unit length of 0.08 km2 /km by the Brahmaputra

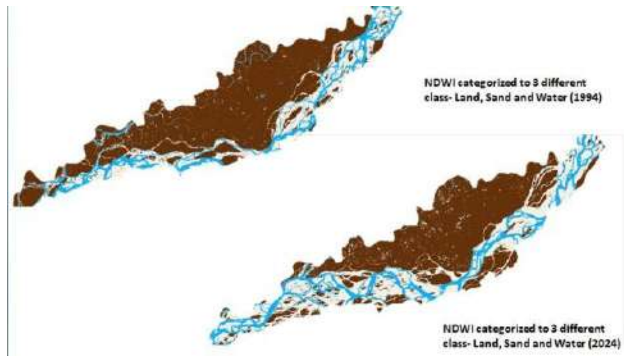

Fig 4. NDWI, Land ,sand and water categorized

Challenges and Solutions

- **Challenges:** Limited resources, inadequate infrastructure, and the remoteness of char lands pose challenges to effective erosion monitoring and mitigation efforts. The socio-economic vulnerability of local communities further complicates the issue.
- **Solutions:** Integrated approaches involving community participation, sustainable land management practices, afforestation, and riverbank protection measures are crucial. Policy interventions focusing on river management, disaster preparedness, and climate resilience are also essential to mitigate erosion impacts.

Conclusion

The fresh water river island Majuli have suffered a significant rate of erosion since historical time. Observation on the bank line migration spanning the period from 1976 to 2024 an extensive rate of migration was observed. Erosion in the char lands of Majuli require a multi-pronged approach that combines scientific research, technological innovation, community engagement and policy support. By understanding the causes, monitoring changes, and implementing sustainable solutions, it is possible to mitigate the adverse effects of erosion and ensure the long-term resilience of Majuli's unique ecosystem and its communities.

Thus, the erosion of the world's largest inhabited river island Majuli should be considered as a national problem and should be addressed in time to stabilize ecological balance.

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GEOGRAPHICAL INDICATION TAGGED AGRICULTURAL PRODUCES IN INDIA: AN OVERVIEW

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Introduction

Geographical Indication represents the specific geographical origin and quality of the product. It provides legal protection to Indian geographical indication which in turn boost exports and it also promotes economic prosperity of producers produced in a geographical territory. Geographical Indication is typically used for agricultural products, food stuffs, wine and spirit drinks, handicrafts and industrial products.

Trade mark and Geographical Indication

Trademark indicates a product or services differentiate from one enterprise to another enterprise. It restricts the commodity duplication in the name of enterprise which is familiar in Industry. Geographical Indication is given to the place of origin that commodity which is having some special characteristics that should not available in any other place of origin.

Laws and Treaties

World Intellectual Property Organization (WIPO) and World Trade Organization (WTO) enacted many laws and treaties for the protection of Geographical Indication.

i. WIPO

Three main treaties are i) Paris convention ii) Mandrid Agreement iii) Listron Agreement

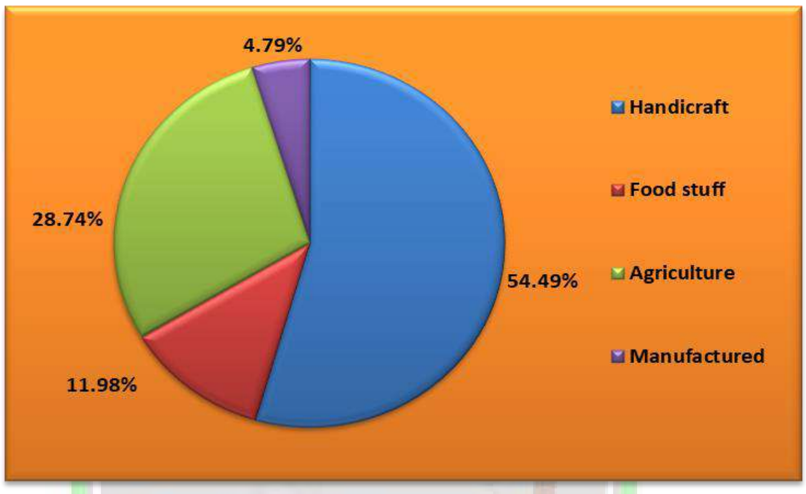
ii. WTO

WTO had Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement.

Geographical Indication – law passed in India

The Act geographical indications of goods (Registration and Protection) on 1999 enacted by Government of India and came into force in September 2003. This tag issued by the geographical indication registry under the Department of Industry promotion and Internal Trade, Ministry of commerce and Industry. The registration of GI is valid for a period of 10 years.

The most famous GI products in Darjeeling Tea for its taste, word and logo made history by becoming the first ever GI produce in India 2004 – 05. As of 2024, there are 635 registered geographical indications in India. Among the states Uttar Pradesh leads first in the list (69 GI tags) followed by Tamil Nadu (58 GI tags).



Registered GIs from various sectors during 2023-2024

Source: Department for promotion of Industry & Internal trade Government of India

State wise Agricultural produces registered under GI in India (2023 -2024)

S.No.	Geographical Indications (As per Sec 2(f) of GI Act 1999)	State	S.No.	Geographical Indications (As per Sec 2(f) of GI Act 1999)	State
1	Ladakh Seabuckthorn (Medicinal plant)	Ladakh (UT)	25	Kachchhi Kharek (Dates)	Gujarat
2	Bhandara Chinoor Rice	Maharashtra	26	Ramban Anardana (Wild pomegranate)	Jammu& Kashmir
3	Kanyakumari Matti Banana	Tamil Nadu	27	Koraput Kalajeera Rice	Odisha
4	Mushqbudji Rice	Jammu&	28	Arunachal Pradesh	Arunachal Pradesh

		Kashmir		Adi Kekir (Ginger)	
5	Agassaim Brinjal	Goa	29	Singpho Tea	Arunachal Pradesh and Assam
6	Sat Shirancho Bhendo	Goa	30	Arunachal Pradesh Angnyat Millet	Arunachal Pradesh
7	Marcha Rice	Bihar	31	Ratlam Riyawan Lahsun (Garlic)	Madhya Pradesh
8	Goa Mankurad Mango	Goa	32	Lakadong Turmeric	Meghalaya
9	Bhaderwah Rajmash (Rajma)	Jammu& Kashmir	33	Vasmat Haldi (Turmeric)	Maharashtra
10	Goa Cashew	Goa	34	Nandurbar Amchur (Mango)	Maharashtra
11	Khamti Rice	Arunachal Pradesh	35	Nandurbar Mirchi(Red Chilli)	Maharashtra
12	Uttarakhand Beringag Tea	Uttarakhand	36	Bundelkhand Kathiya Gehu (Wheat)	Uttar Pradesh and Madhya Pradesh
13	Uttarakhand Mandua (Ragi)	Uttarakhand	37	Banaras Lal Bharwamirch	Uttar Pradesh
14	Uttarakhand Jhangora (Barnyard millet)	Uttarakhand	38	Panchincholi Tamarind	Maharashtra
15	Uttarakhand Gahat (Horse gram)	Uttarakhand	39	Borsuri Tur Dal	Maharashtra
16	Uttarakhand Lal Chawal (Red Rice)	Uttarakhand	40	Kasti Coriander	Maharashtra
17	Uttarakhand Kala Bhat (Black soybean)	Uttarakhand	41	Chiraigaon Karonda of Varanasi	Uttar Pradesh
18	Uttarakhand Malta Fruit (Orange)	Uttarakhand	42	Badlapur Jamun	Maharashtra
19	Almora Lakhori Mirchi (Yellow chilli)	Uttarakhand	43	Bahadoli Jamun	Maharashtra
20	Uttarakhand Chaulai	Uttarakhand	44	Dagdi Jowar of Jalna	Maharashtra

	(Ramdana/ Amaranth)				
21	Ramnagar Nainital Litchi	Uttarakhand	45	Bodo Gongar Dunjia (Spiny coriander)	Assam
22	Ramgarh Nainital Aadu (Peach)	Uttarakhand	46	Bodo Khardwi (alkali liquid)	Assam
23	Nayagarh Kanteimundi Brinjal	Odisha	47	Bodo Keradapini (wild edible vegetable)	Assam
24	Kalonunia Rice	West Bengal	48	Uttarakhand Pahari Toor Dal	Uttarakhand

Details of Agricultural produces registered under GI in Tamil Nadu

1	**KODAIKANAL MALAI POONDU** (DINDIGUL - 2019) ➢ Medicinal and Aromatic properties ➢ It has anti-oxidant and anti-microbial properties ➢ Higher amount of organosulfur compounds, phenols and flavonoids compared to other garlic varieties	
2	**VIRUPAKSHI HILL BANANA** (DINDIGUL - 2008) ➢ Delicious and distinctive sweet taste ➢ It takes approx. 15 months to generate mature fruit for harvesting. ➢ Shelf life of the fruit > 10 days under normal conditions.	
3	**SIRUMALAI HILL BANANA** (DINDIGUL - 2008) ➢ Its smell and flavor is unique ➢ Fruit pulp is slightly harder with less moisture content, larger sugar content (230 brix) and high potassium	
4	**ERODE TURMERIC** (ERODE - 2019) ➢ Golden yellow colour ➢ It is known for its high curcumin (>90%) and resistant to pests after boiling	

5	**AUTHOOR VETRILAI** (THOOTHUKUDI - 2020) ➢ Unique pungency and spiciness of these leaves – Thamirabarani river basins ➢ Petiole of the leaves are lengthy helps to retain moisture content and increases the shelf life.	
6	**RAMANATHAPURAM MUNDU CHILLI** (RAMNAD - 2022) ➢ Round shaped chilli ➢ Dark shiny and thick skin and is a directly sown rain-fed crop grown ➢ Highly tolerant to drought and salinity ➢ Low input crop – use previous crop seed for next season	
7	**CUMBUM PANNEER THRATCHAI** (THENI- 2023) ➢ It is also known as Muscat Hamburg, is popular for its quick growth and early maturity. ➢ It dominates over 85% of the grape-growing areas in Tamil Nadu.	

8	**VELLORE SPINYBRINJAL** (VELLORE - 2022) **Description:** ➢ Oval in shape with thorns present in all parts of the plant, except fruit. ➢ High tolerance to drought and high temperature and is uniquely linked to the agro-climatic conditions in vellore region.	
9	**KANYAKUMARI MATTI BANANA** (KANYAKUMARI - 2023) **Description:** ➢ Little and slightly curved in shape ➢ Vitamin C and B6, potassium and dietary fibre are all abundant than other banana varieties.	

Government initiatives and schemes for promoting GIs product

The government has launched many schemes and programs for encourage the production and marketing of GI tagged products. The important schemes are:

i) Schemes of fund for Regeneration of Traditional Industries (SFURTI)

a) It provides sustained employment for traditional Industry artisans and rural entrepreneurs.

b) Facilitate for registration and protection of traditional products under GIs.

ii) One District One Product (ODOP)

a) ODOP programs main aim is to promote traditional and Indigenous products from each district of the country.

b) Identify the products that qualify for a GI tag which is present in the states of unpenetrated areas.

iii) Open Network for Digital Commerce (ONDC)

a) It act as a marketplace for ODOP scheme, the mandatory of this scheme is to promote unique products which comes under GI.

b) This scheme connect potential buyers and consumers from across the country and beyond. It unlock the new opportunities for growth and development for traditional industries.

Export promotion bodies

i. Directorate General of Foreign Trade (DGFT)
ii. Export Promotion Councils (EPCs)
iii. Commodity boards
iv. Export Development Authorities
v. Federation of Indian Export Organizations (FIEO)
vi. Agricultural and Processed Food Products Development Authority (APEDA)

APEDA facilitates exports of GI food and Agriculture related products to different destinations, including Naga Mircha (king chilli) from Nagaland to the UK, Black rice from Manipur to the UK, Assam Lemon to UK and Italy, and three GI varieties of Mango (Fazli, Khirsapati, and Laxmanodhog) form Bihar to Bahrain and Qatar.

Benefits obtained from GI

- Enhances economic growth

- Prevents unauthorized use of GI tags
- Expands Business
- Increases Tourism

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ACCELERATING DECOMPOSITION IN COMPOSTING: TECHNIQUES AND BEST PRACTICES FOR ENHANCING NUTRIENT CYCLING AND MICROBIAL ACTIVITY

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Introduction

Farm waste composting is a sustainable practice that promotes the proliferation of beneficial microorganisms in the soil. This process plays a vital role in improving soil structure, nutrient availability and uptake, ultimately benefiting plant growth. Aerobic decomposition, facilitated by the presence of oxygen, is more efficient, retains more nutrients and reduces environmental impacts compared to anaerobic decomposition. Shredding farm waste creates smaller pieces, exposing more surface area to microorganisms, thereby accelerating the decomposition process. The increased surface area and decomposition lead to the breakdown of organic matter, making nutrients available for plants when compost is applied to the soil. Microorganisms, secrete enzymes that break down complex organic compounds into simpler forms, releasing essential nutrients such as nitrogen, phosphorus and potassium. The microbial activity also contributes to the creation of stable organic matter, known as humus, which improves soil structure and water retention. To enhance the rate of decomposition, strategies such as regular turning or mixing of the compost pile, proper moisture management, and maintaining an optimal carbon-to-nitrogen ratio are essential. Adding nitrogen-rich materials, compost activators, or microbial consortia can further accelerate decomposition.

Farm waste generation refers to the production of various types of waste materials in agricultural activities. It includes the residues, by-products, and unused materials generated during farming and related processes. Farm waste can originate from different sources, such as crop cultivation, livestock rearing and post-harvest activities. The amount and composition of farm waste vary depending on the type of agricultural practices, the scale of farming operations and the specific crops or livestock involved. After harvesting crops, residues such as straw, stalks, stems, leaves and husks are left behind in the field. These materials can accumulate in significant quantities and can either be incorporated back into the soil as organic matter or utilized for other purposes like composting or animal bedding. Similarly, livestock farming produces substantial amounts of manure, which can be a valuable source of organic nutrients for the soil.

During the process of harvesting, transportation and storage, certain percentage of perishable crops commodity may spoil and become unusable for human consumption. This spoilt produce becomes a form of farm waste. Trimmings and pruned branches from trees and bushes on the farm also contribute to the overall farm waste. These materials can be composted or used as mulch. During seed processing and grain cleaning, there may be a generation of debris or impurities that need to be managed. Other than the above, farming operations also involve the use of various packaging materials for transportation and storage of produce. Plastic bags, cardboard boxes and other packaging materials add to the waste generated on farms. Empty pesticide and fertilizer containers can also contribute to farm waste. Though these packing materials and synthetic containers can not be composted, proper disposal or recycling of these containers is essential to prevent environmental contamination.

Proper management of farm waste is crucial for minimizing its environmental impact and maximizing its potential benefits. Recycling and reusing farm waste can promote sustainability and reduce the need for external inputs in agricultural practices. Composting, anaerobic digestion and mulching are some of the common practices used to manage and utilize farm waste effectively. Enhancing the rate of decomposition in waste composting requires creating optimal conditions that promote the activity of decomposer organisms.

Strategies to accelerate the decomposition process

Aerobic decomposition

Aerobic decomposition is a more efficient process compared to anaerobic decomposition. In aerobic conditions, microorganisms have access to oxygen, which allows them to break down organic matter more effectively and rapidly. This results in faster decomposition and nutrient release, making the nutrients available to plants more quickly. Aerobic decomposition retains more nutrients in the compost or soil. During aerobic decomposition, the breakdown of organic matter produces carbon dioxide and water as byproducts, which allows for the preservation of essential nutrients like nitrogen, phosphorus and potassium. Under anaerobic conditions, some of these nutrients are lost as volatile gases like methane and ammonia. Aerobic decomposition is less odorous than anaerobic decomposition. In anaerobic conditions, the breakdown of organic matter produces foul-smelling gases, such as hydrogen sulphide and ammonia, leading to unpleasant odours, making it more suitable for composting in urban or residential areas.

Aerobic decomposition generates higher temperatures, which can help to get rid of harmful pathogens and weed seeds. The heat produced during the process aids in the destruction of disease-causing organisms, reducing the risk of disease transmission. In anaerobic conditions, the lack of heat may not be sufficient to eliminate pathogens and weed seeds effectively. Anaerobic decomposition produces methane, a potent greenhouse gas that contributes to global warming. By promoting aerobic conditions, the generation of methane is minimized, leading to a lower environmental impact. Stability of Compost: Compost produced through aerobic decomposition tends to be more stable and mature, with a better balance of nutrients. It is less likely to cause nutrient imbalances or contribute to soil acidity, which can occur with immature compost produced under anaerobic conditions. Aerobic decomposition supports a diverse range of microorganisms that play different roles in breaking down organic matter leading to a more efficient and balanced decomposition process, resulting in a higher-quality compost.

Shredding the waste for enhancing decomposition

Shredding farm waste for compost making is an effective technique to accelerate the decomposition process and create high-quality compost. Farm wastes, such as coconut husks and fronds, is often tough and fibrous, which can slow down the natural breakdown of these materials. Shredding the farm waste into smaller pieces exposes more surface area to microorganisms, allowing them to break down the material more efficiently. This enhances the composting process and reduces the overall composting time. Smaller shredded pieces create air pockets within the compost pile, improving aeration which is essential for the aerobic decomposition process, preventing the compost from becoming anaerobic and smelly. Shredded waste releases nutrients more readily during composting. The increased surface area and accelerated decomposition lead to the breakdown of organic matter, making nutrients available for plants when the compost is applied to the soil. Shredding helps in creating a more uniform and consistent compost pile. It ensures that the farm waste is evenly distributed, along with other composting materials, leading to a balanced compost mixture.

Considerations and strategies

Shredding has some valid considerations in terms of investment and handling. Shredding requires suitable machinery, such as a chipper or shredder, capable of handling tough fibrous materials. Commercial composting units often use specialized machinery for shredding waste. The size of the shredded waste matters for effective composting. Ideally, the pieces should be small enough to promote rapid decomposition but not too fine to hinder airflow. When shredding farm waste, it is essential to maintain proper ratios of green (nitrogen-rich) and brown (carbon-rich) materials in the compost pile. A balanced mix ensures an optimal C:N ratio, facilitating efficient decomposition. To speed up decomposition, mix waste with nitrogen-rich materials like kitchen scraps, grass clippings or manure to achieve an ideal C:N ratio of around 30:1. Since, shredded waste can retain moisture, leading to an excessively wet compost pile, adequate moisture management is crucial to prevent the compost from becoming waterlogged. Adequate moisture is essential for microbial activity. Regularly check and adjust the moisture content to around 50-60 per cent of the compost's water-holding capacity.

More importantly, regular turning or mixing of the compost pile is essential when using shredded waste. This helps distribute heat, oxygen and moisture evenly, ensuring uniform decomposition throughout the pile. Turning or mixing the compost pile regularly (every few days to a week) not only provides aeration but also allows microorganisms to thrive and break down the materials faster. If decomposition is sluggish, adding nitrogen-rich materials like fresh grass clippings or a small amount of high-nitrogen fertilizer can give microorganisms an extra boost. Commercial compost activators or inoculants or microbial consortia can be added to the compost pile to introduce a diverse range of decomposer microorganisms, speeding up the decomposition process. Covering the compost pile with a tarp or mud or using an insulated compost bin can help retain heat, creating warmer conditions that encourage microbial activity and faster decomposition. Create a well-layered compost pile with alternating layers of waste and other organic materials. This encourages proper mixing and distribution of microbes throughout the compost pile. Monitor the compost pile's temperature, moisture and overall progress regularly. Adjust any imbalances or conditions that may hinder decomposition.

As the compost pile is regularly turned or aerated, oxygen is introduced, providing aerobic conditions that support the growth of beneficial microorganisms. These beneficial microorganisms, including bacteria, fungi, and actinomycetes, play a crucial role in the decomposition of organic matter. They secrete enzymes that break down complex organic compounds in the farm waste into simpler forms, such as carbon dioxide and water. This breakdown process, known as mineralization, releases essential nutrients, including nitrogen, phosphorus and potassium, from the organic matter, making them available for plant uptake.

Moreover, the microbial activity in the compost aids in the creation of stable organic matter, known as humus. Humus improves soil structure by binding soil particles together, creating aggregates that enhance soil porosity and water infiltration. This improved soil structure allows roots to penetrate easily, promoting better nutrient and water absorption by plants. The presence of beneficial microorganisms in the soil also contributes to disease suppression. Some microorganisms produce antibiotics and other compounds that inhibit the growth of plant pathogens, helping to protect plants from diseases and improve their overall health.

Farm waste composting fosters a diverse and thriving microbial community in the soil, leading to improved soil structure, nutrient mineralization, enhanced nutrient availability and uptake. This enhanced microbial activity in the compost and the subsequent application to the soil result in healthier and more productive plants, ultimately benefiting plant growth and agricultural productivity. Further, shredding, aerobic decomposition and strategies for enhancing the decomposition offers several advantages over anaerobic decomposition in terms of nutrient retention, efficiency, odour control, pathogen suppression and environmental impact.

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AI REVOLUTION IN AGRIBUSINESS: TRANSFORMING THE SUPPLY CHAIN

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Introduction

The agricultural sector is experiencing a technological revolution, with artificial intelligence (AI) emerging as a game-changer in agribusiness management. From farm to fork, AI is reshaping every stage of the agricultural supply chain, promising increased efficiency, productivity, and sustainability. Let's explore how AI is transforming each phase of agribusiness operations.

Pre-Production: Smart Planning and Resource Management

Before seeds even touch the soil, AI is already at work. Advanced algorithms analyze historical data, market trends, and climate predictions helps farmers to make informed decisions about crop selection and resource allocation. Machine learning models can predict optimal planting times, taking into account factors like soil conditions, weather patterns, and market demand (Liakos et al., 2018).

AI-powered systems also assist in precision agriculture, optimizing the use of water, fertilizers, and pesticides. By analyzing data from satellites, drones, and ground sensors, these systems can create detailed field maps, identifying areas that need specific attention. This targeted approach not only reduces costs but also minimizes environmental impact, aligning with the growing demand for sustainable farming practices

Production: Automated Farming and Crop Management

During the growing season, AI takes center stage in monitoring and managing crops. Computer vision technologies, coupled with drone imagery, can detect early signs of pest infestations or diseases. Machine learning algorithms can then recommend precise interventions, often before problems become visible to the human eye.

Autonomous machinery, guided by AI, is becoming increasingly common in fields. From self-driving tractors to robotic harvesters, these machines can operate 24/7, significantly increasing efficiency. They can navigate fields with centimeter-level precision, reducing fuel consumption and soil compaction (Sharma et al., 2020).

Post-Harvest: Quality Control and Processing

Once crops are harvested, AI continues to play a crucial role. Computer vision systems can rapidly sort and grade produce, ensuring consistent quality and reducing human error. These systems can detect defects or contaminants that might be missed by human inspectors, enhancing food safety. In processing facilities, AI-powered robotics handle tasks like cutting, packaging, and palletizing with high precision and speed. Machine learning algorithms optimize processing parameters in real-time, ensuring product quality while minimizing energy consumption and waste

Distribution: Smart Logistics and Supply Chain Optimization

AI is revolutionizing how agricultural products move from farm to market. Predictive analytics help businesses forecast demand more accurately, reducing waste and ensuring fresher products reach consumers. AI algorithms can optimize routing and logistics, considering factors like traffic, weather, and product shelf-life to determine the most efficient delivery paths.

Blockchain technology, often integrated with AI, is enhancing traceability in the food supply chain. This not only improves food safety by quickly identifying the source of contaminations but also meets the growing consumer demand for transparency in food production (Yadav et al., 2020).

Retail and Consumer Interface: Personalized Marketing and Smart Inventory Management

At the retail level, AI is transforming how agribusinesses interact with consumers. Machine learning algorithms analyze purchasing patterns and consumer preferences to tailor marketing strategies and product offerings. AI-powered inventory management systems can predict stock needs, automatically reorder products, and even adjust pricing in real-time based on demand and shelf-life.

Moreover, AI chatbots and virtual assistants are enhancing customer service, providing instant responses to queries about product origin, nutritional information, or cooking suggestions. This direct interaction with consumers provides valuable feedback that can inform future production decisions, closing the loop in the supply chain.

Challenges and Future Prospects

While the potential of AI in agribusiness management is immense, its adoption is not without challenges. The initial cost of implementing AI systems can be substantial, potentially putting smaller farms at a disadvantage. There's also a need for digital literacy and technical expertise, which may be lacking in traditional farming communities.

Data privacy and security concerns also need to be addressed, especially as more sensitive farm data is collected and analyzed. Ensuring that farmers retain control over their data while benefiting from AI insights will be crucial for widespread adoption.

Despite these challenges, the future of AI in agribusiness looks promising. As AI technologies become more accessible and affordable, we can expect to see even broader adoption across the industry. The global AI in agriculture market is projected to grow from $1 billion in 2020 to $4 billion by 2026, indicating significant investment and expansion in this sector (Markets and Markets, 2021).

As we move forward, the successful integration of AI into agribusiness management will likely depend on collaborative efforts between technologists, agronomists, policymakers, and farmers. By harnessing the power of AI across the entire agricultural supply chain, the industry is poised to meet the challenges of feeding a growing global population while promoting sustainability and efficiency.

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BIOACTIVE PACKAGING AND ITS ROLE IN FOOD PROCESSING

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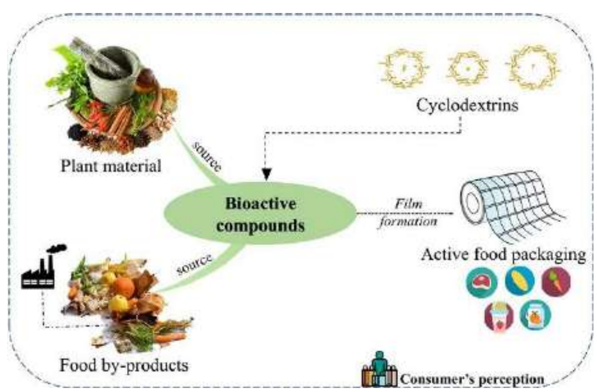
Introduction

Food packaging is an essential aspect of the modern food industry, as it not only guarantees the protection and preservation of food products but also plays a significant role in enhancing the shelf life of food. Over the years, there has been a growing interest in developing innovative packaging solutions that go beyond traditional purposes. Bioactive packaging is one such advancement that has recently gained considerable attention.

What is Bioactive Packaging?

Bioactive packaging denotes to a type of packaging material or system that incorporates bioactive compounds to improve the quality and safety of food products. These bioactive compounds can be natural or synthetic and are specifically chosen for their ability to interact with food components by enhancing food preservation, extending shelf life, or providing health benefits to consumers. In other words we



can say that the bioactive packaging is thus a novel set of technologies designed to give response to a number of issues related to the feasibility, stability and bioactivity of functional ingredients for the food industry.ik

Role of Bioactive Packaging in Food Processing

Preservation and Shelf-Life Extension: Bioactive packaging materials are designed to inhibit the growth of spoilage microorganisms and pathogens in food products. They can release antimicrobial agents, such as essential oils, enzymes, or bacteriocins, which create a protective barrier around the food, thereby prolonging its shelf life. This not only reduces food waste but also ensures that consumers receive fresher and safer products.

Oxygen and Moisture Control: Oxygen and moisture are two major factors responsible for food deterioration. Bioactive packaging can be engineered to control the permeability of oxygen and moisture, preventing oxidation and moisture loss. This is especially crucial for products like snacks, baked goods, and cereals, which can become stale or lose their crispness over time.

Nutrient Retention: Certain bioactive packaging materials are designed to preserve the nutritional value of food products. For example, packaging that releases antioxidants can help protect vitamins and other sensitive compounds in foods. This is particularly important for products like fruits, vegetables, and dairy items.

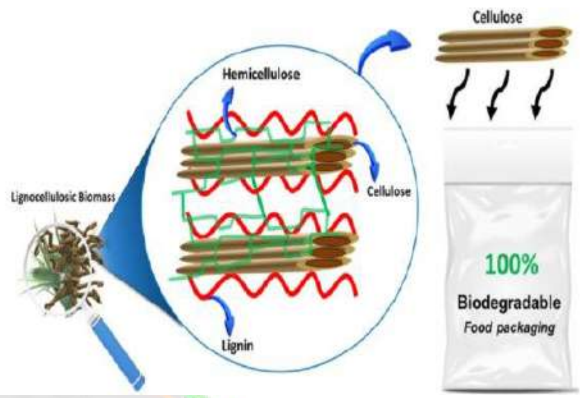
Flavor and Aroma Enhancement: Bioactive packaging can be used to enhance the flavor and aroma of food products. For instance, packaging infused with volatile compounds from herbs and spices can impart a pleasant fragrance and taste to packaged items, making them more appealing to consumers.

Health Benefits: Some bioactive packaging materials are tailored to release bioactive compounds that can provide health benefits to consumers. For example, packaging with probiotics or prebiotics can improve gut health, while packaging infused with vitamins or minerals can fortify food products and contribute to overall nutrition.

Environmental Sustainability: Bioactive packaging materials can also play a role in sustainability efforts. Biodegradable and compostable bioactive packaging options can help reduce the environmental impact of packaging waste, addressing concerns about plastic pollution.

Challenges and Future Prospects

While bioactive packaging holds great promise, there are challenges that need to be addressed. These include:



Safety and Regulatory Compliance: The safety of bioactive compounds and their migration into food must be rigorously assessed to ensure they do not pose health risks to consumers. Regulatory frameworks need to be developed and updated to accommodate these emerging technologies.

Cost and Scalability: Developing bioactive packaging materials can be cost-intensive, and large-scale production may face challenges in terms of cost-effectiveness. Manufacturers need to find ways to make these materials more affordable and scalable.

Consumer Acceptance: Educating consumers about the benefits of bioactive packaging and addressing any concerns related to the use of active substances in packaging is crucial for widespread adoption.

Compatibility: Bioactive packaging materials must be compatible with a wide range of food products, including different pH levels, moisture content, and storage conditions. This requires careful selection and customization of packaging materials for specific applications.

Conclusion

Bioactive packaging is a promising innovation in the field of food processing. It has the potential to improve food safety, extend shelf life, enhance nutritional value, and even provide health benefits to consumers. As technology advances and research in this area continues, bioactive packaging is likely to become more prevalent in the food industry, contributing to safer, healthier, and more sustainable food products for consumers worldwide. However, addressing challenges related to safety, cost, and consumer acceptance will be essential for the successful integration of bioactive packaging into mainstream food processing practices.

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THE RISE OF DIGITAL RUPEE CBDCS AND THEIR IMPACT ON INDIAN FINANCIAL LANDSCAPE

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Introduction

The Reserve Bank of India (RBI) has been exploring the concept of a Central Bank Digital Currency (CBDC) since 2017. In late 2022, India launched its digital rupee pilot project, marking a significant step towards modernizing its financial system. CBDCs are digital representations of a country's fiat currency, issued and regulated by the central bank. Unlike cryptocurrencies, CBDCs are centralized and backed by the government, offering the benefits of digital transactions while maintaining monetary stability.

The Rise of Digital Payments in India

India has witnessed a rapid surge in digital payments over the past few years. The Unified Payments Interface (UPI) has been a game-changer, processing over 9.36 billion transactions worth ₹14.89 trillion in May 2023 alone (National Payments Corporation of India, 2023). This digital payment revolution has set the stage for the introduction of a CBDC, which could further accelerate financial inclusion and streamline transactions.

Potential Benefits for the Indian Economy

1. **Financial Inclusion:** A digital rupee could bring millions of unbanked Indians into the formal financial system, providing them with access to banking services and credit.
2. **Reduced Cash Dependency:** CBDCs could significantly reduce the cost of printing, distributing, and managing physical currency, which currently accounts for a substantial portion of the RBI's expenses.

3. **Enhanced Monetary Policy:** With a CBDC, the RBI could have more direct control over money supply and implement monetary policy more effectively.
4. **Cross-Border Transactions:** International remittances and trade could become faster and cheaper with the introduction of CBDCs, benefiting India's large diaspora and export-oriented businesses.

Challenges and Considerations

1. **Digital Infrastructure:** Ensuring widespread access to digital infrastructure and addressing the digital divide will be crucial for the success of a CBDC in India.
2. **Privacy Concerns:** Balancing transaction transparency with individual privacy rights will be a key challenge in implementing a CBDC.
3. **Cyber security:** Robust security measures will be essential to protect the CBDC system from cyber threats and fraud.
4. **Impact on Commercial Banks:** The introduction of a CBDC could potentially disrupt the traditional banking system, requiring careful planning and regulation.

The Way Forward

As India continues its CBDC pilot project, policymakers must carefully consider the potential impacts on various stakeholders in the financial ecosystem. Collaboration between the government, RBI, and private sector will be crucial in developing a CBDC that meets India's unique needs and challenges. The introduction of a digital rupee has the potential to revolutionize India's financial landscape, fostering innovation, enhancing financial inclusion, and positioning the country as a leader in the global digital economy. However, a measured and thoughtful approach will be essential to ensure its successful implementation and adoption.

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CLIMATE FINANCE AND INDIA'S PATH TO CARBON NEUTRALITY

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Introduction

As the world grapples with the urgent need to address climate change, India stands at a crucial crossroads. The world's third-largest emitter of greenhouse gases has set ambitious goals to achieve carbon neutrality by 2070. However, the path to this target is paved with significant challenges, chief among them being the need for substantial climate finance.

India's Climate Commitments

At the COP26 summit in Glasgow, Prime Minister Narendra Modi announced India's pledge to reach net-zero emissions by 2070. This commitment was accompanied by interim targets, including increasing non-fossil fuel energy capacity to 500 GW and meeting 50% of energy requirements from renewable sources by 2030. These goals represent a major shift for a country that still relies heavily on coal for its energy needs.

The Financial Challenge

The transition to a low-carbon economy requires massive investments in renewable energy infrastructure, energy-efficient technologies, and sustainable transportation systems. According to a report by the International Energy Agency (IEA), India needs to invest $160 billion annually in clean energy technologies by 2030 to achieve its climate goals. This figure is nearly three times the current investment levels.

The Role of Climate Finance

Climate finance plays a crucial role in bridging this investment gap. It encompasses both domestic and international funding sources aimed at supporting mitigation and adaptation efforts. For India, accessing and effectively utilizing climate finance is essential to its carbon neutrality journey.

International Climate Finance

Developed countries have pledged to provide $100 billion annually in climate finance to developing nations. However, this target has consistently been missed, with the latest figures showing only $83.3 billion mobilized in 2020. India has been vocal in calling for increased climate finance from developed nations, arguing that historical emitters bear a greater responsibility in supporting the global transition to a low-carbon future.

Domestic Initiatives

While international support is crucial, India has also taken significant steps to mobilize domestic resources for climate action. The country has implemented innovative financing mechanisms such as:

1. Green Bonds: In January 2023, India issued its first sovereign green bonds, raising $1 billion to fund renewable energy projects.

2. Carbon Market: India is developing a domestic carbon market to incentivize emissions reductions across industries.

3. National Clean Energy Fund: Funded by a cess on coal, this initiative supports clean energy research and projects.

Private Sector Engagement

The private sector plays an increasingly important role in India's climate finance landscape. Many Indian corporations have set their own net-zero targets and are investing in renewable energy and sustainable practices. For instance, Reliance Industries, one of India's largest conglomerates, has pledged to invest $80 billion in clean energy projects over the next 10-15 years.

Challenges and Opportunities

1. Policy uncertainty and regulatory barriers
2. High perceived risks in clean energy investments
3. Limited capacity to develop bankable projects

Addressing these challenges presents opportunities for both domestic and international stakeholders. Streamlining regulations, enhancing risk mitigation tools, and building capacity for project development can unlock greater climate finance flows.

The Road Ahead

India's path to carbon neutrality is ambitious but achievable with adequate financial support and effective policy implementation. As the country continues to advocate for increased international climate finance, it must also focus on creating an enabling environment for domestic and private sector investments in clean energy and sustainable development. By leveraging a diverse range of financing sources and mechanisms, India can accelerate its transition to a low-carbon economy, potentially even surpassing its current climate targets. The success of India's efforts will not only be crucial for the country's sustainable development but will also play a significant role in global climate action.

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HARNESSING SOCIAL MEDIA AND DIGITAL PLATFORMS FOR AGRIBUSINESS SUCCESS

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Introduction

In today's digital age, the agricultural sector is embracing new technologies to grow more than just crops. Agribusinesses increasingly turn to social media and digital platforms to cultivate market reach and nurture consumer engagement. This shift is revolutionizing how farmers, producers, and agricultural companies connect with their audiences, sell their products, and thrive in a competitive landscape.

The Digital Farmer's Market

The era of farmers depending solely on local markets to sell their produce is a thing of the past. Social media platforms have emerged as virtual farmers' markets, enabling agribusinesses to present their products to a global audience. Platforms like Instagram and Facebook allow farmers to share captivating visuals of their harvests, narrate their stories, and directly engage with consumers who are increasingly keen on understanding the origins of their food.For example, many small-scale organic farms use Instagram to post daily updates on their crops, share behind-the-scenes glimpses of farm life, and announce when fresh produce is available. This direct-to-consumer approach not only boosts sales but also builds a loyal community of supporters who feel connected to the farm and its mission.

Educating and Engaging Consumers

Digital platforms offer unique opportunities for agribusinesses to educate consumers about agricultural practices, sustainability efforts, and the benefits of their products. YouTube channels and TikTok accounts run by farmers and agricultural experts have gained massive followings by sharing informative and entertaining content about farming techniques, animal husbandry, and rural life.

This educational content serves a dual purpose: it satisfies consumers' curiosity about food production and builds trust in the agribusiness brand. As consumers become more informed, they're more likely to make purchasing decisions that align with their values, often favoring businesses that demonstrate transparency and sustainable practices (Jansen & Vellema, 2021).

E-commerce: From Field to Doorstep

The rise of e-commerce has opened new avenues for agribusinesses to reach consumers directly. Online marketplaces and dedicated e-commerce websites allow farmers and producers to sell their products beyond geographical constraints. This digital transformation has been particularly beneficial for specialty and niche products that may have limited local demand but can find a broader market online.

Moreover, subscription-based models for fresh produce delivery have gained popularity, especially in urban areas. These services often source from local farms and use social media to promote their offerings, creating a win-win situation for both farmers and consumers seeking fresh, local produce (Fritz et al., 2019).

Data-Driven Decisions

Digital platforms not only facilitate sales and engagement but also provide valuable data insights. Agribusinesses can analyze consumer behavior, preferences, and trends to make informed decisions about product development, marketing strategies, and inventory management. This data-driven approach allows for more efficient operations and better alignment with consumer demands (Wolfert et al., 2017).

For instance, a dairy company might use social media analytics to gauge interest in new flavored milk products before launching them, or a fruit grower might adjust their planting schedule based on online search trends for specific fruits.

Challenges and Opportunities

While the digital landscape offers immense potential, it also presents challenges for agribusinesses. Maintaining an active and engaging online presence requires time and resources, which can be scarce in the demanding world of agriculture. Additionally, navigating the ever-changing algorithms of social media platforms and staying ahead of digital marketing trends can be daunting for those more accustomed to working the land than working a keyboard.

However, the opportunities far outweigh the challenges. By embracing digital platforms, agribusinesses can:

- Increase brand awareness and market reach
- Build direct relationships with consumers
- Gain valuable insights into consumer preferences
- Diversify revenue streams through e-commerce
- Collaborate with influencers and other brands for cross-promotion

As we look to the future, the integration of social media and digital platforms in agribusiness is likely to deepen. From blockchain technology ensuring food traceability to augmented reality apps allowing consumers to virtually visit farms, the digital revolution in agriculture is just beginning (Klerkx et al., 2019).

For agribusinesses willing to adapt and innovate, the digital landscape offers fertile ground for growth, engagement, and sustainable success. By leveraging these tools effectively, the agricultural sector can not only feed the world but also nurture a more connected and informed global community of consumers.

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EMPOWERING FARMERS: THE DIGITAL REVOLUTION IN FARMER PRODUCER ORGANIZATIONS

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Introduction

In recent years, the agricultural sector has witnessed a transformative shift with the digitization of Farmer Producer Organizations (FPOs). This technological leap is revolutionizing how small-scale farmers collaborate, access markets, and improve their livelihoods. As FPOs embrace digital tools, they're unlocking new potentials for efficiency, transparency, and growth.

The Rise of Digital FPOs:

Farmer Producer Organizations have long been vital in empowering small-scale farmers. By pooling resources and collectively marketing produce, FPOs help farmers achieve economies of scale. However, traditional FPOs often face challenges in management, market access, and member engagement. Enter digitization – a game-changer that's reshaping the FPO landscape.

Digital technologies are transforming various aspects of FPO operations:

- **Member Management:** Digital platforms allow FPOs to maintain accurate records of their members, track contributions, and manage shareholdings efficiently. This improves transparency and trust within the organization (Kumar et al., 2019).
- **Supply Chain Management:** Digital tools enable FPOs to track produce from farm to market, ensuring quality control and traceability. This is particularly crucial in meeting the growing consumer demand for transparent food sourcing (Trebbin, 2022).
- **Market Linkages**: E-commerce platforms and mobile apps are connecting FPOs directly with buyers, eliminating intermediaries and potentially increasing farmer incomes. These

digital marketplaces provide real-time price information, helping farmers make informed decisions about when and where to sell their produce.

Benefits of FPO Digitization

- **Enhanced Efficiency:** Digital tools streamline operations, reducing paperwork and manual processes. This allows FPOs to allocate more resources to core activities that benefit their members.
- Improved Financial Access: Digital records and transactions create a financial history for FPOs and their members. This digital footprint can enhance creditworthiness, making it easier to access loans and other financial services (Chatterjee et al., 2020).
- **Data-Driven Decision Making:** With digital systems, FPOs can collect and analyze data on crop yields, market trends, and member needs. This information enables more informed strategic planning and resource allocation.
- **Expanded Market Reach:** Online platforms allow FPOs to showcase their products to a wider audience, potentially accessing new markets both domestically and internationally.
- **Increased Transparency:** Digital systems provide clear, traceable records of all transactions and decisions, fostering trust among members and external stakeholders.

Challenges in Digitizing FPOs

- **Digital Literacy:** Many farmers, especially in rural areas, may lack the skills to use digital tools effectively. FPOs must invest in training and capacity building to ensure all members can benefit from digitization (Raut et al., 2021).
- **Infrastructure Limitations:** Poor internet connectivity and lack of reliable electricity in some rural areas can hinder the adoption of digital technologies.
- **Initial Costs:** Implementing digital systems requires upfront investment in hardware, software, and training. This can be challenging for resource-constrained FPOs.
- **Data Security and Privacy:** As FPOs collect more digital data, ensuring its security and protecting member privacy becomes crucial. This requires robust cybersecurity measures and data governance policies.
- **Resistance to Change:** Some farmers and FPO leaders may be hesitant to adopt new technologies, preferring traditional methods they're familiar with.

Future Outlook: The Digital Horizon for FPOs

- **Blockchain Integration:** Blockchain technology could further enhance transparency and traceability in FPO operations, potentially increasing trust and opening up premium markets for produce with verified origins.
- **Artificial Intelligence (AI) and Machine Learning:** These technologies could help FPOs optimize crop planning, predict market trends, and personalize services for members.
- **Internet of Things (IoT):** Smart farming techniques using IoT devices could allow FPOs to monitor crops in real-time, improving yield and quality.
- **Mobile-First Solutions:** As smartphone penetration increases in rural areas, more FPO services will likely become accessible through mobile apps, further democratizing access to digital tools.
- **Public-Private Partnerships:** Governments and private sector entities are increasingly recognizing the potential of digitized FPOs. This could lead to more supportive policies and investments in digital infrastructure for agriculture.

Conclusion

The digitization of Farmer Producer Organizations represents a significant leap forward in empowering small-scale farmers. While challenges remain, the benefits of improved efficiency, market access, and data-driven decision-making are transforming the agricultural landscape. As FPOs continue to embrace digital technologies, they are not just keeping pace with the times – they are sowing the seeds for a more prosperous and sustainable future in agriculture.

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SENTINELS OF NATURE: INSECTS AS INDICATORS OF ECOLOGICAL HEALTH

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Abstract

Insects are useful to evaluate the effects of anthropogenic activities on the terrestrial ecosystem as well as aquatic system and atmosphere, because they come into direct touch with hazardous substances present in soil, water and air. Furthermore, they are extremely sensitive to changes in the environment that affect an organism's ability to perform essential functions including growth, reproduction, and metabolism. Because of these attributes, insects are useful as bioindicators. The majority of insects, including termites, ephemeropterans, beetles, ants, bees, and butterflies, are employed as ecological indicators. Lastly, the ability of insects to sense their surroundings has been helpful in determining the state of ecosystems. In this article we have emphasized the usefulness of the insects as a tool in monitoring different ecosystems and climate change.

Keywords: Ecology, Indicators, Insects, environment change

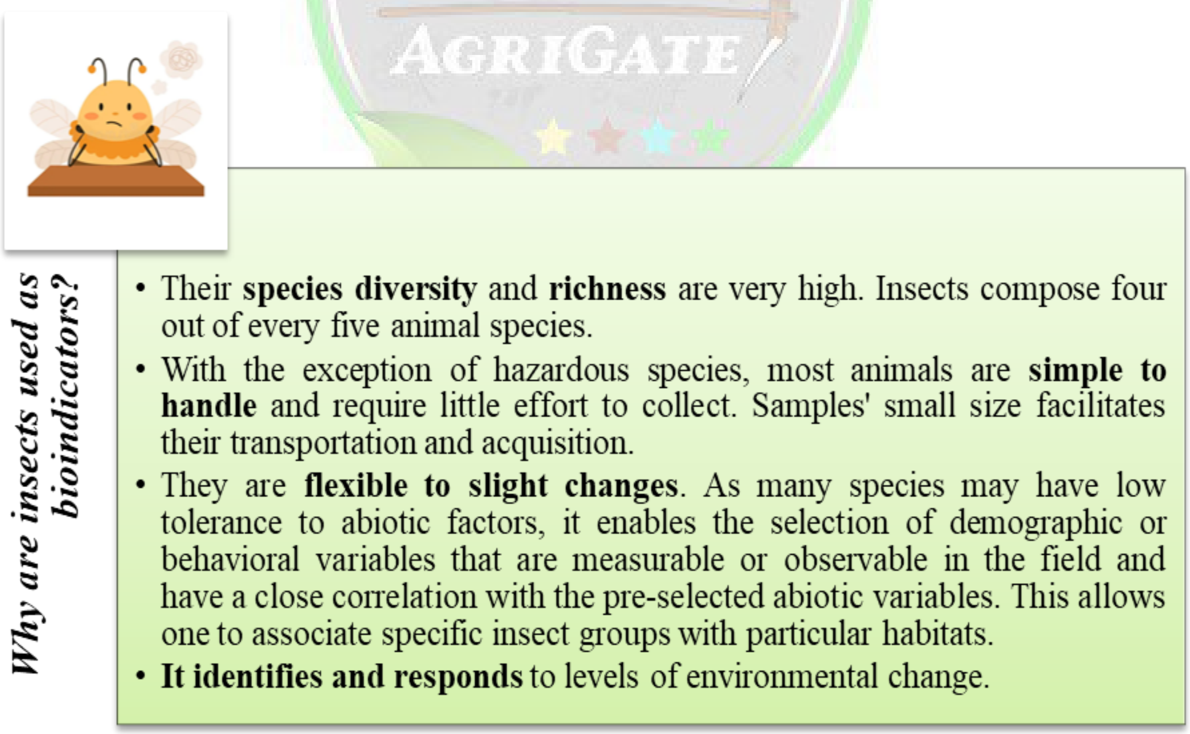
Introduction

"An organism or biological response which indicates the presence of the contaminants by the appearance of typical symptoms or observable behaviors" is known as a bioindicator. By altering physiologically, chemically, or behaviorally, these creatures (or communities of organisms) provide information about changes in the environment or the number of contaminants present in the environment.

Biological indices are determined employing the proportional abundances of several indicator species (species richness, biodiversity). An appropriate bioindicator that not only responds to a fast change in the significant factor (or factors) but also shows the long-term interplay of many environmental circumstances acts an integral part in biomonitoring.

Insects become significant helpful bioindicators of shifting circumstances out of all of them. Due to their short lifespans, high rates of reproduction, and sensitivity to biochemical changes in their supplies, they are often preferred as bioindicators because they can alert us to changes in the quantity or health of larger, longer-lived plants or vertebrates before they become noticeable. Ecosystem services that are especially vital to the maintenance of agricultural and urban output consist of ecological health and water quality.

The sensitivity of aquatic insects to variations in the quality of the water makes them especially valuable water quality indicators. For instance, the emergence of eutrophic chironomid species in Lake Superior replaced oligo-mesotrophic chironomid species, indicating elevated levels of pollution. The overall health of the ecosystem and the state of ecological restoration are measured by ant interactions. Before obvious signs of stress, such as chlorosis, were evident, insect herbivores may have signaled modifications in plant biochemistry. Water quality can be evaluated by observing the sensitivity of mayfly nymphs (Ephemeroptera) to contaminants and oxygen levels in their environment.



Role of insects as bioindicators

Sensitivity to pollution

•Insects, particularly aquatic ones like **mayflies** and **stoneflies**, are extremely **sensitive to water pollution**.

Climate change indicators

•Changes in temperature and weather patterns due to climate change have a profound impact on **insect populations.**

Pesticide and chemical exposure

•In agriculture, insects can signal the presence of harmful pollutants or heavy metals in environment.

Habitat quality

•Insects are integral to the functioning of ecosystems as pollinators, decomposers, and prey for other organisms.

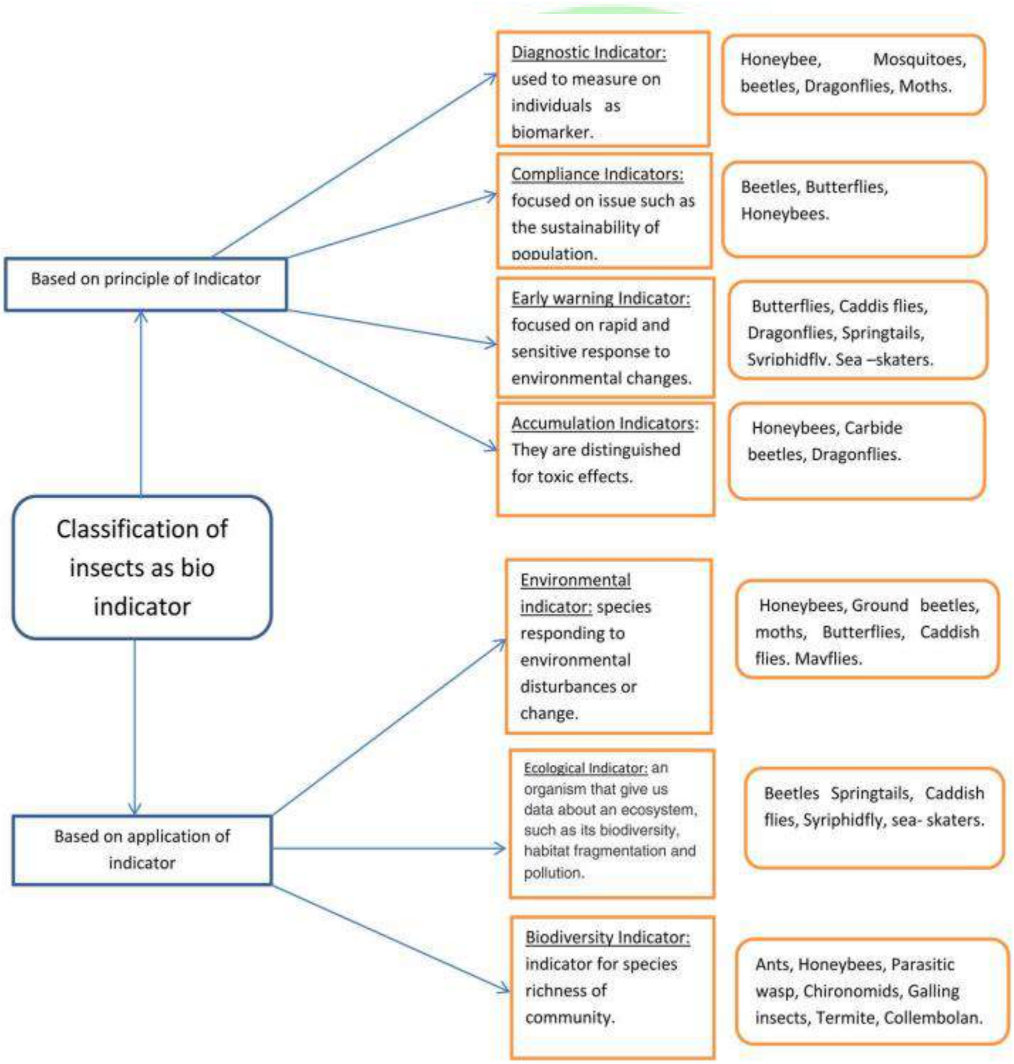


Fig. 1: Classification of insects as bioindicator (Parikh *et al.*, 2020)

Bioindicator insect groups to monitor environmental changes

1) Lepidopterans as bioindicator

Changes in temperature have a major effect on the egg-laying sites, fecundity & hatching rates, development of larvae, and the lifespan of butterflies. According to Heliövaara *et al*. (1989), the size of the pupae of Noctuidae and Geometridae species varies with the concentration of industrial air pollution.

2) Ants as bioindicator

Ants are present in food chains, nearly every trophic level of the web, and other ecological processes. According to Kaspari and Majer (2000) and Andersen *et al*. (2002), they serve as a good bioindicator group for a variety of pollution types, such as heavy metal contamination in soil (Gramigni *et al*., 2013; Khan *et al*., 2017), aerial phthalate pollution (Lenoir *et al*., 2014), and restoration of land (Khan *et al*., 2017). In Australia, ants have proven to be effective bioindicators. As noted by Andersen (1999), ant richness in recovered mining sites is positively associated with microbiological activity. Ants have also been utilized as indicators of pollution, grassland conditions, and a healthy forest.

Furthermore, vegetation has a significant impact on ants. While higher levels of vegetation complexity lead to higher densities and group diversity, lower levels of vegetation can sometimes have an advantageous impact on species found in open, warmer environments and adversely influence species observed in closed, cooler regions (Jose *et al*., 2010).

3) Termites as a bioindicator

A typical category of insects that serve as bioindicators of fertility of soil are termites. Termites are also important for the circulation, transport, and recycling of nutrients in the soil. By creating nests that increase the amount of organic carbon, clay, and nutrients, termites function as ecological architects (Nithyatharani *et al*., 2018). Since termites are decomposers, their primary source of food is plant detritus. Termites' guts have evolved to accommodate the rise in pH, oxygen, and hydrogen all of which are critical for the chemical and physical changes that occur in soil (Leonard and Rajot, 2001).

4) Bugs as bioindicator

Many families of Hemiptera order, including Nepidae, Corixidae, Notonectidae, Gerridae, Pleidae, Belostomatidae, Veliidae, and Mesoveliidae, are used as bioindicators to assess the quality of water (John and Polhemus, 2008). Spittlebug (*Neophilaenus* *lineatus*) exhibits rapid, frequent yearly variations in their higher altitudinal limit in response to fluctuating mean temperatures.

5) Bees as bioindicator

When foraging, social insects may ingest contaminants, which they might subsequently transfer to their larvae or incorporate into the substances that they utilize to construct their hives. Bee contaminants can also get into stored food, including honey or bee bread (Feldhaar and Otti, 2020). Since they indicate environmental chemical degradation due to a high mortality rate and having the ability to catch pollutants dispersed in the air or on flowers, honey bees are dependable and effective biological indicators.

6) Ephemeroptera taxa as bioindicator

The order Ephemeroptera, Plecoptera, and Trichoptera (EPT) includes mayflies, stoneflies, and caddisflies. These insects are good bioindicators of water quality. Mayflies are susceptible to a decrease in oxygen level in water. According to Parikh et al. (2020), caddisflies are vulnerable to water contamination and are utilized as bioindicators that indicate water freshness, while stoneflies signal heavily oxygenated water. Given their abundance in waterways with low levels of toxic stress, caddisflies and mayflies have been suggested to be indicators of varying degrees of stress caused by heavy metals (Winner et al., 1980).

7) Dragonflies as bioindicator

Dragonflies are considered a highly trustworthy ecological indicator in aquatic and riverside ecosystems. Especially in lakes and waterlogged areas, they react delicately to habitat disruption and heavy metal accumulation (Shafie *et al*., 2017). Any water body which contains them in it is not contaminated with pollutants (Azam et al., 2015).

Table 1: Bioindicators for specific variables in terrestrial and aquatic habitats

Group	Biomonitors and bioindicator	Habitat	References
Honeybees	Heavy metals and radioactive substances	L	Asif *et al*. (2018)
Butterflies	More sensitive to climate change and heavy metals	L	Sharma & Sharma (2017)
Syrphid flies	Biodiversity of various forested habitats	L	Fikri *et al*. (2013)
Ants	Degraded and reforested areas recovery	L	Majer and Nichols (1998)

Parasitic wasps	More abundant in species-rich mixed woodland habitats.	L	Parikh *et al*. (2020)
Springtails	Contaminated soil, Air pollution/Acid deposition	L	Menta and Remelli (2020)
EPT	Degree of water pollution or water quality.	A	Lindenmayer *et al*. (2000); Afzan *et al*. (2018)
Dragonflies	Presence of heavy metals in water body	A	Azam *et al*. (2015)

Note: L-Land; A-Aquatic

Table 2: Climate change interactions with pheromonal communication

Concerning insect	**Climate change**	**Impact**	**References**
Male beewolf, *Philanthus triangulum*	Increase of 5°C temperature during larval rearing	Adult male produces more pheromonal secretions	Roeser-Mueller *et al*. (2010)
Female moth, *Striacosta ablicosta*	Increase in the temperature difference between the photophase & scotophase	Calling behavior is greatly affected	Mozūraitis & Būda (2006)
Ladybird larvae	Increasing temperature	Deposit more long chain hydrocarbons & act as oviposition deterrent pheromone	Sentis *et al*. (2015)
Drosophila melanogaster	Ozone fumigation at between 40 & 120 ppb conc.	Lose their biological activity	Arndt (1995)
Male moth, *Caloptilia fraxinella*	Elevated temperature condition	Altered male pheromone responsiveness	Lemmen & Evenden (2015)
Springtail, *Orchesella cincta*	Heat stress (35.2°C)	Heat exposure alters the spermatophore pheromone biosynthesis pathway.	Zizzari *et al*. (2017)

Conclusion

Lastly, the ability of insects to sense their surroundings has been helpful in determining the state of ecosystems. Only a few species are reacting based on these changes in the surrounding environment. Aquatic insects are frequently employed as water quality indicators. Important early indicators of global changes are also provided by insects' reactions to temperature variations and other habitat-related changes. Because we can utilize it to detect pollutants in the soil, water, and air as well as climate change, this insect will be extremely valuable as an indicator species in the future. We will be able to stop habitat loss and future pollution by doing this.

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DIGITAL PAYMENTS: TRANSFORMING FINANCIAL INCLUSION IN RURAL INDIA

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Introduction

In recent years, India has witnessed a digital revolution that is reshaping its financial landscape, particularly in rural areas. The surge in digital payment adoption is not just a trend but a powerful force driving financial inclusion across the country's vast hinterlands. This transformation is bridging the gap between formal financial services and millions of previously unbanked individuals, marking a significant milestone in India's economic development.

Digital India

The Digital India Initiative, launched in 2015, laid the groundwork for this transformation. However, it was the demonetization move in 2016 that catalyzed the widespread adoption of digital payments. Since then, the growth has been nothing short of phenomenal. According to the Reserve Bank of India (RBI), digital payments in India grew at a compound annual growth rate (CAGR) of 55% by volume and 15% by value between 2016 and 2021 (Reserve Bank of India, 2022).

Rural India, home to about 65% of the country's population, has been at the forefront of this digital payment revolution. The Unified Payments Interface (UPI), a real-time payment system developed by the National Payments Corporation of India (NPCI), has been a game-changer. In March 2023, UPI recorded over 8.7 billion transactions worth ₹14.05 trillion (approximately $170 billion), a significant portion of which came from rural and semi-urban areas (National Payments Corporation of India, 2023).

The impact of this digital transformation on financial inclusion has been profound. The World Bank's Global Findex Database 2021 reveals that 78% of adults in India now have a bank account, up from 53% in 2014. More importantly, the gender gap in account ownership has narrowed significantly, with 77% of women now owning an account compared to 43% in 2014 (World Bank, 2022).

Digital empowerment in rural India

Digital payments have addressed several challenges that traditionally hindered financial inclusion in rural India:

1. Accessibility: Digital platforms have eliminated the need for physical bank branches, bringing financial services to remote areas.

2. Affordability: Low-cost digital transactions have made financial services more accessible to low-income groups.

3. Convenience: Mobile-based applications have simplified banking processes, making them user-friendly for even those with limited literacy.

4. Transparency: Digital transactions create a verifiable trail, reducing the risk of fraud and enhancing trust in the financial system.

Success of digital payments in rural India

The success of digital payments in rural India can be attributed to a combination of factors. Government initiatives like the Pradhan Mantri Jan Dhan Yojana (PMJDY), which aims to ensure access to financial services for all households, have played a crucial role. As of April 2023, over 480 million bank accounts have been opened under this scheme, with 55.4% of account holders being women (Department of Financial Services, 2023).

The rapid penetration of smartphones and internet connectivity in rural areas has been another key driver. India's internet user base is expected to reach 900 million by 2025, with rural users accounting for 45% of this population (IAMAI-Kantar ICUBE, 2021). This digital infrastructure has provided the necessary foundation for the growth of mobile payment applications and digital banking services.

Challenges

Digital literacy, cybersecurity concerns, and sporadic internet connectivity in some areas are hurdles that need to be addressed. The government and private sector are working together to overcome these challenges through initiatives like the Digital Saksharta Abhiyan (DISHA) for promoting digital literacy and the implementation of robust security measures in payment systems.

Future ahead

The future of digital payments and financial inclusion in rural India appears promising. Emerging technologies like artificial intelligence and blockchain are expected to further enhance the efficiency and security of digital financial services. The RBI's vision for 2025 aims to increase digital payments by more than 10 times, with a special focus on rural areas (Reserve Bank of India, 2023). As digital payments continue to evolve and penetrate deeper into rural India, they are not just transforming financial services but are also catalyzing broader economic development. By providing easy access to credit, savings, and investment opportunities, digital payments are empowering rural communities, fostering entrepreneurship, and contributing to the overall economic growth of the nation.

The digital payment revolution in rural India stands as a testament to the power of technology in driving financial inclusion. As this transformation unfolds, it promises to create a more inclusive, efficient, and robust financial ecosystem that leaves no one behind in India's journey towards economic prosperity.

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GLANDERS IN EQUINES: RESURGENCE AND IMPLICATIONS FOR VETERINARY AND PUBLIC HEALTH

Article ID: AG-V04-I07-18

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Introduction

Many emerging and re- emerging diseases are causing great threat to the wellbeing of humans as well as livestock. Glanders is one such disease that is highly zoonotic, contagious and fatal disease of donkeys, mules and horses. The disease has been eradicated from many developed countries like North America, Europe and Australia. But disease incidence is still being recorded in developing countries of Asia, Africa and Latin America. The disease is one of re-emerging fatal bacterial disease. Glanders is caused by bacteria, *Burkholderia mallei*. There are incidences of use of *B.mallei* as a biological warfare agent due to its highly contagious nature. Due to its economic impact on the global commerce in animals and byproducts, glanders is a transboundary animal disease that needs to be notified to the World Organization for Animal Health (OIE).

Glanders

Glanders occurs in acute form and is often fatal in donkeys and mules. Horses usually present a chronic form. The equine keepers, veterinarians, farriers, and animal workers are occupational groups that are at high risk to glanders. Glanders is mainly transmitted by contact with infected horses, mules and donkeys, most often via their respiratory secretions and exudates from skin lesions. This bacterium can enter the body through skin abrasions and mucous membrane contamination, or inhalation of aerosols.

In animals, the disease commonly occurs in three forms as pulmonary, cutaneous (farcy) and nasal glanders. In glanders, the entire upper and lower respiratory tracts are affected by an acute or chronic lung infection, and numerous abscesses occur due to dissemination. Contrarily, farcy manifests as swelling in subcutaneous tissues that ulcerate. Local lymph nodes and adjacent lymphatic veins harden and expand.

a. Nasal form of Glanders

b. Cutaneous form of Glanders

Infection in humans

Infection in humans presents as two forms as both acute and chronic forms, and affects mainly the respiratory system, skin and subcutaneous soft tissues. The disease is a recognized occupational risk for veterinarians, equine butchers, stable handlers and laboratory workers, and it was more common during wars in which large numbers of horses were used. Humans usually experience respiratory symptoms with fever that can develop into airway necrosis and ulceration. Following may be lobar or bronchopneumonia, swollen lymph nodes in the neck and mediastinum, pustular skin lesions, and spread to internal organs. Skin nodules may grow and develop pus after skin exposure, and adjacent lymph nodes may expand. This frequently comes with symptoms including exhaustion, fevers, chills, and malaise.

The drugs like sodium sulfadiazine effectively treated acute glanders but penicillins were not effective. Drugs like ceftazidime, gentamicin, sulfadiazine, Imipenem, and others are used alone or in combination in horses. No human or veterinary vaccines are available for immunization/prevention of glanders still today. Usually animals are screened by Mallein test and the reactors will be eliminated. To prevent further transmission, it is very essential that dead bodies due to glanders should not be opened and must be properly buried or incinerated. Contaminated environments like manure, bedding and feed residue should be burned or buried and follow required disinfection programme for houses, feed and water trough. The isolation of suspected animals and humans, properly tested and positive animal should be culled. There should be restriction of the movement of animals to the suspected area. Proper hygiene and sanitation procedures should be adopted.

Conclusion

Glanders is indeed a concerning disease that has resurfaced in certain regions recently, including Delhi and Bengaluru. The resurgence of Glanders highlights ongoing challenges in disease control and surveillance, emphasizing the need for stringent veterinary measures to prevent its spread. The disease's reappearance underscores the importance of public awareness and proactive health measures to mitigate its impact on both animal and human health.

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THE RISE OF GREEN BONDS: FINANCING A SUSTAINABLE FUTURE

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Introduction

The global financial landscape has witnessed a remarkable transformation in recent years as investors and corporations increasingly prioritize sustainability. At the forefront of this shift is the rapid growth of green bonds, innovative financial instruments designed to fund projects with environmental benefits. This article explores the rise of green bonds and their pivotal role in financing a sustainable future.

What are Green Bonds?

Green bonds are fixed-income securities that raise capital for projects with environmental or climate benefits. These may include renewable energy initiatives, energy-efficient buildings, clean transportation, and sustainable water management. Unlike conventional bonds, green bonds assure investors that their money will be used for environmentally friendly purposes.

The Green Bond Market: A Snapshot

The green bond market has experienced exponential growth since its inception in 2007 when the European Investment Bank issued the world's first climate awareness bond. According to the Climate Bonds Initiative (2023), the global green bond market reached a cumulative issuance of $2 trillion by the end of 2022, with annual issuance hitting a record $522.7 billion that year.

This remarkable growth reflects the increasing awareness of climate change and the urgent need for sustainable development. Governments, corporations, and financial institutions worldwide are leveraging green bonds to finance their transition to a low-carbon economy.

Driving Forces Behind the Green Bond Boom

- **Investor Demand:** As environmental, social, and governance (ESG) considerations become mainstream, investors are actively seeking opportunities to align their portfolios with sustainability goals.
- **Regulatory Support:** Governments and regulatory bodies are introducing policies and frameworks to promote green finance, such as the European Union's Green Bond Standard.
- **Corporate Commitments:** Many companies are setting ambitious sustainability targets and using green bonds to finance their environmental initiatives.
- **Climate Urgency:** The growing recognition of climate change as a global threat is driving the need for increased investment in sustainable projects.

Benefits of Green Bonds

Green bonds offer advantages to both issuers and investors in the following table 1.

Table 1: Benefits of Green Bonds

For Issuers	For Investors
➢ Enhanced reputation and credibility in sustainability efforts ➢ Access to a broader investor base ➢ Potential for lower borrowing costs	➢ Opportunity to support environmental projects ➢ Transparency in the use of proceeds ➢ Potential for competitive financial returns

Challenges and Future Outlook

- **Standardization:** The lack of universally accepted standards for what qualifies as "green" can lead to greenwashing concerns.
- **Limited Supply:** Despite rapid growth, green bonds still represent a small fraction of the overall bond market, limiting investment opportunities.
- **Verification and Reporting:** Ensuring the proper use of proceeds and measuring impact can be complex and costly.

    - Despite these challenges, the future of green bonds looks promising. The Climate Bonds Initiative projects that annual green bond issuance could reach $5 trillion by 2025, driven by increased climate action and sustainable development goals.

- **Emerging Trends in Green Finance**
- **Sustainability-Linked Bonds:** These bonds tie the coupon rate to the issuer's achievement of predetermined sustainability performance targets.
- **Blue Bonds:** Focused on ocean conservation and sustainable marine projects, blue bonds are gaining traction in coastal and island nations.
- **Transition Bonds:** These bonds help carbon-intensive industries finance their transition to more sustainable operations.
- **Digital Green Bonds:** Blockchain technology is being explored to enhance transparency and traceability in green bond issuance and reporting.

Conclusion

The rise of green bonds represents a significant shift in how we finance our sustainable future. By channeling capital towards environmentally beneficial projects, green bonds are playing a crucial role in addressing climate change and promoting sustainable development. As investors, corporations, and governments increasingly recognize the urgency of environmental challenges, the green bond market is poised for continued growth and innovation. While challenges remain, the momentum behind green finance suggests that these instruments will be instrumental in shaping a more sustainable global economy. The success of green bonds demonstrates that financial innovation can be a powerful tool for positive change. As we move forward, it is clear that the financial sector will play an increasingly important role in our collective efforts to build a sustainable future for generations to come.

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IMPACT OF CROP INSURANCE SCHEMES IN INDIA: TRENDS AND DATA ANALYSIS OVER THE YEARS

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Introduction

India's agricultural sector, the backbone of the nation's economy, has long grappled with the unpredictability of weather and market fluctuations. To mitigate these risks, the government has implemented various crop insurance schemes over the years. This article examines the trends and impact of these schemes, analyzing data to gauge their effectiveness in protecting farmers and promoting agricultural stability.

The Evolution of Crop Insurance in India

Crop insurance in India has undergone significant evolution since its inception. The first structured scheme, the Comprehensive Crop Insurance Scheme (CCIS), was introduced in 1985. This was followed by the National Agricultural Insurance Scheme (NAIS) in 1999, which aimed to provide broader coverage. In 2016, the government launched the Pradhan Mantri Fasal Bima Yojana (PMFBY), touted as a game-changer in crop insurance.

The PMFBY sought to address the shortcomings of previous schemes by offering lower premiums for farmers, faster claim settlements, and the use of technology for crop-cutting experiments. However, despite these improvements, the scheme has faced challenges in implementation and achieving its targeted coverage.

Trends in Coverage and Adoption

Over the past eight years since its inception in 2016, the Pradhan Mantri Fasal Bima Yojana (PMFBY) has demonstrated significant impact. More than 56.80 crore farmer applications have been registered, with over 23.22 crore farmers receiving claims. Farmers collectively contributed approximately Rs. 31,139 crore as premiums, resulting in claims disbursed exceeding Rs. 1,55,977 crore. This translates to farmers receiving approximately Rs. 500 in claims for every Rs. 100 paid in premium.

PMFBY operates as a demand-driven and voluntary scheme for both states and farmers. Notably, the number of farmer applications surged by 33.4% and 41% year-on-year in 2021-22 and 2022-23, respectively. By the year 2023-24, there has been a 27% increase in enrolled farmers. Additionally, 42% of farmers covered in FY 2023-24 are non-loanee farmers (Source: Ministry of Agriculture & Farmers Welfare)

Globally, PMFBY ranks as the third-largest insurance scheme by premium volume. Designed to safeguard farmers from crop losses due to unforeseen events, the scheme effectively supports farmers' income stability, particularly during periods affected by natural calamities. As a Central Sector Scheme, PMFBY operates without state-specific allocations or releases (Kumar et al., 2022).

Impact on Farmers' Financial Resilience

One of the primary objectives of crop insurance schemes is to enhance farmers' financial resilience against crop failures. A study by Verma et al. (2019) found that insured farmers were more likely to invest in high-quality inputs and adopt modern farming practices, leading to higher productivity.

However, the impact varies across regions and farm sizes. Small and marginal farmers, who constitute the majority of India's farming community, often face challenges in accessing and benefiting from these schemes. Data shows that in 2019-20, only 30% of small and marginal farmers were covered under PMFBY, compared to 45% of medium and large farmers (Rao & Bharati, 2023).

Challenges and Areas for Improvement

Despite the progress made, crop insurance schemes in India face several challenges. Delayed claim settlements remain a significant issue, with only 32% of claims settled within the stipulated two-month period in 2019-20 (Kumar et al., 2022). This delay can have severe consequences for farmers' financial stability and their ability to prepare for the next cropping season.

Another challenge is the accuracy of crop loss assessment. Traditional methods of crop cutting experiments are time-consuming and prone to errors. The government has been promoting the use of satellite imagery and remote sensing technologies to improve the accuracy and speed of assessments, but implementation at scale remains a challenge.

The Way Forward

As India continues to refine its crop insurance schemes, there is a need for a data-driven approach to policy formulation and implementation. Recent initiatives, such as the integration of land records with insurance databases and the use of smartphone apps for real-time reporting of crop losses, show promise in improving the efficiency of these schemes.

Furthermore, there is a growing emphasis on index-based insurance products, which can potentially reduce administrative costs and expedite claim settlements. A pilot study in Maharashtra showed that weather index-based insurance led to a 12% increase in technology adoption among farmers (Gulati & Terway, 2020).

Crop insurance schemes in India have come a long way in providing a safety net for farmers. While data shows improvements in coverage and sum insured, challenges remain in terms of inclusivity, timely claim settlements, and accurate loss assessment. As the agricultural sector faces increasing threats from climate change and market volatilities, the continued evolution and refinement of crop insurance schemes will be crucial in ensuring the resilience of India's farming community.

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DIFFERENT SCHEMES AT KRISHI VIGYAN KENDRAS IN INDIA

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Introduction

Krishi Vigyan Kendras are the centres for agriculture extensions created by Indian Council for Agricultural Research (ICAR) and its affiliated institutions at the district level. KVKs are an integral part of the National Agricultural Research System (NARS) and serve as the link between the NARS and the farmers. The KVK centre provides various types of farm support to the agricultural sector and creates awareness about the improved agricultural technologies.

KVK Overview

1. The first Krishi Vigyan Kendra, on a pilot basis, was established in 1974 at Puducherry (Pondicherry) under the administrative control of the Tamil Nadu Agricultural University, Coimbatore.
2. KVKs are sanctioned to Agricultural Universities, ICAR institutes, related Government Departments and Non-Government Organizations (NGOs) working in Agriculture. Usually, a KVK is associated with a local agricultural university.
3. All KVKs fall under the jurisdiction of one of the 11 Agricultural Technology Application Research Institutes (ATARIs) throughout India.

4. These Krishi Vigyaan Kendra are 100% financed by the Government of India and are crucial to fulfilling the target of doubling farmer's income in near future. Read about Krishi Kalyan Abhiyan Scheme on the given link.

1. **Tribal Sub Plan (TSP)**

The Tribal Sub-Plan (TSP) strategy of tribal development is a concept intended to address the issues of backwardness in tribal areas and tribal population in an integrated way. The aim is to minimize the gap between the livelihood of tribal people and general communities.

2. **Schedule caste sub plan (SCSP)**

The basic objective of the SCSP has been to channel the flow of outlays and benefits from the general sectors in the Plan of States for the development of Scheduled Castes, at least in proportion to their population, both in physical and financial terms.

3. **Cluster Frontline Demonstration in Oilseeds**

Cluster Frontline Demonstration on Oilseeds is a significant step by DAC & FW, GOI to demonstrate newly released crop production and protection technologies on various oilseed crops. These technologies include seed treatment, application of bio fertilizer, integrated nutrient management, Integrated pest management, line sowing, weed management, irrigation management etc. CFLD Oilseeds project launched in the year 2015-16 under NFSM & NMOOP. The demonstration programme conducted by the KVKs.

Objectives

The main objective of Cluster Front-Line Demonstrations is to demonstrate newly released crop production and protection technologies and its management practices in the farmers' field under different agro-climatic regions and farming situations. While demonstrating the technologies in the farmers' field, the scientist to study the factors contributing higher crop production, field constraints of production and thereby generate production data and feedback information. The field demonstrations conducted under the close supervision of scientists of the KVKs because the technologies are demonstrated for the first time by the scientists themselves before being fed into the main extension system of the State Department of Agriculture.

Salient features of CFLD Oilseeds

- Cluster Frontline Demonstrations are conducted under the close supervision of the scientists of the KVKs of ICAR Institute and State Agricultural Universities.

- Only newly released technologies or those likely to be released in near future are selected for the Cluster Front-Line Demonstrations.
- Only critical inputs are provided from the scheme budget, remaining inputs are supplied by the farmers themselves.
- Cluster Front-Line Demonstrations are used as a source of generating data on factors contributing higher crop yields and constraints of production under various farming situation

Technological Interventions under CFLD Oilseeds

Seed Treatment:

The concept of seed treatment is the use and application of biological and chemical agents that control or contain primary soil and seed borne infestation of insects and diseases which pose devastating consequences to crop production and improving crop safety leading to good establishment of healthy and vigorous plants resulting better yields. Seed treatment complexity ranges from a basic dressing to coating and pelleting. Under CFLD Oilseeds seed treatment mainly done by using chemicals like *Trichoderma viridi*, Bavistin, Propinophex, Carboxin, Thiram etc. For seed inoculation in Groundnut Rhizobium sp and Azotobactor are used.

Use of improved variety:

Improved varieties offer much higher yields, better quality and more stable production. These varieties has the properties like disease and insect resistance, high yield, early maturity, plant height, superior quality and nutrient level.

IPM:

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment.

Sowing Method:

Sowing is an art of placing seeds in the soil at particular depth for good germination of the seeds. Sowing plays a major role in Agriculture. Sowing is step followed next to land levelling. Perfect sowing is placing the seed at a specific depth with the correct amount of seed per unit are with good spacing between plant to plant and row to row. In line sowing uniform row to row spacing is maintained and the seed requirement is less than broad casting.30×10 cm spacing is ideal for most of the oilseeds in line sowing method.

Weed Management:

Weeds may compete with desirable crop plants for light, water and nutrients. Weeds are also a primary source of insects such as aphids, whiteflies, thrips and other pests such as mites, slugs and diseases. An integrated weed management program will help to effectively manage weed populations. This approach includes preventive measures, sanitation, physical barriers, hand weeding and the selective use of post emergence herbicides.

4. Cluster frontline demonstration in Pulses:-

Cluster frontline demonstration is a unique approach by the Indian Council of Agricultural Research on Oilseed and Pulse crops to provide a direct interface between scientists and farmers where farmers are guided by the KVK scientists during demonstrations in implementation of improved technologies like seed treatment, IPM, INM, land preparation etc . Demonstrated fields are regularly monitored by the scientists. Cluster Frontline Demonstration project started since 2015-16 under NFSM and NMOOP.

India is the largest producer of pulses and pulses are major protein supplements in the food. The major pulse crops grown in India are Redgram, Bengalgram, Greengram and Blackgram.

Salient features of CFLD pulses:

Objective

The main objective of Cluster Front-Line Demonstrations is to demonstrate newly released crop production and protection technologies and its management practices in the farmer's field under different agro-climatic regions and farming situations. While demonstrating the technologies in the farmersâ□™ field, the scientist study the factors contributing higher crop production, field constraints of production.

I. Cluster Frontline Demonstrations are conducted under the close supervision of the scientists of the KVKs of ICAR Institute and State Agricultural Universities.

II. Only newly released technologies or those likely to be released in near future are selected for the Cluster Front-Line Demonstrations.

III. Only critical inputs are provided from the scheme budget, remaining inputs are supplied by the farmers themselves.

Cluster Front-Line Demonstrations are used as a source of generating data on factors contributing higher crop yields and constraints of production under various farming situation.

Guidelines:

I. The demonstrations of each pulse crop should be organized in cluster approach (at least 10 ha. in each cluster).

II. KVK should provide seed as one of the critical inputs to farmers for organization of demonstrations

III. The High Yielding Varieties of pulse crops to be included in the demonstrations should not be older than 10 years.

IV. More focus should be given to organize demonstration on pulses in rice fallow areas in eastern India.

V. Under C-FLDs, full package kit like seed, INM, IPM material should be given to farmers at the time of sowing.

There by generate production data and feedback information.

5. **Targeting technologies to agro-ecological zones-large scale demonstration of best practices to enhance cotton productivity**

Ministry of Agriculture & Farmers Welfare, Govt. of India has approved a special project on cotton entitled ‘Targeting technologies to agro-ecological zones- large scale demonstrations of best practices to enhance cotton productivity’ under National Food Security Mission (NFSM) for implementation during 2023-24. The project is being implemented through ICAR-Central Institute of Cotton Research (CICR), Nagpur on PPP mode in the identified clusters through value chain approach by collaboration with Ministry of Textiles, CITI & SIMA; Seed Industry Associations (NSAI and FSII); Extension partners (Cotton Development and Research Associations of CITI and SIMA); Agricultural Technology Application Research Institutes (ICAR-ATARIs) & their Krishi Vigyan Kendras (KVKs); State Departments of Agriculture-ATMA, Textile partners and Cotton Corporation of India (CCI) to increase productivity of cotton and production of Extra Long Staple (ELS) cotton.

The Pilot Project comprises of three technologies namely High Density Planting System (HDPS), Closer Spacing planting system and Production technology for ELS cotton.

The assistance under the project is to be provided to marginal & small farmers through DBT besides geo-referencing of project sites.

6. Out scaling of natural farming through KVKs

The project "Out scaling of Natural Farming" aims at bringing sustainability in production system and restoring soil fertility. Natural Farming offers a solution to various problems, such as food insecurity, farmers' distress, and health problems arising due to pesticide and fertilizer residue in food and water, global warming, climate change and natural calamities. It also has the potential to generate employment, thereby stemming the migration of rural youth. Ministry of Agriculture and Farmers Welfare has taken an initiative for promotion of Natural Farming as BharatiyaPrakritik Krishi Paddhati Programme (BPKP) under centrally sponsored scheme-Paramparagat Krishi Vikas Yojana (PKVY). It is largely based on on-farm biomass recycling with major stress on biomass mulching, use of on-farm cow dung-urine formulations; periodic soil aeration and exclusion of all synthetic chemical inputs.

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LEGHAEMOGLOBIN: ORCHESTRATING SYMBIOTIC NITROGEN FIXATION IN LEGUMES

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Abstract

The capacity to transform atmospheric nitrogen into usable forms is prevalent among free-living bacteria. However, the majority of nitrogen fixation in soil is attributed to the symbiotic relationship between specific bacteria and plants. This process necessitates energy and anaerobic conditions, both provided by plants, explaining the prevalence of symbiotic nitrogen fixation. Legume cultivation contributes significantly to Earth's biological nitrogen fixation. This process involves plant infection by soil bacteria called rhizobia, leading to the formation of specialized structures known as nodules. Within nodules, leghaemoglobin, a hemoprotein, plays a crucial role by maintaining anaerobic conditions, safeguarding the activity of oxygen-sensitive nitrogenase enzyme and facilitating nitrogen fixation. Rhizobia multiply around germinating legumes, adhering to root hairs through specific interactions.

Introduction

The ability to convert atmospheric nitrogen into plant available forms is a widespread characteristic among bacteria that live freely in the environment. While nitrogen-fixing bacteria like Azotobacter are commonly found in soils, it's believed that majority of nitrogen fixation on soil occurs through symbiotic associations between plants and specific types of bacteria. This process demands a significant amount of energy and conditions of low oxygen or limited oxygen availability, both of which can be facilitated by plants. This explains why symbiotic nitrogen fixation is prevalent. Around half of Earth's biological nitrogen fixation is attributed to the cultivation of legumes. Symbiotic nitrogen fixation involves a select group of plant and bacterial species. In the most significant types of this process, the plant gets infected by free living soil bacteria, the rhizobia. The plant then conserves these bacteria within its cells and creates an environment conducive for nitrogen fixation. Simultaneously, the host plant restricts the bacteria's ammonia assimilation, leading the bacteria to release NH^{4+}, which the plant's cells then absorb. The association between these plant and bacterial species tend to have varying levels of specificity.

Leghaemoglobin – the vital protagonist

Haemoglobins, widely found across nature, are some of the most well-studied proteins. Within plants, symbiotic haemoglobins believed to play a crucial role in symbiotic nitrogen fixation (SNF). In legumes, the process of SNF unfolds within specialized structures known as nodules. These nodules contain countless nitrogen-fixing rhizobia, termed bacteroids which are morphologically modified rhizobia larger than the free-living bacteria and have altered cell walls. Central to this process is leghaemoglobin, a hemoprotein that functions as a unique oxygen scavenger. The enzyme nitrogenase is synthesised by the bacteria and if leghaemoglobin is present, nitrogen fixation will occur. Its key role is to maintain anaerobic conditions within the legume, thus protecting the activity of nitrogenase—a highly oxygen-sensitive enzyme which is the principal catalyst driving the process of biological nitrogen fixation in leguminous plants. Leghaemoglobin is a product of the symbiotic interaction, since globin is produced by the plant and the haem is synthesised by the bacteria.

The legume nodules encompass three structurally and physiologically distinct zones called external cortex, internal cortex and central region. The external cortex is separated from the internal cortex by a layer of cells called endodermis which may act as a physical barrier to oxygen diffusion. The central region is formed mainly by infected cells containing the bacteroids. Bacteroids are not free in the cytoplasm of infected cells but are confined inside vesicles called symbiosomes.

A successful mutualistic relationship between host plants and rhizobia relies on intricate molecular signaling interactions. In conditions of low nitrogen, initial signal exchange occurs in the rhizosphere, where legume roots release flavonoids, attracting rhizobia and inducing the secretion of Nod factors, also known as lipo-chitooligosaccharides, by these bacteria. The perception of Nod factors in the root's susceptible region triggers two concurrent yet interconnected processes: bacterial infection in the epidermis and cortex cell division to establish nodules housing rhizobial symbionts. Following their release from infection threads, bacteria within organelle-like symbiosomes differentiate into bacteroids, converting nitrogen gas into ammonia within mature nodules' low-oxygen environment.

Rhizobia

Rhizobia, which are capable of fixing nitrogen, can be found as free-living in soil. While they are relatively uncommon in soils devoid of legume cultivation for extended periods, they thrive abundantly in the rhizosphere, the soil area surrounding legume roots. This prevalence is further stimulated by the compounds released by the roots, known as root exudates. A crucial player in nitrogen fixation within legumes is a hemeprotein called symbiotic haemoglobin or leghaemoglobin. This substance is found in small concentrations within the infected cells of legume roots. Its presence is vital for the nitrogen fixation process in legumes. The formation of leghaemoglobin is a consequence of the symbiotic association between the bacteroid (bacterial partner) and the plant. Leghaemoglobin serves a dual role. On one hand, it protects the nitrogenase enzyme from denaturation that could occur if it were exposed to the excess concentration of oxygen. This nitrogenase enzyme is crucial for nitrogen fixation. On the other hand, leghaemoglobin also ensures a steady supply of oxygen to the bacteria, supporting their respiratory needs. This intricate balance of protection and oxygen provisioning plays a pivotal role in the success of nitrogen fixation within legumes.

Rhizobia multiply around germinating legumes, a phenomenon that sets the stage for a significant biological association. This partnership, essential for nitrogen fixation, involves a process wherein the bacteria adhere to the root hairs of the legume. The success of this adhesion is vested with the specific legume species and the strain of symbiotic bacteria involved. Some strains, have the ability to infect multiple legume species and certain legumes can establish nodules with different strains of rhizobia too. This adhesive interaction is facilitated by the production of specialized lectins by the host plant and specific polysaccharide cell coatings produced by the bacteria. Once adhesion is achieved, a root hair initiates an infection thread through which the bacteria penetrate the root. This initiates a sequence where the bacteria invade root cells, undergoing a transformation into bacteroids. These bacteroids undergo swelling and deformation, losing their ability to divide. This transformation triggers the root to form nodules, specialized structures that can harbour the infected cells.

Notably, the nitrogen-fixing root nodules exhibit a marked difference from the tumours induced by *Agrobacterium tumefaciens* – commonly referred to as crown galls. Unlike the tumours, the nitrogen fixed within the nodules is utilized by the host plant, resulting in the emergence of a regulated function and the development of a novel organ. In contrast, galls are essentially a form of parasitism, detrimental to the host plant's well-being.

Factors affecting nodule formation

Several environmental factors exert adverse effects on the efficiency of symbiotic nitrogen fixation in legumes. These influences occur at various stages, encompassing the survival of rhizobia in the soil, the infection process, nodule growth, nodule functionality and the overall growth of host plants. Salinity stress stands out as a critical limiting factor that significantly impacts the productivity of leguminous crops. The presence of high soil salinity levels impedes both the survival and growth of rhizobia in the soil, disrupting the formation of the rhizobia-legume symbiosis. Consequently, the yield of legumes is reduced due to these inhibitory effects.

Remarkably, rhizobia often exhibit greater tolerance to salinity compared to their corresponding plant hosts. Their inherent resistance to salt stress frequently becomes the limiting factor in saline soils. Paradoxically, some salt-tolerant bacteria may form ineffective nodules, exhibiting diminished symbiotic efficiency and nitrogen fixation rates. In legumes, salinity-induced effects manifest as root systems devoid of root hairs and a mucilaginous layer, rendering them incapable of forming infection threads. Such salt-induced injury impedes not only nodule formation but also leads to reduced nitrogenase activity and hindered growth of the host plant. Salinity can further induce the development of non-functional nodules with abnormal structures and the degradation of the peribacteroid membrane.

Water movement into nodules chiefly occurs through vascular connections with the roots. Nodules primarily rely on the surface area for gaseous exchange, which renders them more predisposed to water loss rather than uptake. To facilitate the export of fixation products, nodules require an efficient water supply. When plants face water scarcity, their transpiration rates decrease. This reduced rate of water movement out of the nodule during drought stress can constrain the export of nitrogen fixation products, thereby impeding nitrogenase activity through a feedback mechanism. Moreover, water shortage can induce oxidative stress within nodules, leading to a decrease in overall antioxidant activities associated with nodule senescence.

Interestingly, excess water also has notable consequences for many legumes. Although excessive water affects nodule development and function more significantly than the infection process itself, certain outcomes, such as decreased nitrogenase activity, can be even more pronounced than in cases of water deficit. Overall, these complex interactions among environmental factors and nodule formation underscore the importance of maintaining optimal conditions for symbiotic nitrogen fixation in leguminous plants. It is important to note that factors such as high ambient concentrations of combined nitrogen, acidic conditions and low phosphate availability can also impede the process of nodulation.

Despite leghaemoglobin's significant physiological role, its degradation pathway remains largely unexplored. The metabolic breakdown of leghaemoglobin apoprotein involves proteases with a strong affinity for leghaemoglobin, particularly prevalent in senescing nodules. Within these nodules, the degradation is facilitated by two pigments, choleglobin and biliverdin, with biliverdin's accumulation leading to a color shift from red to green, signaling diminished nitrogen-fixing activity in leguminous plants.

Conclusion

Symbiotic nitrogen fixation in legumes is a dynamic process influenced by various environmental factors. Salinity stress significantly impacts leguminous crop productivity by inhibiting rhizobia survival and growth in the soil, disrupting symbiotic relationships. Water scarcity, oxidative stress, and excess water also influence nodule formation and function. Legumes' intricate relationship with rhizobia, the presence of leghaemoglobin, and the formation of nodules contribute to efficient nitrogen fixation. Understanding the intricate interactions and optimizing conditions for symbiotic nitrogen fixation is crucial for enhancing agricultural sustainability and legume productivity.

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MODIFIED ATMOSPHERIC PACKAGING AND ITS IMPORTANCE

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Introduction

Fresh fruits and vegetables that are packaged using a modified atmosphere (MAP) are those that are sealed in polymeric film packages while actively respiring, hence altering the levels of oxygen and carbon dioxide in the package's atmosphere. In order to affect the product's metabolism or the activity of organisms that cause decay, it is frequently preferable to create an atmosphere that is low in oxygen and/or high in carbon dioxide. This will increase the product's storability and/or shelf life. It may be preferable for some products to change both the O2 and CO_2 levels; in fact, changing the O_2 level also changes the CO_2 level. MAP significantly increases moisture retention in addition to altering the environment, which may have a bigger impact on quality preservation than O2 and CO_2 concentrations. Additionally, packing keeps the goods sealed off from the outside world and aids in . Furthermore, packaging isolates the product from the external environment and helps to ensure conditions that, if not sterile, at least reduce exposure to pathogens and contaminants.

Gas permeability of specific films must be such that oxygen can enter the package at a rate that is equal to the amount of oxygen that the commodity is respiring in order to create and preserve an acceptable atmosphere inside the package. In a similar vein, carbon dioxide must be released from the container to prevent buildup (Kader, 1997). Additionally, the packets would help to maintain a high relative humidity by acting as a barrier to the movement of water vapor. It was found that using modified environment packaging could double the commodity's shelf life, and using refrigeration in addition to the changed atmosphere packaging could quadruple the shelf life.

The interaction of the package film with the internal gas atmosphere and the product being stored is known as modified atmosphere packaging. It's critical to understand that, although modifying the climate can help some fruits and vegetables store longer, it can also have unfavorable consequences. If reduced oxygen levels are insufficient to maintain aerobic respiration, fermentation and off-flavors may occur (Kays, 1997). In a similar vein, damage will result from CO_2 levels that are too high. According to Rajesh (2001), because horticulture commodities are living beings, they vary from other food products. For the duration of the marketing cycle, these products maintain their high respiration rate and other ripening-related metabolic processes. The utilization of modified environment packaging approach has the potential to successfully impede both chemical and biological degradation.

Modified atmosphere (MAP)

MAP creates an MA around the packaged product and selective permeability of the packaging material by using polymeric with selective permeability for O_2, CO_2, and water vapour. Fresh fruits and vegetables deterioration is successfully delayed by MAP, which is most useful for extremely perishable items. According to Zhang et al. (2003), MAP can prevent respiration and weight loss, extend the shelf life of Pleurotus nebrodensis mushrooms to 90 days, and delay the titrable acidity, anthocyanin decline, and soluble sugars of strawberries.

When compared to peppers held in vacuum packaging, fresh cut peppers with MAP showed superior visual quality, less juice leakage, and increased stiffness. A 21-day shelf life was found by microbiological and quality tests when fresh-cut peppers were kept at 5ºC. When compared to peppers held in vacuum packaging, fresh cut peppers with MAP showed superior visual quality, less juice leakage, and increased stiffness. A 21-day shelf life was found by microbiological and quality tests when fresh-cut peppers were kept at 5ºC.

To maintain quality and increase shelf life, fresh-cut cucumbers were packed in argon, nitrogen, and air-based MA after being coated with varying concentrations of edible chitosan solutions. Throughout a 12-day storage period at 5°C, the impact of both single and combination treatments on a few quality parameters was evaluated on a periodic basis. Fresh-cut cucumbers' shelf life was increased and their quality and microbiological safety were preserved when chitosan coating and MA packaging were combined.

The primary candidates for MAP are horticultural products, and fresh food appears to benefit from lower oxygen and higher CO2 levels in the atmosphere in a number of ways. MA delays ripening and senescence, lowers the rate of microbial development and spoiling, enhances the retention of chlorophyll and other pigments, lowers ethylene production, sensitivity, and texture losses.

Active and passive modified atmospheric packagings are the two systems generally recognised for packaging of fresh-cut produce. A passive modification consisted of allowing the appropriate atmosphere to evolve within a closed chamber by respiration of the produce and maintaining that atmosphere by selective permeability of gasses through the membranes or by diffusion channels.

Active MAP

While passive modification happens when the product is packaged using a chosen film type and a desired atmosphere develops naturally as a result of product respiration and the diffusion of gases through the film, active modification involves moving the gases in the package and replacing them with a desired mixture of gases. In China, passive MAP is widely used to increase the shelf life of fresh produce, including cut fruits and vegetables. This is because passive MAP is a far more cost-effective method of extending the shelf life than controlled atmosphere (CA) methods. Active MAP refers to systems that are added to emit (e.g., N2, CO2, ethanol) or remove (e.g., O2, CO2) gases during packaging or distribution. More recently, systems that are gas-scavenging or emitting have also been included. In case of a gas-scavenging or emitting system, reactive compounds are either contained in individual sachets or stickers associated to the packaging material or, more recently, directly incorporated into the packaging material.

Reactive compounds are either held in separate sachets or stickers attached to the packaging material in the case of a gas-scavenging or emission device, or, more recently, directly incorporated into the packaging material. O_2 scavengers could also have a beneficial effect on O_2 sensitive respiring products such as fresh or minimally processed fruits and vegetables.

modified atmosphere of green asparagus combined with refrigeration at 2ºC, showed the best results among the treatments (packaged and non-packaged, refrigeration at 2ºC, MAP at 2ºC, and MAP at 10ºC after 5 days at 2ºC.) in terms of retaining sensory and nutritional quality, increasing the safety, and extending the shelf-life. This storage system was shown to be the most suitable, increasing the shelf-life of green asparagus by 12 days when compared with refrigerated storage and 6 days when compared with MAP at 10ºC (after 5 days at 2ºC). MAP has also shown a significant difference among packaged and non- packaged green asparagus in terms of the following parameters like Gases (O_2 and CO_2), external appearance, weight loss, pH and acidity, vitamin C, texture, and microbial quality, along with a microscopical analysis.

The right cleaning method (using ozone and chlorine) combined with MAP extended the shelf life, preserved the quality, and improved food safety of asparagus. Freshly cut asparagus kept its quality for 23 days at 4ºC after being cleaned in chlorinated water and stored in an active MAP of oriented polypropylene (OPP) bags with 8.15 kPa CO2 and 17.51 kPa O2.

MAP testing on celery sticks in various films (OPP, LDPE), with PE perforated bags serving as the control, showed that MAP enhanced the sensory experience, prevented the color from fading, reduced the emergence of pithiness, and slowed the growth of microbes. Additionally, it was found that no treatment contained any odd flavors or smells. After 15 days at 4ºC, the oriented polypropylene bags reached a steady-state environment, and the celery sticks kept within these bags had the best quality.

After being minimally processed and flushed with 5% O2 and 2% CO2, the modified atmosphere packaging (MAP) of bok choy reduced respiration rate, ion leakage, chlorophyll content, and chlorophyll fluorescence. The MAP was then stored at 10ºC and sealed either directly in a polyethylene (PE) bag or in a perforated oriented polypropylene (POPP) bag. Comparing minimally processed Bok Choy in MAP to direct sealing in PE and POPP bags, the shelf life of the former was around ten days.

According to reports, broccoli packaged in a modified atmosphere with minimal processing did not significantly alter the food's stability of carotenoids and tocopherols, nor did it change the phytochemicals' in vivo bioavailability—even after up to nine days of storage—or the serum responses that resulted from eating the food.

When endives were packed with macro perforated oriented polypropylene (OPP), the effect of passive MAP on color changes was comparable to that of UAP (unmodified atmosphere packaging) in a stable modified atmosphere with a composition of 3 kPa O2 and 4.5 kPa CO2. O2 scavengers or low density polyethylene (LDPE) were the two alternative packaging materials utilized. The benefit of MAP of endives was achieved by employing an O2 scavenger, or active MAP, which, in contrast to passive MAP, did not alter the partial pressure of O2 and CO2 during the steady state period but instead caused a 50% reduction of the transient duration. Endive greening and browning were significantly delayed as a result of this reduction.

The length of storage had an impact on rocket leaves' metabolic activity (generation of CO_2 and ethylene), but cutting degree had no effect. This led to non-significant variations in the color and a few nutritional characteristics of the rocket leaves, as well as in the atmospheric composition (CO_2 and ethylene concentration) of the packages containing leaves with varying degrees of cutting.

Cucumbers (*Cucumis sativus* L.) stored in perforated modified atmosphere packaging (MAP) under cold room (4 ± 1 °C and 90 ± 2 % RH) and ambient condition (23–26 °C and 63–66 % RH) were evaluated for firmness, weight loss (WL), colour, chilling injury and sensory characteristics. The study revealed that cucumber can be stored under MAP with 2 perforations at 4 ± 1 °C and 90 ± 2 % RH and ambient condition (23–26 °C and 63–66 % RH) for 12 and 6 days, respectively.

Table.1 Type of MAP for fresh cut-produce

	Passive	**Active**
Definition	Modification of the gas composition inside the package due to interplay between the product respiration rate and the gas exchange rate through the package	Modification of the gas composition inside the package by replacing, at the moment of packaging, the air with a specific gas mixture either by drawing a vacuum or filling a gas mix
Equilibrium time	1 – 2 days to 10 – 12 days	1 – 2 h
Products suitable for	Mushrooms, carrots, strawberry, spinach	Cut apples, dry fruits
Cost	No extra cost involved if the package is properly designed	Extra investment is required for special machinery *i.e.*, gas, gas mixer, packaging machine for MAP
Requirements for labelling	No	Yes

Factors Influencing Modified Atmosphere Packaging

- Gas composition
- Temperature
- Relative humidity

Packaging Materials

Film type and thickness used in MAP

MAP involves the use of plastic film, with known permeability to gases, for the packaging of products. Many factors influence film permeability, among which polymer type and film thickness are most important. Many plastic films have been in for MAP of a variety of produce. Packaging film of correct permeability can create desirable MA of fresh fruit and vegetables. Due to difference in the respiration rates of individual fruits or vegetables, the type of plastic film required to achieve any special equilibrium MA must be defined for each commodity.

MAP utilises polymeric films with selective permeability for O_2, CO_2 and water vapour to create an MA around the packaged product due to the respiration of the produce and the selective permeability of the packaging materials (Guevara *et al*., 2003).

Mangaraj *et al.* (2009) reported that though the MAP industry has an increasing choice of packaging films, most packs are still constructed from four basic polymers viz., Polyvinyl chloride(PVC), Polyethylene teriphthalate (PET), Polypropylene(PP) and Low density polyethylene(LDPE) for packaging of fresh produce.

Plastic film

LDPE films are the most used films for packaging of fresh produce. According to a study the best packaging material for MAP storage of pioneer cherry has been reported as 0.02mm LDPE film and Nectarines packed in 0.03mm LDPE showed significantly less polygalacturonase and cellulase activities, decreased respiration rate and ethylene production, and a slower decrease in flesh firmness and increase in relative membrane permeability than the control. PP and PVC films are often used to pack fruits and vegetables such as waxberry (0.025mm PVC).

Composite membrane containing LDPE and PVC was superior to single LDPE and PVC membranes to optimize the gas composition of (2.5 % O_2 plus 16 % CO_2) in MAP for strawberry. MAP could inhibit the respiration and weight loss strawberries and retard soluble sugars, titrable acidity and Anthocyanin decrease. (Zhang *et al.*, 2003).

Packaging material containing Biaxially Oriented Polypropylene (BOPP): PET: LDPE was reported to be the best choice for keeping bamboo shoots free. Fuji apples packed in five types of plastic film bags for seven months showed that apples in MAP film of PVC or LDPE had a fresh like quality.

Silicon gum film

Jacobson *et al.* (2004) studied the sensory quality of broccoli stored in modified atmosphere packages (OPP, PVC and LDPE). The LDPE package contained an ethylene absorbing sachet. The samples were stored at different storage temperatures for 1 week. After storage, the broccoli was evaluated both raw and cooked using a triangle test and a quantitative descriptive analysis. It has been observed that the sensory properties of broccoli packaged in LDPE (5 % O_2, 7 % CO_2) that contained an ethylene absorber was perceived to be the sample most similar to fresh broccoli. There were no differences in weight loss between broccolis stored in the different packaging materials.

Shengmin Lu, (2007) investigated the effectiveness of different packaging materials *viz.*, MAP, polyethylene (PE) bag or in perforated oriented polypropylene (POPP) bags in inhibiting quality deterioration of minimally processed Bok Choy. Modified atmosphere packaging (MAP) flushed with 5 per cent O_2 and 2 per cent CO_2 resulted in a reduction of respiration rate and ion leakage and the shelf life also extended up to 10 days in MAP than in poly films.

Li *et al.* (2007) stated that packages with silicon gum film window with initial concentrations of 5 per cent O_2 and 10 per cent CO_2 were the most effective for maintaining mushroom quality. The effect of silicon gum films as windows for gas exchange on the respiration and quality change of stored edible mushroom *Agrocybe chaxingu* was evaluated, and proved that silicon gum film windows could extend the shelf life by 8 days compared to the control. Different sizes of silicon gum film windows had a significant effect on the mushroom quality (Li and Zhang, 2008).

Fresh celery stalks were packed in two packaging films *viz.*, polyolefin with an antifogging additive (AF) and Micro perforated film were kept at 4 ± 1ºC, 90 per cent RH for 35 days, using unpacked celery as control. Both the films allows the shelf life of 31 days but the qualitative parameters such as weight loss, texture and colour in AF were close to the fresh samples than the MAP Packed. Moreover, the weight loss in AF film was less than 3 per cent (Rizzo and Muratore, 2009).

The results of cut broccoli florets packed with different packages (OPP, MP - PP and PVC) confirmed that the mass transport properties of the packaging film strongly influenced the headspace gas concentration, thus suggesting that the selection of the proper packaging is of crucial importance to create conditions able to guarantee the maintenance of quality characteristics. The MP - PP - 20 and MP - PP - 7 films were the most effective films in controlling mass loss, wilting and sensory quality for a longer period and extend the shelf life of cut broccoli florets for about 20 days compared to control samples (Lucera *et al.,* 2011).

Conclusion

Modified atmospheric packaging system was most effective method compared to storing under normal condition

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HOME GARDEN PEST PAPAYA MEALYBUG, *PARACOCCUS MARGINATUS* A SERIOUS UNNOTICED PROBLEM TO GARDEN LOVERS

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Introduction

Paracoccus marginatus Williams and Granara de Willink, called as papaya mealybug, is a small hemipteran that attacks several genera of host plants, including economically important tropical fruits and ornamentals. This mealybug is exotic in origin and introduced into India from Mexico and Central America.

Description

- The mealybug infestations are typically observed as clusters of cotton-like masses on the above-ground portion of plants.
- The adult female is yellow and is covered with a white waxy coating. Adult females are approximately 2.2 mm long (1/16 inch) and 1.4 mm wide.
- A series of short waxy caudal filaments less than 1/4 the length of the body exist around the margin.

- Eggs are greenish yellow and are laid in an egg sac that is three to four times the body length and entirely covered with white wax.
- The ovisac is developed ventrally on the adult female.
- Adult males tend to be colored pink, especially during the pre-pupal and pupal stages, but appear yellow in the first and second instar.
- Adult males are approximately 1.0 mm long, with an elongate oval body that is widest at the thorax (0.3 mm).
- Adult males have ten-segmented antennae, a distinct aedeagus, lateral pore clusters, a heavily sclerotized thorax and head, and well-developed wings.
- Specimens of papaya mealybug turn bluish-black when placed in alcohol, as is characteristic of other members of this genus.

Biology

- In general, mealybugs have piercing-sucking mouthparts and feed by inserting their mouthparts into plant tissue and sucking out sap.
- Mealybugs are most active in warm, dry weather. Females have no wings, and move by crawling short distances or by being blown in air currents.
- Females usually lay 100 to 600 eggs in an ovisac, although some species of mealybugs give birth to live young.
- Egg-laying usually occurs over the period of one to two weeks. Egg hatch occurs in about 10 days, and nymphs, or crawlers, begin to actively search for feeding sites.
- Female crawlers have four instars, with a generation taking approximately one month to complete, depending on the temperature.
- Males have five instars, the fourth of which is produced in a cocoon and referred to as the pupa.
- The fifth instar of the male is the only winged form of the species capable of flight. Adult females attract the males with sex pheromones.
- Under greenhouse conditions, reproduction occurs throughout the year, and in certain species may occur without fertilization.

Host Plants

Economically important host plants of this mealybug include papaya, *Jatropha*, mulberry, hibiscus, avocado, citrus, cotton, tomato, eggplant, peppers, beans and peas, sweet potato, mango, cherry, and pomegranate.

Damage

- The mealybug injects a toxin as it feeds on leaves and fruit which results in chlorosis (yellowing), stunting, deformation, early leaf and fruit drop, and buildup of honeydew.
- Sooty mould fungus, *Capnodium* growing on honeydew excreted by the mealybugs interferes with photosynthesis resulting in black colour covering the affected parts.

Spread

Planting materials, infested materials, weed hosts, ants and wind

Management

- Regular scouting in the garden to detect early infestations
- The infested portions should be removed and destroyed to avoid further spread
- Keep garden free from alternate hosts and weeds
- Gun spray of water using home hose pipe may reduce the population buildup
- Spray any one of the following insecticides when the infestation occurs
    - Profenophos 50 EC @ 2 ml/litre
    - Imidacloprid 17.8 SL 0.6 ml/litre
    - Thiomethoxam 25 WG 0.6 g/litre
    - Chlorpyriphos 20 EC 2 ml/litre
    - Buprofezin 25 SC 2 ml/litre
- Add one ml Teepol or Sandovit/litre
- Spraying can be repeated after fifteen days with Neem oil 20 ml/l
- Use recommended dose with recommended dilution
- Avoid using same chemical repeatedly
- Conserve the predator, *Spalgis epius* (Lycaenid) since the larval stage feeds on different stages of mealybug
- Release the parasitoid, *Acerophagus papayae*

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DROUGHT MANAGEMENT TECHNOLOGIES IN DRYLAND AGRICULTURE

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Introduction

Physiologically, it is explained as the reduction in leaf water potential which occurs due to excess transpiration than the water absorption. That is, when water absorption lag behind transpiration, water deficit develops. It is also defined as, "deficiency or dearth of water severe enough to check the plant growth".

Factors causing drought

Besides the deficiency of soil moisture, high temperature, low relative humidity, fast wind etc. aggravate the adverse effect of drought.

Response of plants to drought stress

Plants growing in drought stress may have the ability to control / avoid stress by escaping (Enduring Drought) or tolerating stress (by developing succulent or Non-succulent habit). These two capabilities are collectively termed as Drought Tolerance

These plants endure drought with the following adaptive features:

1. Smaller leaves with thick cuticle
2. Sunken stomata with hair (pubescence) eg. Nerium
3. Shedding their leaves during summer to avoid excess water loss
4. Dehydration of protoplasm
5. Reducing enzyme activity
6. Favouring the syntheses of ABA (stress hormone) and Ethylene (senescence hormone)
7. Closing stomata due to increase ABA concentration, thereby reducing water loss

Drought management Techniques

1. Nutritional Management

Among the major nutrients, potassium and magnesium are found to be highly deficient due to water deficit conditions. Therefore, application of potassium enhances the water uptake as well as the water relations in the plant tissues by osmoregulation processes, by acting as a potent osmoregulator (osmolyte), thereby the solute potential is reduced. Besides, potassium nutrition also helps in the favourable stomatal regulatory mechanisms, which regulate the water balance of the plants. This has also resulted in the increased WUE of the plants. Similarly, magnesium is component of chlorophyll, its content and uptake is drastically reduced due to the water stress effect. This is most prominent in Mg-loving crops like cotton. Besides macronutrients, deficiencies of micronutrients also appear under water deficit situations due to the following reasons:

2. Use of Antitranspirants

Drought reduces the yield by 0 – 100% depending upon the severity. Prolonged drought can drastically reduce the yield to zero level. But, intermittent drought for 10 – 15 days at early or late stage is common under rainfed conditions. Drought during the critical phonological phase like flowering and grain development is highly detrimental. However, the crop productivity is dependant on how fast a plant can recover after a stress of 6-10 days. The severity of intermittent drought of 6-10 days during critical stages of the crop can reasonably be avoided by the use of antitranspirants and thus crops can be saved. Antitranspirants can effectively be used to the crop under water stress with adverse rainfall.

Classification of Antitranspirants

1. Materials causing stomatal closure
2. Reflectant Types
3. Thin-forming chemicals
4. Polyethylene materials forming thick films

The purpose of ATs is to maintain the growth and productivity under stress conditions and it is never recommended for high productivity / unit area. It saves the crop and helps to get marginal yield when the expectations are zero.

3. Use of plant growth regulators (PGRS)

The plants possessing moderate canopy development (moderate values for LAI), less reduction in photosynthesis, deeper root system, higher root / shoot ratio and delayed senescence will perform better under water stress conditions. Toward this, application of some of the PGRs will prove beneficial for better crop growth and development when grown under water deficit situations. Some of the PGRs and their effects on crops in order to suit to the water stress conditions are cycocel and mepiquat chloride

Agro-techniques for mitigating Water Stress

- Foliar spray of 2%c DAP + 1% KCl (MOP) during critical stages of flowering and grain formation
- 3% Kaoline spray at critical stages of moisture stress
- Foliar spray of 500 ppm Cycocel (1 ml of commercial product per litre of water)
- Mulching with 5 tones of sorghum / sugarcane trash, which saves 19-20% of irrigation water by reducing evaporation loss of water
- Split application of N and K fertilizers as in cotton at 45 and 60 DAS

Other management practices

1. Adjusting the plant population: The plant population should be lesser in dryland conditions than under irrigated conditions. The rectangular type of planting pattern should always be followed under dryland conditions.

2. Mid-season corrections: The contingent management practices done in the standing crop to overcome the unfavourable soil moisture conditions due to prolonged dry spells are known as mid season corrections.

a) Thinning: This can be done by removing every alternate row or every third row which will save the crop from failure by reducing the competition

b) Spraying: In crops like groundnut, castor, redgram, etc., during prolonged dry spells the crop can saved by spraying water at weekly intervals or 2 per cent urea at 7 to 10 days interval.

c) Ratooning: In crops like sorghum and bajra, ratooning can practiced as mid season correction measure after break of dry spell.

3. Mulching: It is a practice of spreading any covering material on soil surface to reduce evaporation losses. The mulches will prolong the moisture availability in the soil and save the crop during drought conditions.

4. Weed control: Weeds compete with crop for different growth resources more seriously under dryland conditions. The water requirement of most of the weeds is more than the crop plants. Hence they compete more for soil moisture. Therefore the weed control especially during early stages of crop growth reduces the impact of dry spell by soil moisture conservation.

5. Water harvesting and life-saving irrigation: The collection of run-off water during peak periods of rainfall and storing in different structures is known as water harvesting. The stored water can be used for giving the life-saving irrigation during prolonged dry spells.

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RECENTLY EMERGING CONTAMINANTS ASSOCIATED WITH PHARMACEUTICAL AND PERSONAL CARE PRODUCTS

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Introduction

Pharmaceuticals are categorized as xenobiotics originating from human activities, commonly known in the literature as PPCPs (pharmaceuticals and personal care products). The PPCPs group encompasses not only pharmaceuticals but also food supplements and nutrients, often referred to as nutraceuticals, along with various types of cosmetics and their additives. These products frequently contain antiseptic and antibacterial properties, such as shampoos, UV blockers, toilet water, and antiseptics. Additionally, this group includes disinfectants, including both antibacterial and antiviral agents, the usage of which has surged since 2020 due to the SARS-CoV-2 and Covid 19 pandemic. (Phonsiri *et al*., 2019, Adhikari *et al.*,2022). Pharmaceuticals and personal care products (PPCPs), encompass a variety of substances used for personal health and personal care products. Among them are Caffeine, Carbamazepine, IBP (Ibuprofen), Naproxen (NPX). (Gurudatta *et al*., 2021).

As the medical field rapidly advances and there is a growing emphasis on personal health, the utilization of pharmaceuticals and personal care products (PPCPs) has become widespread. PPCPs encompass various items, including medications (such as antibiotics, beta-blockers, anticonvulsants, and lipid modulators) and everyday products (like disinfectants, sunscreen, shampoos, and preservatives). (Nantaba *et al.*, 2021, Wang *et al.*,2021). The primary sources of PPCPs in aquatic systems predominantly stem from sewage treatment plants (STPs), effluents from wastewater treatment plants (WWTPs), leaching from landfills, improper disposal, and manufacturing processes. (Ebele *et al.*, 2017, Ebele *et al.*,2020).

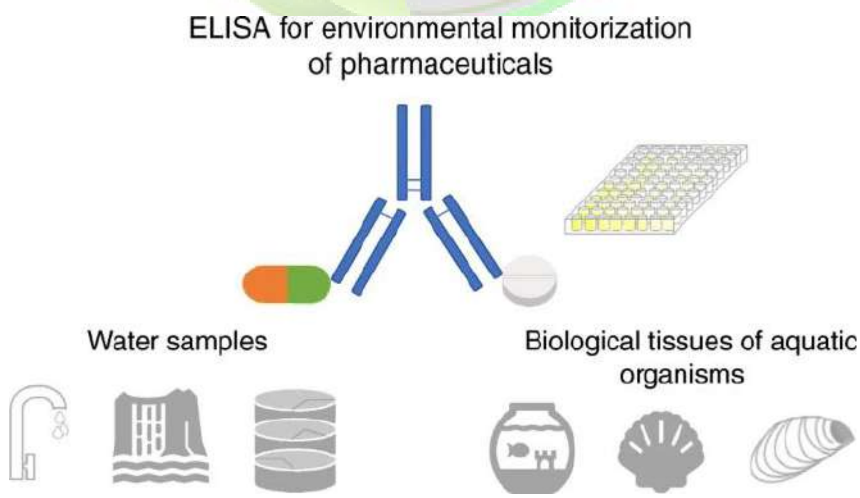
2. The Environmental Consequences of PPCPs:

PPCPs are extensively utilized in our daily lives, yet their constituents pose significant risks to aquatic organisms. These substances readily enter the aquatic environment by pharmaceutical waste and personal care products. (Dhanendra Kumar *et al*.,2023). The distribution and impact of pharmaceuticals and personal care products (PPCPs) in the environment. The pervasive presence and detrimental effects of pharmaceuticals and personal care products (PPCPs) in the environment. With a focus on their detection in ground and surface water, as well as their persistence in wastewater treatment plants (WWTPs), It explores the organic constituents of PPCPs, including antimicrobial agents, hormones, antibiotics, preservatives, disinfectants, and synthetic fragrances that cause health problems. The ramifications of PPCP contamination extend beyond aquatic ecosystems to human and veterinary waste, agricultural runoff, and aquaculture practices. Examining the profound impact of PPCPs on both human and ecological health underscores the urgent need for comprehensive strategies to mitigate their environmental footprint. (Preethi Chaturvedi *et al.*,2021). Pharmaceuticals and personal care products represent distinct elements among the emerging pollutants in aquatic ecosystems due to their particular capacity to elicit physiological responses in humans even at minimal concentrations. (Ebele *et al.*,2017).

The presence of emerging pollutants in the worldwide aquatic ecosystems varies depending on their source, with wastewater treatment plants being the main contributor. Certain emerging pollutants exhibit significant trends towards accumulating in organisms and increasing in concentration up the food chain. (Yuan *et al*., 2024). Emerging pollutants lead to heightened bioaccumulation and present ecological hazards. Emerging pollutants lead to heightened bioaccumulation and present ecological hazards. (Arayo *et al.*, 2020; Wang *et al.*, 2022, Wei *et al.*, 2023). As industries upgrade and globally industries, the issues of environmental pollutants in developing nations remains severe. (Shukla *et al.*,2024; Sruthy and Ramasamy *et al.*,2017). Assessing the bioaccumulation, fate, and ecological risks of emerging pollutants (EPs) is essential for establishing effective strategies for future environmental monitoring and management. (Alygizakis *et al.*, 2023, Arman *et al*., 2021).

3. Techniques for Identifying and quantifying contaminants:

Chromatographic methods, including both gas chromatography (GC) and liquid chromatography (LC) coupled with various types of detectors, have become indispensable for identifying a wide array of chemical compounds and contaminants present in water. These techniques encompass a range of instruments such as GC-MS (gas chromatography-mass spectrometry), GC-Orbitrap-MS, GC-MS/MS (tandem mass spectrometry), GC-HRMS (high-resolution mass spectrometry), GC × GC-TOFMS (comprehensive two-dimensional gas chromatography-time-of-flight mass spectrometry), GC-ECD (electron capture detector), LC-MS/MS (liquid chromatography-tandem mass spectrometry), HPLC-UV (high-performance liquid chromatography-ultraviolet detection), HPLC-PDA (photodiode array detection), and UPLC-QTOFMS (ultra-performance liquid chromatography-quadrupole time-of-flight mass spectrometry). These methods are extensively employed to identify emerging organic contaminants in urban water and other aquatic media. (Paulina *et al.*,2024).



The predominant analytical approaches for identifying these compounds have been high-performance liquid chromatography (HPLC) and gas chromatography (GC) coupled with mass spectrometry. These methods offer the capability to characterize and quantify intricate substances in the environment even at low concentrations. Monitoring and detection of contaminants of emerging concern (CECs) have predominantly been observed in proximity to urban areas. This underscores the inadequacies of outdated wastewater treatment plants and sanitation infrastructures, which hinder the effective removal of these pollutants from the environment. (Miguel *et al.*,2024).

High-resolution mass spectrometry imaging (HR-MSI) is a crucial technique in environmental research, allowing for the precise mapping of contaminants, metabolites, and other substances without the need for sample homogenization. It provides valuable insights into the spatial distribution and fate of pollutants like wastewater treatment plant (WWTP) constituents and perfluorinated alkyl substances (PFAS), shedding light on their impact on ecosystems. Additionally, HR-MSI can reveal changes in natural compounds after exposure to pollutants, offering potential biomarkers for environmental effects. Looking forward, integrating ion mobility spectrometry (IMS) with HR-MSI shows promise for even more sophisticated analyses, improving compound identification and expanding our understanding of environmental systems. (Selby *et al.*, 2024). Numerous analytical techniques have been devised to detect and quantify trace levels of contaminants in water, such as high-performance liquid chromatography (HPLC), gas chromatography (GC), and capillary electrophoresis (CE), often paired with various detectors. Nevertheless, these methods typically entail laborious and costly procedures for sample purification and concentration. While enzyme-linked immunosorbent assay (ELISA) and similar immunoassay methods are frequently applied to examine biological specimens like urine and blood, there has been a significant uptick in research utilizing ELISA for assessing pharmaceuticals in intricate environmental samples in recent times. (Jaria *et al.*, 2020).

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RECENT DEVELOPMENTS IN DNA FINGERPRINTING

Article ID: AG-VO4-I07-27

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Introduction:

The blood sample is an important piece of evidence for personal identification, forensic analysis, and even reconstruction of crime scenes. In past decades, novel reagents (chemicals, new recent techniques, and advanced materials have emerged in the development of blood fingerprinting. It serves as forensic science efficiently. We can also determine age by using fingerprints. DNA typing is otherwise called DNA fingerprinting. It has been developing since the mid-1980s. It is used not only in crime investigation but evolved into a versatile discipline with a wide range of applications. The gene that used for the protein synthesis for only 2-6% of coding DNA involves while remaining 95% junk or non-coding DNA present in the cell which are otherwise called as repetitive DNA. The differences in the minisatellites pattern that are detected by a probe along with stable inheritance forms basis for DNA fingerprinting. It includes

- DNA sequencing technologies
- Mixture analysis
- Body fluid identification
- Phenotyping profiling
- Forensic genealogy
- Microbiological analysis
- Exploration of novel markers
- Ethical and legal consideration

These developments make it possible to analyse difficult samples and provide comprehensive insights into the origins of biological evidence. Forensic genetics now includes a broad range of applications for instance mixture analysis, body fluid identification, phenotypic profiling, rapid DNA analysis, forensic genealogy, and forensic microbiology. Advances in DNA sequencing technology have greatly impacted diverse fields for example genomics, forensics and medicine. The field of DNA sequencing technology rapidly developed since the completion of HGP (2003). It is leading to various breakthroughs and innovations. In forensics, one of the high-throughput sequence technology such as MPS, also known as NGS, the second-generation sequence has become an invaluable tool for the analysis of DNA evidence. Traditional Sanger sequencing method enables fast, parallel sequencing of millions of DNA sequencing/ fragments simultaneously and also greater sensitivity, specificity, and ability to deal with complex DNA mixtures.

PCR in Forensic Science:

The introduction of PCR into forensic science marked the beginning of a new era of DNA profiling. This era pushed PCR to its limits and allowed genetic data to be generated from trace DNA. Trace samples contain a very small amount of DNA associated with inhibitory compounds and ions. The PCR is a technique used to amplify the DNA by using a small amount of samples. There are five components required for amplification of DNA.

1. Deoxynucleotide triphosphate (dNTPs)
2. DNA polymerase
3. Template DNA
4. Primers
5. Buffer containing potassium and magnesium

The PCR programs involve three basic steps:

1. Denaturation
2. Annealing
3. Extension

Historical significance and advantages of PCR in forensic science:

1981 The entire human mitochondrial genome was sequenced known as Cambridge Reference Sequence CRS).

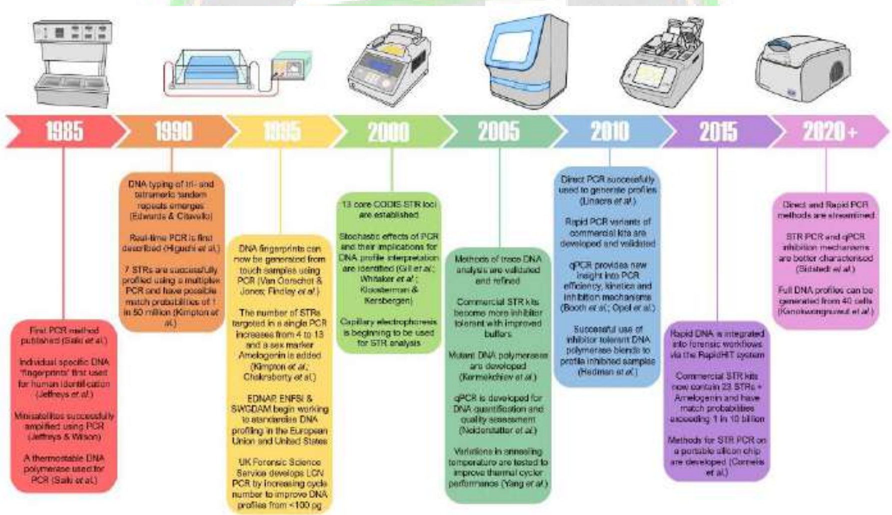
1985 **Jeffrey** used radioactive probes to identify minisatellites(VNTR) to solve disputed parental affairs.

1990 Initially, forensic science was conducted by using restriction enzymes that targeted hypervariable regions within the human nuclear and mitochondrial genomes which is called RFLP (Restriction Fragment Length Polymorphism)

1991 PCR is used to amplify two regions of the mitochondrial genome which are HV1 and HV2 from skeletal remains using oligonucleotide hybridization.

1993 AFLP is used as a marker for finding out the human major histocompatibility complex (MHC), also known as HLA or DQa.

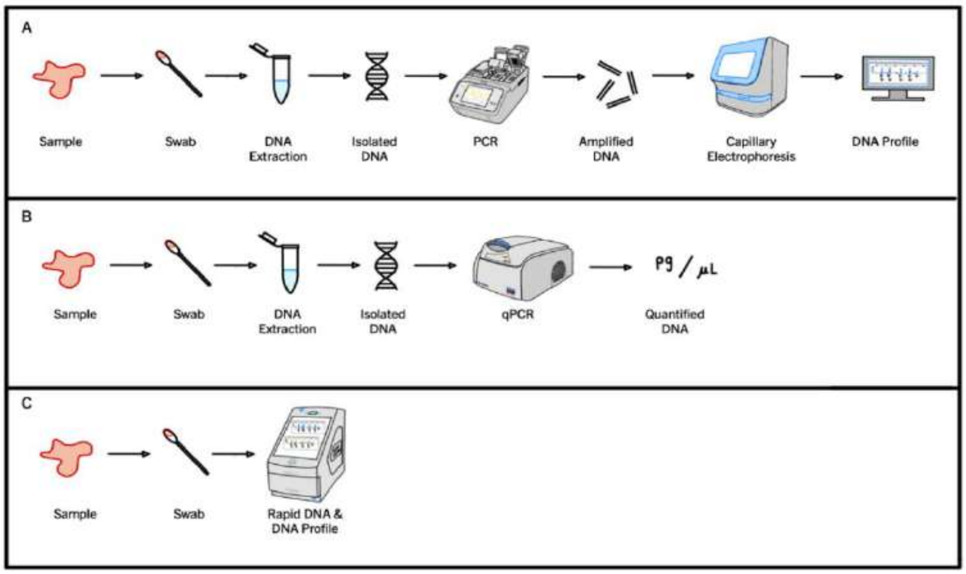
1994 STR analysis and mtDNA were used to identify the Romanor family in the Russian forest which is missing case has investigated by using forensic science.



DNA Fingerprinting in crop improvements:

Plant breeding is vigorously developing by using crop DNA fingerprinting because of its advantages in forensic science, research, dispute resolution and variety protection. Before coming to proteomic and technology, the varieties were detected using morphological markers. In the 20th century, protein-based markers were used for genetic diversity analysis in crops and DNA markers are mainly served for crop fingerprinting like RFLP, RAPD, SSRs, AFLPs, ISSRs, SNPs, and DAr (Diversity Array Technology). The upcoming innovations of crop fingerprinting are contingent to the creation of whole genome sequencing methods that are reasonable.

A comparison of the steps required to go from the initial crime scene sample to the final product via three different PCR methodologies: traditional PCR (**A**), quantitative PCR (qPCR) (**B**), and Rapid DNA (**C**).



DNA profiling and its role in forensic odontology:

DNA fingerprinting made DNA evidence most widely accepted in court. It has transformed the features of forensic odontology. DNA fingerprinting pushed a long way from conventional fingerprinting. DNA is liable for all the cells' transfer of information both healthy and disease-related. But it is very difficult to detect DNA while mass calamities or fire explosions, carbonization and dissolutions, teeth consist a rich content of DNA. It has high physical and chemical resistance. It is served for the detection and determination of disaster victims and involves comparing related antemortem data available with their post-mortem reports. DNA profiling is the only reliable and responsible method for identifying when ante mortem data are not available.

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SOPHOROLIPIDS FROM YEAST: A GREEN PATHWAY FOR SUSTAINABLE AGRICULTURE TRANSFORMATION

Article ID: AG-VO4-I07-28

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Abstract

Sophorolipids, known biosurfactants produced by yeasts, offer versatile applications spanning from nanomaterials, medicine and cosmetics to larger-scale uses like cleaning and soil remediation. Due to their environmentally friendly attributes, they have attracted substantial attention as a sustainable and ecological substitute for petroleum-based surfactants. Initially discovered by Gorin and his co workers in 1961, these compounds are created by nonpathogenic yeast species, primarily using osmophilic and non-pathogenic strains like *Candida bogoriensis*, *Candida apicola*, *Starmerella bombicola*, *Candida bombicola* and *Wickerhamiella domericqiae*. Their potential applications encompass wound healing, cosmetic formulations, anticancer and antimicrobial agents, food preservation, management of food waste and agricultural practices.

Introduction

Sophorolipids, the intricate glycolipid biosurfactants, combine a hydrophilic sophorose unit with a hydrophobic fatty acid tail. These biosurfactants are classified as secondary metabolites, synthesized during the latter stages of fermentation—both at the tail end of the exponential phase and the outset of the stationary phase. Their production involves a single hydrophilic carbon source (such as carbohydrates) or in conjunction with hydrophobic sources (including lipids, hydrocarbons, vegetable oils or animal fat). The remarkable biodegradability and low toxicity of sophorolipids have spurred extensive exploration of their potential as biosurfactants. They find applications in diverse realms, reducing surface and interfacial tension, enhancing hydrocarbon dissolution rates, facilitating solubilization and absorption of compounds. Among natural biosurfactants, sophorolipids stand out as exceptionally promising. Their multi-faceted biological activities encompass antimicrobial, anticancer, antiviral and immunomodulatory properties, adding to their allure and potential for a wide array of applications.

Utilization of sophorolipids

The utilization of *Starmerella bombicola* yeast species for the production of sophorolipids has gathered significant interest across various industries, including cosmetics, pharmaceuticals, food and health sectors. This keen interest can be attributed to the diverse range of active substances they offer, derived from sources like carbon sources such as glucose and fatty acids. These active substances are invaluable for applications in these industries, contributing to the development of novel and effective products. One of the standout features of sophorolipids is their inherent status as natural compounds. This characteristic holds considerable importance, especially in the context of their application in products intended for personal care, health and consumption. Natural compounds are generally perceived as having a reduced likelihood of causing undesirable side effects, thus adding to their appeal and making them a focal point of ongoing research and development efforts. This aspect aligns well with the increasing consumer preference for natural and safe ingredients in various consumer goods.

Furthermore, sophorolipids synthesized by non-pathogenic yeast species have attracted significant attention within the scientific community and industries alike. The non-pathogenic nature of the yeast species used in their production contributes to the overall safety profile of the resulting sophorolipids, making them even more attractive for integration into products intended for human use or consumption. As a result, these sophorolipids have emerged as a subject of intense exploration and experimentation, with their potential impact and applications continuing to expand across multiple sectors. Yeast-derived biosurfactants present a range of advantageous properties, including resistance to high temperatures, antioxidant capabilities and a lack of pathogenic risk. These attributes underscore their potential for meaningful integration into food formulations, holding promise for various applications within the food industry.

Sophorolipids, the prominent class of biosurfactants, are primarily synthesized by non-pathogenic yeast strains encompassing *Candida batistae, C. apicola, Starmerella bombicola, Rhodotorula bogoriensis, Wickerhamiella domercqiae* and *Rhodotorula babjevae*. In particular, sophorolipids exhibit remarkable commercial value due to their higher production yields compared to other types of glycolipid biosurfactants. Their versatility extends to various applications, including their antimicrobial potential against a diverse range of bacterial and fungal pathogens. This is achieved through mechanisms like increased permeabilization and destabilization of microbial membranes.

Biosynthesis of sophorolipids

Biosurfactants, classified as secondary metabolites, are synthesized in the presence of oxygen, typically during the stationary phase of microbial growth. Their production is initiated by nitrogen deficiency and depletion of phosphates in the growth medium, often independent of microbial growth and development. The metabolic preferences for biosurfactant production lean toward glucose and oleic acid as the favoured sources. Among the various organic and inorganic nitrogen sources investigated, yeast extract emerges as the most effective source due to its comprehensive nutrient and mineral composition. Exploring alternative substrates for sophorolipid production has resulted in several promising options which encompass animal fat, used cooking oil, agricultural residues such as wheat and rice straw, cane molasses, maize meal, potato, soybean, corn husk and sugarcane bagasse.

Multi-functional role of Sophorolipids

Addressing specific agricultural challenges, sophorolipids have proven effective against key fungal pathogens such as Fusarium, Colletotrichum, Aspergillus and Botrytis. These pathogens are responsible for causing substantial damage to stored fruits, grains and vegetables. Fusarium, for instance, leads to the characteristic yellow and orange sporulation in fruits. Colletotrichum, on the other hand, poses a significant post-harvest threat to fruits like mango, papaya, avocado, citrus and apple. Given the concerns associated with the continued use of agrochemicals for disease control, the adoption of alternative solutions like yeast-derived biosurfactants has gained attention. This shift towards more sustainable and environmentally friendly approaches aligns with the imperative of ensuring both the safety of our food and the protection of our ecosystem.

Sophorolipids demonstrate a high degree of suitability for agricultural applications, particularly as agents that enhance the solubility and mobility of essential plant nutrients leading to enhanced crop growth, biomass, root growth and consequently, the yield. Moreover, their utility extends to areas such as biodegradation of oils, the bioremediation of soils contaminated with heavy metals and their potential role as biopesticides for managing phytopathogens in crop cultivation. The prevalent use of chemical pesticides has led to the emergence of challenges like widespread insecticide resistance and concerns over their elevated toxicity, posing risks to both human health and the environment. Consequently, the introduction of innovative biomolecules capable of disease control and crop yield enhancement has gained significant attention as a compelling alternative.

Sophorolipids, with their multifaceted properties and environmentally friendly attributes, offer a promising solution to these pressing issues in modern agriculture. Their potential application as enhancers of nutrient availability, as well as their ability to address soil contamination and phytopathogenic challenges, underscores their role in revolutionizing agricultural practices towards greater sustainability and effectiveness.

Sophorolipids as Bio-surfactant in Agriculture

Incorporating sophorolipids into agricultural practices can offer a sustainable and effective means of combatting plant diseases while promoting plant growth and yield. Due to their demonstrated antimicrobial effectiveness against phytopathogenic bacteria and fungi, sophorolipids hold potential for wide-ranging application in agriculture as a natural and sustainable agent for plant crops and soils. Although synthetic pesticides have emerged for the management of crop diseases, their chemical surfactants, which enhance their efficacy, are recognized as organic pollutants due to environmental and health concerns. In light of these challenges, researchers are exploring alternatives, with biosurfactants gaining attention for their eco-friendliness and dual roles as adjuvants and active agents. Sophorolipids exhibit antimicrobial activity through their amphiphilic nature, inducing a surfactant effect that disrupts pathogen membranes, reducing tension and promoting permeability changes. These properties could enhance the efficacy of pesticides and herbicides. Additionally, sophorolipids have shown promise as postemergence herbicides, enhancing plant cuticle permeability. Sophorolipids' antimicrobial potential against phytopathogenic microorganisms like *Pythium ultimum* and *Fusarium oxysporum* has also been documented.

Sophorolipids for bioremediation

Biosurfactants have emerged as a highly promising and environmentally friendly alternative for bioremediation efforts. They offer a dual advantage by facilitating the biodegradation of contaminants while also catalyzing their self-degradation. Additionally, these biomolecules play a crucial role in enhancing the activity of microorganisms, thereby boosting the decomposition of pollutants. The effectiveness of biosurfactant-assisted bioremediation largely hinges on their unique mechanism. These compounds have the capacity to form complexes, known as micelles, with metals. This interaction elevates the solubility and bioavailability of these metals within the soil solution, setting the stage for enhanced remediation processes.

Sophorolipids, in particular, have realized significant attention in the solubilization and emulsification of hydrophobic contaminants of petroleum derivatives and oil. Furthermore, they contribute to the removal of heavy metals such as chromium, lead, zinc, copper, cadmium, iron and mercury, along with aiding in the mitigation of pesticides present in aqueous phases. This multifaceted action positions sophorolipids as a highly versatile and effective tool for addressing diverse environmental contamination challenges through bioremediation strategies.

Conclusion

Sophorolipids are in limelight in recent decades due to their remarkable bioactive properties, notably their ability to lower surface and interfacial tension, as well as their capability in emulsification and solubilization processes. Notably, sophorolipids exhibit non-toxic attributes, exceptional efficiency and stability under extreme conditions. Additionally, they boast environmentally friendly characteristics that set them apart from conventional chemical surfactants. In the realm of soil bioremediation, sophorolipids offer a potential avenue for a more sustainable approach to contaminant removal. Their versatility extends to effectively addressing a range of pollutants, including heavy metals, hydrocarbons, oils and antibiotics. As a result, their integration into bioremediation strategies holds promise for creating a greener and more effective approach to tackling environmental contamination challenges.

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VIRUS MEDIATED GENE SILENCING: A POWERFUL TOOL FOR FUNCTIONAL GENOMICS

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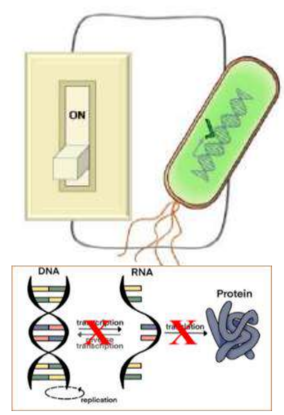
Abstract

Virus-induced gene silencing (VIGS) is a useful technique for examining gene function in plants. VIGS application is predicted to be useful in the future for the functional analysis of numerous genes due to the expanded discovery of gene expression variations under various biological circumstances. VIGS has demonstrated itself as a sophisticated instrument for functional characterizing genes linked to changes caused by environmental stress during the past few years. Here, we give a summary of how VIGS is utilized in several kinds of crops to identify genes linked to illness. We present instances from investigations in which VIGS is utilized to examine genes associated with stress caused by abiotic factors. We also outline the main benefits of VIGS over other functional genomics technologies that are already on the market. We provide an overview of the latest developments in VIGS and its drawbacks as a tool for researching how plants react to both abiotic and biotic stresses.

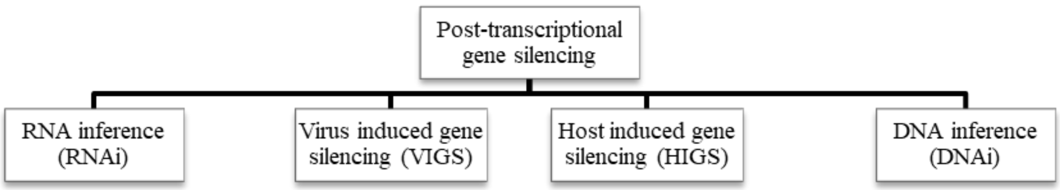
What is gene silencing?



It is known as "turning off," or the disruption or reduction of gene expression. Although gene silencing and gene knockdown are sometimes confused, they are not the same. Genes that are knockdown have reduced expression, but genes that are knockout have no expression at all since they have been entirely removed from the organism's DNA. Natural gene silencing takes place at the transcriptional or post-transcriptional levels.

There are two different types of gene silencing:

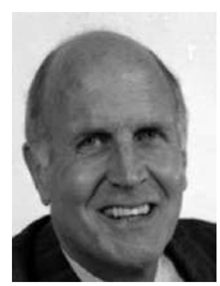
1) Transcriptional gene silencing
2) Post-transcriptional gene silencing



What is Virus-Induced Gene Silencing?

It is the recombinant viral vector-induced silencing of indigenous gene expression in plants or VIGS. If the sequences of the virus and a transgene or an indigenous nuclear gene are identical, VIGS occurs in crops. Many pieces of evidence [Lui *et al*., 2016; Smith *et al*., 2006; Vaucheret *et al*., 2001] suggest that PTGS evolved as a plant antiviral route. In other plant species, viruses can cause PTGS on their own [Smith *et al*., 2006; Marathe *et al*., 2000]. In response to plant defense, viruses have developed proteins that can function as PTGS inhibitors [Smith *et al*., 2006; Voinnet, 2001].

Using viral vectors bearing a desired gene fragment, VIGS is a forward and reverse genetics method for examining the function of genes. It produces dsRNA, which initiates RNA-mediated gene silence. It entails the development of virus with sequences that match the host's gene that has to be suppressed. Viral dsRNA manufacturing is triggered by infection and is a necessary stage in the viral replication process. This causes the target gene to be down-regulated by turning on the anti-viral RNA silencing mechanism.


Albert van Kammen
(Dutch molecular biologist & Virologist)

A good vector for virus-induced grafting (VIGS) must be capable of infecting the host plant and spreading quickly and evenly across its meristematic zones. Furthermore, it shouldn't result in any potent silencing inhibitors. Ab. van Kammen used the word "Virus-Induced Gene Silencing" (VIGS) to refer to the process of viral infection recovery. The first modified virus that uses VIGS techniques on plants is the tobacco mosaic virus (TMV). Numerous DNA and RNA viruses found in plants have been altered to serve as vectors for virus-induced gene silencing (VIGS) in a variety of dicot plant species (Senthil-Kumar and Mysore, 2011; Huang *et al*., 2012).

Several plant viruses, including tobacco rattle virus (TRV), potato virus X (PVX), and tobacco mosaic virus (TMV), have been utilized to create VIGS vectors.

Procedure of VIGS

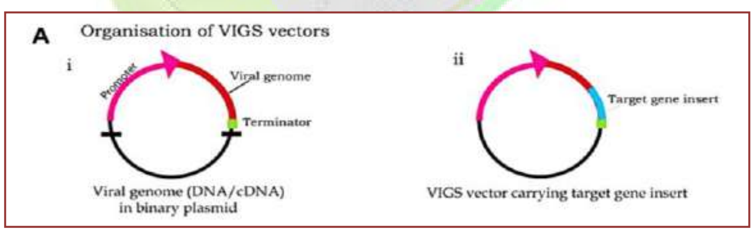
Cloning a 200–1300 bp cDNA fragment from a plant gene of interest into a DNA copy of the genome of an RNA virus. Engineering a viral vector that carries a segment of the desired gene's sequence. Generally obtained from a plant virus that naturally infects plants but is modified to be non-pathogenic or weakly pathogenic. The modified viral vector is then introduced inside cells of the plant, frequently from mechanical inoculation or by agroinfiltration, in which the viral vector is introduced into the tissues of plants via a bacterial transporter. Transfecting the plant with this construct using Agrobacterium. During viral replication, double-stranded RNA from the viral genome, consisting of a sequence from the gene of interest, is formed. The plant enzymes that resemble dicers break down the dsRNA molecules into siRNA molecules. The host tissue's RNA silencing pathway is started by this procedure.

Structure, mode of inoculation and mechanism of VIGS

The following is a diagrammatic summary of Purkayastha and Dasgupta's 2009 VIGS protocol.

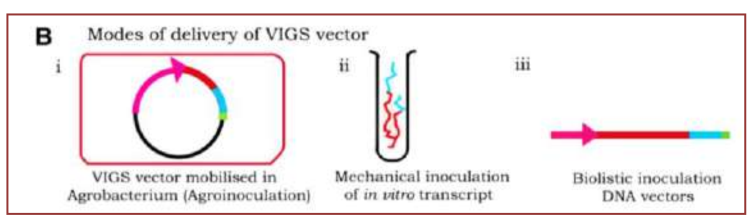
A. DNA-based VIGS vector

i) Genome of DNA virus or cDNA of RNA virus driven by the constitutive promoter and
ii) VIGS vector carrying target insert



B. Modes of inoculation of VIGS vectors

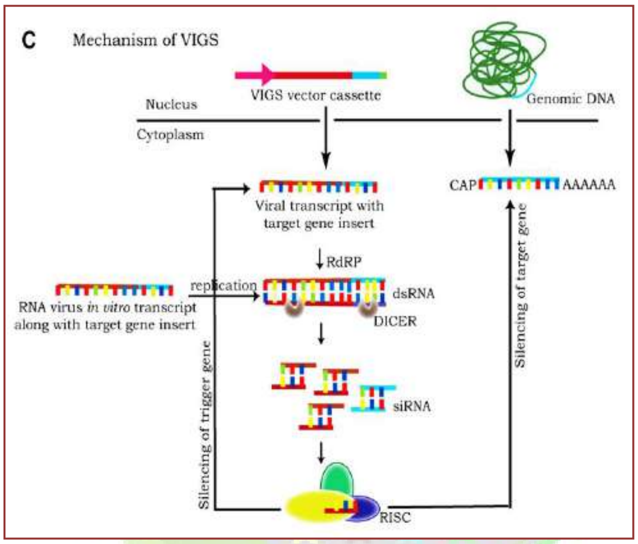
The target insert carried by the VIGS vector was converted into Agrobacterium, that was then able to function when injected into plants. By mechanical transmission, specific insert-carrying RNA virus transcripts can be injected



into plants in the laboratory. By using biolistic bombardment, promoter-insert-terminator structures can be inserted into plant tissues.

C. Mechanism of VIGS

RNA silencing is initiated by the host amplifying viral transcripts and replicate intermediates of RNA viruses that originate from DNA-based vectors to dsRNA. After processing, dsRNA is converted into siRNAs, which function as the guide molecules. The multiprotein effector complex (RISC) is loaded with a single guide strand of siRNA. Target transcripts are degraded by RISC through siRNA as a guiding component.



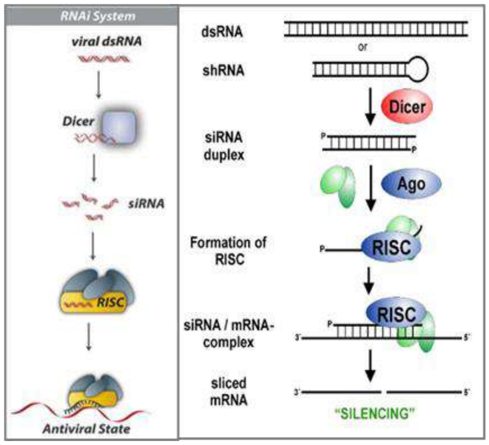
Key steps involved in virus-related RNA silencing

1) **Dicer:** Small interfering RNAs (siRNA) are created when the endonuclease enzyme dicer breaks down and splits dsRNA.

2) **RISC** (RNA-induced silencing complex) is created by endonuclease + siRNA + AGO2 protein (PAZ & PIWI domains).

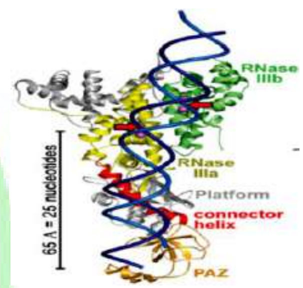
3) The RNAi machinery is directed to the desired mRNA by the unwind siRNA base pairs binding with complementary mRNA.

4) Gene silencing is achieved through the efficient cleavage and subsequent degradation of the target mRNA.



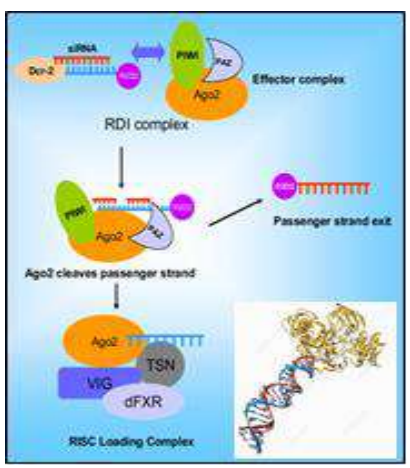
1. Dicer or Dicer-like Protein

Bernstein *et al*. (2001) made the initial discovery of dicer in Drosophila. The primary enzyme that starts the RNA-silencing process is the dicer. It is a dsRNA-specific endonuclease that cleaves target dsRNAs into fragments of 21–24 nts. It resembles Ribonuclease III. The dicer enzyme uses an ATP-independent chopping mechanism. Plant proteins that resemble dicers, DCL 1, DCL 2, DCL 3, and DCL 4.

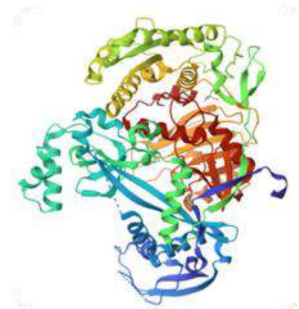


2. RNA Induced Silencing Complex (RISC)

First discovered in Drosophila by Hammond *et al.* (2000). Two types of effector complexes *viz*., cytoplasmic and nuclear complexes have been described for the induction of RNA silencing.



3. Argonaute (AGO) protein



These are very basic, 100 kDa proteins with PAZ and PIWI domains. The PAZ domain makes it easier to attach to the Dicer complex. Endonucleolytic activities are caused by PIWI domains (Hammond et al. 2000). To control gene expression, particular classes of short regulatory RNAs can be transported by particular Argonaute proteins to various cellular compartments.

Table 1: Viruses used to develop VIGS vectors and the genes silenced (Purkayastha & Dasgupta, 2009)

Virus/satellite	Important natural hosts	Silenced hosts	Genes silenced
Cucumber mosaic virus	Cucurbits, *S. lycopersicon*, *Spinacia oleracea*	*Glycine max*	*chs, sf30h1*
Potato virus X	*Solanum tuberosum*, *Brassica campestris sp. Rapa*	*N. benthamiana*, *Arabidopsis thaliana*	*gus, pds, DWARF, SSU, NFL, LFY*
Tobacco mosaic virus	*Nicotiana tabacum*	*N. benthamiana*, *N. tabacum*	*pds, psy*
Tobacco rattle virus	Wide host range	*N. benthamiana*, *A. thaliana*, *S. lycopersicon*	*pds, rbcS, FLO/LFY (NFL)*
Turnip yellow mosaic virus	Brassicaceae	*A. thaliana*	*pds, lfy*

Advantages of gene silencing

- It enhances target gene expression downregulation.
- It prevents the expression of harmful substances and genes.
- Inducing viral resistance
- A powerful tool for analyzing unknown genes in sequenced genomes.
- Useful approach in future gene therapy.

Disadvantages of gene silencing

- It is possible for "high-pressure injection" and electroporation to seriously compromise the integrity of healthy tissues and organs.

- Additionally harmful to the body, liposomes and cationic encapsulated siRNA have the potential to trigger strong host immunological reactions.
- Other cutting-edge approaches, like encapsulation with distinct molecules and chemical modification of siRNA molecules, are still in developmental stages and require more research before being employed in therapeutic applications.
- The efficacy of VIGS can be influenced by various empirical elements, like as temperature, light, and plant age. Expression is difficult, time-consuming, and in some cases, unachievable for certain species.

Conclusion

This led us to the conclusion that one of the reverse genetical techniques for the examination of gene function is virus-induced gene silencing (VIGS), which employs viral vectors containing a specific gene fragment to create dsRNA that initiates RNA-mediated gene silence. Consequently, gain popularity as a technique for plant functional genomics. Molecular scientists and plant virologists are working to create novel VIGS vectors that target specific genes in target plant species, as well as modifying current vectors to expand their host range and improve silencing effectiveness. Additionally, a number of viruses have been altered to efficiently and sequence-specifically suppress the target gene.

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OPTIMIZING NITROGEN UTILIZATION IN DIVERSE AGRICULTURAL LANDSCAPES

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Abstract

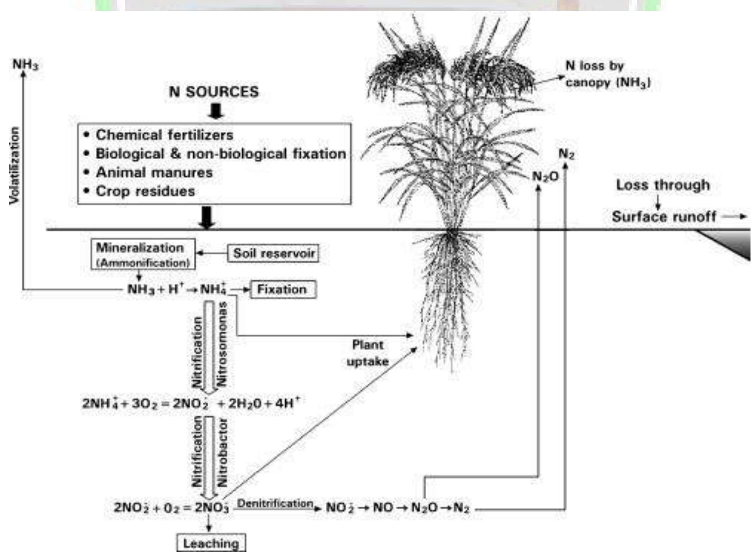
Even though nitrogen is the most common element in the atmosphere, it poses a contradictory problem for farming. Although plants need a lot of resources, only a tiny portion is easily accessible for adoption. Since most organisms cannot use nitrogen as majority of it exists as inert dinitrogen gas (N_2). But then things change, changing it into more reactive forms like ammonium (NH_4^+) and nitrate (NO_3^-). Due to their high mobility in water and air, these forms have the potential to cause losses in soil through leaching, runoff, volatilization, and denitrification in both lowland and highland environments. Minimizing environmental losses and achieving ideal crop growth depends on efficient nitrogen management. This calls for the application of several techniques to improve Nitrogen Use Efficiency (NUE).

Introduction

Food and Agriculture Organization (FAO) data indicates an alarming tendency in the world's population growth surpassing the amount of arable land available. The increasing strain on agricultural resources calls for a change in perspective. Despite being effective at first, the Green Revolution's reliance on applying more and more fertilizer—especially nitrogenous fertilizer—has shown to be unsustainable. Increasing Nutrient Use Efficiency (NUE) through efficient agricultural input management is the current problem. Nitrogen helps plants grow by creating proteins and enzymes that support photosynthesis via chlorophyll and serves as the building block for both DNA and RNA.

A pale green or light color is the first sign of a nitrogen shortage. Aging leaves may exhibit yellowing (chlorosis), particularly at the tips. In extreme situations, this leads to leaf death and/or dropping. This occurs as a result of nitrogen being transferred to younger leaves from older ones to emphasize new growth (Uchida, 2000). Over-abundance of nitrogen can cause hypertrophy, or excessive leaf growth, together with inward-moving necrosis (tissue death) and marginal chlorosis (yellowing at the margins). This is correlated with a decline in stature and an elevated vulnerability to viral invasion.

In terms of parent material, particle size distribution, and soil aeration, uplands and lowlands are in opposition to one another. Lowland soils, which originate from alluvial deposits, have finer textures that are mostly composed of silt and clay fractions (less than 50% sand). Better water holding capacity (WHC) exceeding 40% by weight is a result of this fine texture. However, it also inhibits drainage, which promotes reducing conditions with little oxygen available for plant roots (low redox potential, Eh < 300 mV). On the other hand, highland soils have coarser textures and are more than 50% sand-rich. They originate from weathered bedrock. Better drainage and oxidizing conditions (high Eh > 500 mV) with plenty of oxygen availability for aerobic organisms are made possible by this coarseness.

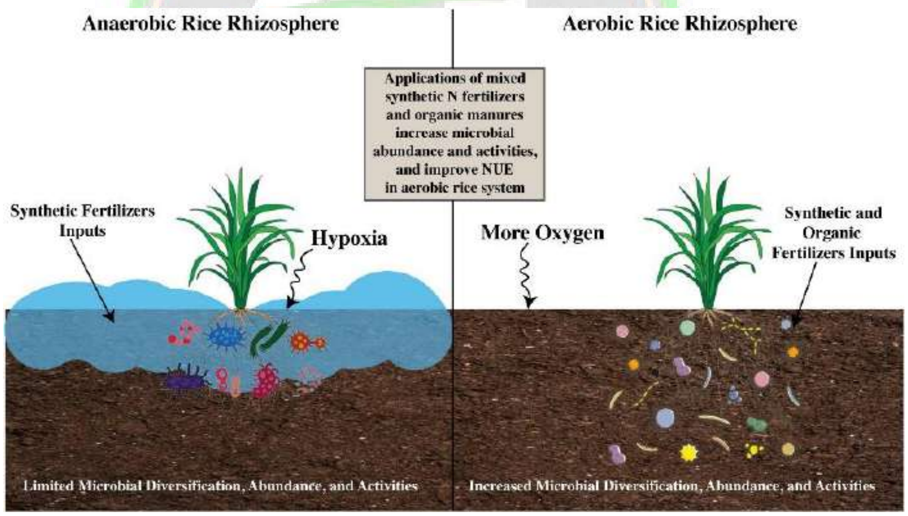


Nitrogen dynamics in upland soils

Microbial mineralization, immobilization, nitrification, denitrification, plant uptake, and leaching are all aspects of nitrogen dynamics in upland soils. Organic nitrogen is broken down by microbes into ammonium, which has the ability to momentarily immobilize. Ammonium is converted to nitrate by nitrifying bacteria, which increases leaching risk but improves plant accessibility. Nitrogen is lost during denitrification, which changes nitrate into gaseous forms in anaerobic environments. While leaching can result in nitrate loss through water movement, plants are able to absorb nitrogen.

Nitrogen dynamics in lowland soils

Limited diffusion through floodwater causes oxygen (O_2) in flooded rice fields to be depleted, resulting in a two-layered soil profile. Oxygenated by ambient O_2, the top layer is responsible for supporting oxidative chemicals and mineralizing organic nitrogen to form nitrate (NO_3). In response to the addition of ammonium (NH_4+) fertilizers, NH_4+ may volatilize, migrate to the lower reduced layer, or experience nitrification. Because there is no oxygen in the reduced layer, organic nitrogen mineralization stops at NH_4+. In oxidized root zones, NH_4+ can accumulate, be absorbed by plant roots, or go through nitrification. The reduced layer's nitrate acts as a faculty anaerobe's electron acceptor when it is denitrified to produce gaseous nitrogen forms.



Strategies for Enhanced NUE

Split application: To maximize crop nutrition, it uses a tailored delivery technique. By coordinating nitrogen availability with times of high crop demand throughout crucial growth stages, this strategy reduces pre-plant volatile N losses (ammonia gas) and post-plant leaching or denitrification (conversion to useless forms). Timing fertilizer availability with crucial growth stages for optimum uptake improves the efficiency of nitrogen utilization.

In-depth positioning:

Rice yield is maintained by deliberately reducing the administration of urea-N (20–40%) using deep-point USG implantation. It reduces floodwater and surface soil NH_4^+ concentration by dispersing 1-2 g USG(Urea super granules) at 5–10 cm depth (anaerobic zone), which inhibits ammonia volatilization, denitrification, and weed N absorption. This increases rice's bioavailable N and might increase BNF because it reduces NH_4^+ in floodwater. Nevertheless, careful consideration of the soil's characteristics (low percolation rate, CEC > 10 cmol (+) kg^{-1}) and varietal selection (short- to medium-duration cultivars recommended) is required for better utilization of Nitrogen by the crop species.

Fertigation:

Using irrigation systems to apply fertilizers provides a precise means of managing nutrients, increasing NUE by as much as 30% in comparison to conventional techniques. Through tailored distribution, nutrient losses from leaching (washout by precipitation), fixation (reactions with soil particles), and volatilization (ammonia gas escape) are minimized. Furthermore, fertigation makes it easier to regulate the release of nutrients during the growing season, coordinating treatment with crop requirements at particular phases.

Foliar application:

This method avoids the soil and the losses that come with leaching, denitrification, and volatilization by supplying nitrogen (N) directly to plant leaves. Direct foliar absorption improves N uptake efficiency with this focused strategy. While foliar N can directly increase a plant's capacity for photosynthesis and enzyme activity, it should be used in conjunction with a balanced fertilization program.

- **Specialty fertilizers:**

A. Slow release:

These fertilizers provide controlled nitrogen delivery via two primary methods: natural and synthetic. For progressive release, synthetic alternatives (such as coated urea and IBDU) use regulated chemical processes or physical barriers. Natural solutions, such as blood meal and compost, depend on a slower rate of microbial breakdown in the soil to minimize nutrient loss and maximize plant uptake during the growing season.

B. Nitrification inhibitors:

These agents use specific techniques to maximize the efficiency of the utilization of nitrogen

The action of Nitrosomonas bacteria is directly inhibited by synthetic alternatives such as Dicyandiamide (DCD) and 3,4-Dimethylpyrazolephosphate (DMPP), which limits the conversion of ammonium (NH_4+) to nitrate (NO3-). Leaching and denitrification losses are reduced as a result. Natural substitutes, such as brassicaceous green manures or neem cake, may have a more indirect effect on nitrification by altering soil microbial communities or the surrounding environment.

C. Inhibitors of urease:

Urea-based urea inhibitors deliberately extend the effectiveness of fertilizers based on urea. The urease enzyme is directly neutralized by synthetic alternatives such as N-(n-butyl) thiophosphoric triamide (NBPT) and N-phenylphosphoric triamide (NPPT), which prevent urea from being converted to ammonia gas and its subsequent dissipation. There are no natural substitutes, however, research points to humic acids and neem cake, which is a nitrification inhibitor that may have modest inhibitory effects on the urease enzyme (found in compost).

- **Effective genotyping:**

Focused breeding initiatives have produced rice cultivars with observably higher nitrogen use efficiencies (NUEs). These include descendants from the NERICA project, which are recognized for their simultaneous drought resistance (typically indica/japonica hybrids), and high-yielding indica strains like Swarna. Similar to this, elite hybrids with superior NUE and other desirable traits, such as DKC 6085, have been generated through maize breeding. Notably, several Agronomic BioTech Quality Protein Maize (QPM) cultivars show simultaneous gains in grain protein content and NUE in maize species.

Site-Specific Nutrient Management (SSNM):

This method maximizes the delivery of nutrients to crops by encouraging a data-driven approach to fertilizer application. This method goes above and beyond the conventional uniform application by taking into account field-specific factors like planned crop production and soil fertility (as determined by analysis). The SSNM strategy's fundamental tenets include crop nutrient requirements for achieving the desired yield and indigenous nutrient supply (INS) from the soil. Applying manures and fertilizers as needed by the crop during its life helps regulate the nutrient gap or the discrepancy between the crop's nutrient requirement and INS. (Gorai et al., 2021). SSNM employs two primary methods,

A. Plant-based analysis:

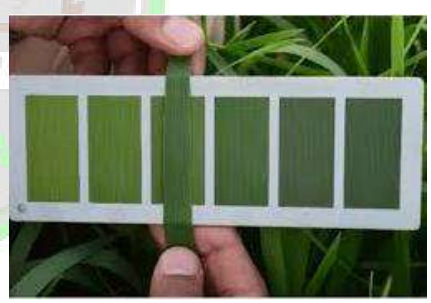
This technique calculates crop nutrient requirements by considering the crop's intrinsic and soil nutrient supply (INS). Then, when the plant responds, fertilizer treatment is dynamically modified throughout the growth cycle of the crop life span respectively.

Plant-Soil-Cum analysis:

This technique uses scientific analysis of plant and soil samples to produce site-specific fertilizer recommendations. These suggestions, which are frequently based on soil test crop response (STCR) or fertilizer adjustment algorithms, guarantee accurate fertilizer dosage to produce the desired yield.

Tools for assessing crop nitrogen (N) status, the **Leaf Colour Chart (LCC)** is an affordable and user-friendly substitute for pricey chlorophyll meters. With the use of this straightforward instrument, which is often a plastic strip with colored panels ranging from yellowish-green to dark green, farmers may determine the relative greenness of the leaves of wheat, rice, and maize. Farmers can determine whether nitrogen fertilizer application is necessary to prevent N deficiency in crops by comparing leaf color to the crucial LCC panel for their crop and variety.

The **SPAD chlorophyll meter** uses light transmission measurements at particular wavelengths to analyze leaf N status in order to determine nitrogen levels in a scientific manner. Nitrogen-containing and necessary for photosynthesis, chlorophyll affects SPAD (Soil Plant Analysis development) values. SPAD values indicate the amount of chlorophyll in a sample of leaves by measuring transmitted light at red and infrared wavelengths with and without a leaf sample.



Spectral reflectance is used by **canopy reflectance sensors**, such as GreenSeeker, to measure crop nitrogen levels. These instruments measure light reflection in the visible and near-infrared (NIR) wavelength ranges. The foundation of the NDVI, a crucial indication of crop health and nitrogen status, is enhanced NIR reflectance, which is seen in healthy,nitrogen-rich crops. These sensors recommend site-specific nitrogen treatment for efficient crop development while minimizing environmental impact by comparing data with reference sites that have received the ideal amount of fertilizer.

The Normalized Difference Vegetation Index (NDVI) can be calculated as follows:

NDVI = (NIR - Red) / (NIR + Red)

- **Soil test Crop response (STCR):**
  A strategy for recommending fertilizer that takes into account both the intended crop output and the innate fertility of the soil is called soil test crop response, or STCR-based management. It makes use of mathematical formulas designed for certain crops and soil types to calculate the amounts of fertilizer needed to get a target yield.
- **Precision agriculture:**
  Precision farming uses GPS receivers for georeferencing tasks, collecting data on soil quality and crop health, and optimizing nitrogen use. GIS software stores and analyzes data to create nutrient variability maps, directing fertilizer applications for optimized crop nutrition. Remote sensing techniques enable precision nitrogen management using spectral and thermal data. Yield monitoring systems use GPS and sensors to generate geo-referenced yield maps, informing decisions on nutrient uptake, profitability, and management zones. Variable Rate Technology (VRT) addresses field variability in fertilizer application using DGPS, pre-made maps, and variable-rate applicators.
- **Integrated Nutrient Management (INM):**
  A. **Integrated Sources:** Strategic fertilizer application based on testing reduces waste (CEC, N mineralization), while organic additives enhance soil health and retention. Soil nitrogen is further enhanced by biological nitrogen-fixing.
  B. **Improved Soil Health:** Less tillage, intercrops (legumes), cover crops, and organic amendments encourage the growth of helpful bacteria for effective N cycling.

- **Precise Application:** Plant uptake is maximized and losses (denitrification, leaching) are reduced by splitting fertilizer application and band placement.

  Handling the five R's:

  The potential of the cultivars, the timing, technique, pace, and supply of N fertilization all affect, how efficiently N is used (Shukla et al., 2012). The fertilizer application is optimized for increased agricultural productivity and sustainability by following the 5 R's: Right Source, Right Rate, Right Time, Right Placement, and Right Method. (Shukla et al., 2004; Shan et al., 2008)

Conclusion

In conclusion, understanding nitrogen dynamics in agricultural ecosystems is pivotal for effective management and sustainable development. By grasping the intricate interplay of nitrogen fixation, mineralization, leaching, and denitrification processes, we can optimize fertilizer use, enhance crop productivity, and minimize environmental impacts. Ultimately, integrating scientific insights with practical management strategies ensures that nitrogen remains a valuable resource in sustaining food security and environmental stewardship for future generations.

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LANTANA CAMARA LINN. : INVASIVE WEED PLANT AS A BOTANICAL NEMATICIDE

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Abstract

Microscopic vermiform plant parasitic nematodes are one of the most dangerous pests that infest and induce heavy yield loss in plants. To control the plant parasitic nematodes chemical nematicides are available but they are not safer thing for the environment and human health. In this concern, botanical nematicides are one of the best methods for the management of plant parasitic nematodes. Among many plant species, 57 families have been reported for its nematicidal properties. Hence, *Lantana camara* is one of the plant reported that they have the nematicidal properties like lantanoside, lantanone, linaroside, Coumaric acid in that aerial portion and phenolic compounds and hydrogen cyanide in their root portion.

Introduction

Nematodes are one of the devasting pests that infest and induce heavy yield loss in many world crops. The nematode control in a safer mode is a necessary step for protecting the health of the soil and environment. Hence, organic additives play a major role in improving soil's physicochemical properties, soil structure, temperature, and relative humidity, which are worthy for plant development. In this aspect, the plant extracts are also a key organic additive because they have many secondary metabolites in their parts. Those organic amendments will improve the soil conditions such as temperature, pH, salinity, oxygen, etc. which are unsuitable for nematode population build-up. Also, they are safer for the environment (El-Deriny *et al.*, 2020). In this point, the plant extract is one of the outstanding alternative control methods for plant parasitic nematodes. Plant extracts containing various bioactive allelochemical components like phenols, organic acids, terpenes, terpenoids, coumarin-like compounds, and other secondary metabolites are reported as nematicidal activity (Muller and Gooch, 1982). Among many plant species, 57 families have been shown to have nematicidal compounds (Sukul, 1992). Among them, the *Lantana camara* is a flowering plant belonging to the Verbenaceae family and native to America. It became an invasive weed plant in India. But this plant has medicinal properties such as antimicrobial activities, cytotoxic activity, antifertility, antifungal activity, anti-inflammatory activity, antimotility activity, antidiabetic activity, larvicidal activity, antioxidant activity, wound healing activity and hepatoprotective activity (Kalita *et al.*, 2012). Also, the *L. camara* has reported for its nematicidal activity of plant parasitic nematodes. Chemical constituents like lantanoside, lantanone, linaroside, and Coumaric acid were found in nematicidal compounds from the aerial parts of *L. camara.* The roots of *L. camara* contains phenolic compounds and hydrogen cyanide which showed nematicidal activities (Shaukat *et al.*, 2002).


Different colored flowers of *Lantana camara*

Nematicidal properties of leaves of *L. camara*

Qamar *et al.* (2005) referred to the natural nematicidal products from the aerial parts of *L. camara.* They stated the presence of Lantanilic acid, camaric acid, and oleanolic acid possessing nematicidal activity against root-knot nematode and exhibited 98%, 95%, and 70% mortality of the same nematode. Various concentrations of aqueous leaf extract of *L. camara* L. were tested against second stage of root-knot nematode juveniles by Ganesh Ghimire *et al.* (2015) for its nematicidal potential studies as *in-vitro* conditions. They found the leaf extract (50% concentration) of *L. camara* effectively immobilized the second-stage root-knot nematode juveniles in 48 hrs. 100% of leaf extract was found highly nematostatic against *Meloidogyne* spp. at the rate of 98.66% mortality in 48 hrs. Mahloatjie Malahela *et al.* (2021) reported the fermented plant parts of *L. camara* efficacy against *Meloidogyne javanica.* The pot culture studies give the reduced nematode population after 8 weeks of application of fermented plant parts but this must be validated in field trails.

Nematicidal properties in roots of *Lantana camara:*

The root leachate of *L. camara* contains phenolic compounds like *p*-hydroxybensoic acid, vanillic acid, caffeic acid, ferulic acid, and quercetin glycoside. It also contains hydrogen cyanide as a weak enzyme. These chemical constituents serve as a nematicidal property of the roots of *L. camara*. Hence, Shaukat *et al.* (2003) studied the nematicidal activity of *L. camara* roots against the plant parasitic nematode *Meloidogyne javanica*. Finally, they reported the high concentration of root exudates caused substantial mortality of the *M. javanica* juveniles also it retarded the plant height and shoot fresh weight but the diluted concentrations actually enhance the plant growth. Root extract was significantly decreasing the egg hatching of root-knot nematode. The percentage of reduction of egg hatching were 23.38,49.24, 66.16 and 76.47% at the concentration of 500, 1000, 2000 and 4000 ppm respectively compared to control was reported by Haroon *et al.* (2018).

Conclusion

Based on the above studies the *L. camara* plant parts can minimize the nematode population and improve the plant growth when applied at low concentrations. These experiments provide enough informations about the nematicidal activities of *L. camara* plant at laboratory experiments. Hence, the need of field evaluations is required for the nematicidal acitivites of *L. camara*. Thus, I conclude the paper for further investigations, formulations of *L. camara* have to do and develop the application methods also needed for the management of plant parasitic nematodes.

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ANTIVITAMINS, THEIR ROLES AND MODE OF ACTION

Article ID: AG-VO4-I07-32

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Introduction

An antivitamin is a substance that interferes with the function or utilization of a specific vitamin. This interference can occur in various ways, such as by blocking the vitamin's absorption, inhibiting its activity, or promoting its degradation. Antivitamins can be naturally occurring or synthetically produced.

Here are some examples of antivitamins and how they work:

1. **Avidin**: Target vitamin - Biotin (Vitamin B7)
   Found in raw egg whites, avidin binds to biotin and prevents its absorption in the digestive tract. Cooking egg whites denatures avidin, rendering it inactive and allowing biotin to be absorbed.
2. **Dicoumarol and Warfarin**: These compounds act as antivitamins for vitamin K. They inhibit the enzyme vitamin K epoxide reductase, which is necessary for recycling vitamin K in the body. This inhibition reduces the activation of vitamin K-dependent clotting factors, leading to anticoagulant effects.
3. **Thiaminase**: Target vitamin - Thiamine (Vitamin B1)An enzyme found in certain fish, shellfish and plants that destroys thiamine (vitamin B1). Consuming large amounts of thiaminase-containing foods without adequate thiamine intake can lead to thiamine deficiency.
4. **Pyrithiamine**: Target vitamin - Thiamine (Vitamin B1)

A synthetic antivitamin that mimics thiamine but inhibits thiamine-dependent enzymes, leading to symptoms of thiamine deficiency. It is often used in research to study thiamine deficiency and related metabolic processes.

5. **Antifolates**: Target vitamin - Folic Acid (Vitamin B9)

   Compounds like methotrexate and aminopterin that inhibit dihydrofolate reductase, an enzyme involved in the conversion of folic acid to its active form. This inhibition disrupts DNA synthesis and cell division, making it useful compounds in cancer therapy and certain autoimmune diseases.

6. **Isoflavones:** Target vitamin - Vitamin D

   Studies suggest that isoflavones, found in soy products, can interfere with vitamin D metabolism, though the clinical significance of this effect is still under investigation. (e.g., Genistein)

7. **Hydroxythiamine:** Target vitamin - Thiamine (Vitamin B1)

   Hydroxythiamine is a thiamine analog that competes with thiamine for binding to thiamine-dependent enzymes, thus inhibiting their activity.

Modes of action for antivitamins:

Antivitamins exert their effects through various mechanisms, depending on the specific vitamin they target. Here are some common modes of action for antivitamins:

1. Inhibition of Absorption

- **Example**: Avidin
- **Target Vitamin**: Biotin (Vitamin B7)
- **Mode of Action**: Avidin is a protein found in raw egg whites that binds strongly to biotin, forming a complex that is not absorbed by the digestive tract. This binding prevents biotin from being absorbed into the bloodstream, leading to a deficiency if consumed in large amounts over time without adequate biotin intake from other sources.

2. Enzyme Inhibition

- **Example**: Warfarin and Dicoumarol
- **Target Vitamin**: Vitamin K
- **Mode of Action**: These compounds inhibit vitamin K epoxide reductase, an enzyme essential for recycling vitamin K. By inhibiting this enzyme, they reduce the regeneration

of active vitamin K, which is necessary for synthesizing clotting factors. This leads to an anticoagulant effect, preventing blood clot formation.

- **Example**: Antifolates (e.g., Methotrexate)
- **Target Vitamin**: Folic Acid (Vitamin B9)
- **Mode of Action**: Antifolates inhibit dihydrofolate reductase, an enzyme that converts folic acid to its active form, tetrahydrofolate. This inhibition disrupts DNA synthesis and cell division, making antifolates useful in cancer therapy and certain autoimmune diseases.

3.Destruction of the Vitamin

- **Example**: Thiaminase
- **Target Vitamin**: Thiamine (Vitamin B1)
- **Mode of Action**: Thiaminase is an enzyme found in certain fish, shellfish, and plants that cleaves and inactivates thiamine. By breaking down thiamine, thiaminase prevents its utilization in metabolic processes, leading to deficiency symptoms if thiaminase-containing foods are consumed in large quantities without adequate thiamine intake.

4.Competitive Inhibition

- **Example**: Pyrithiamine
- **Target Vitamin**: Thiamine (Vitamin B1)
- **Mode of Action**: Pyrithiamine is a synthetic analog of thiamine that competes with thiamine for binding to thiamine-dependent enzymes. By occupying the active sites of these enzymes, pyrithiamine inhibits their activity, leading to symptoms of thiamine deficiency.

5. Interference with Metabolic Pathways

- **Example**: Isoflavones (e.g., Genistein)
- **Target Vitamin**: Vitamin D
- **Mode of Action**: Isoflavones are phytoestrogens found in soy products that can interfere with vitamin D metabolism. Although the precise mechanism is not fully understood, isoflavones are thought to affect the expression of vitamin D receptors or enzymes involved in vitamin D activation and breakdown, potentially impacting calcium metabolism and bone health.

Understanding these mechanisms helps in the appropriate use of antivitamins in medical treatments and managing their effects in dietary contexts.

Applications, merits and demerits:

Antivitamins have significant benefits, particularly in medical and research contexts, by providing valuable tools for treatment and scientific inquiry.

Applications of Antivitamins

- **Medical Use**: Antivitamins like warfarin and methotrexate are used therapeutically to manage blood clotting disorders and treat certain cancers, respectively.
- **Nutritional Impact**: Natural antivitamins like avidin and thiaminase can impact nutrition if not properly managed. Cooking and food preparation techniques can mitigate some of these effects.
- **Research**: Antivitamins are valuable tools in scientific research to study vitamin functions and metabolic pathways.

Merits of Antivitamins

1. **Medical Treatments**:

- **Anticoagulants**: Compounds like warfarin act as vitamin K antagonists, which are used to prevent blood clots in conditions like deep vein thrombosis and atrial fibrillation.
- **Cancer Therapy**: Antifolates, such as methotrexate, inhibit folic acid activity, thereby limiting cell division and being effective in treating certain cancers.

2. **Research Tool**:

- **Nutritional Studies**: Antivitamins are used in research to study vitamin functions and deficiencies, helping to understand their roles in metabolism and health.
- **Metabolic Pathway Analysis**: By inhibiting specific vitamins, researchers can elucidate the metabolic pathways and biochemical processes that depend on these vitamins.

3. **Antimicrobial Use**:

- **Antibiotics Development**: Some antivitamins can inhibit the growth of bacteria by disrupting their vitamin-dependent metabolic processes, contributing to the development of new antibiotics.

Demerits of Antivitamins

1. **Health Risks**:

Nutrient Deficiencies: Consumption of antivitamins in food or supplements can lead to deficiencies in essential vitamins, resulting in various health issues like weakened immunity, anemia and neurological problems.

- **Toxicity**: Excessive use of synthetic antivitamins can be toxic and lead to severe health complications.

2. **Dietary Concerns**:
    - **Food Safety**: Naturally occurring antivitamins in certain foods (e.g., avidin in raw egg whites) can pose risks if not properly managed (e.g., cooking to denature avidin).
    - **Dietary Balance**: Ensuring a balanced intake of vitamins while avoiding antivitamin effects can be challenging, especially in populations with limited access to diverse foods.
3. **Side Effects in Medical Use**:
    - **Warfarin**: While effective as an anticoagulant, it requires careful monitoring to avoid excessive bleeding and interactions with other medications and dietary vitamin K.
    - **Methotrexate**: While used in cancer therapy, it can cause side effects like liver damage, gastrointestinal issues and immune suppression, requiring close medical supervision.
4. **Resistance Development**:
    - **Microbial Resistance**: Overuse of certain antivitamins as antibiotics can lead to the development of resistant strains of bacteria, reducing the effectiveness of these treatments over time.

Antivitamin use must be carefully managed to avoid adverse health effects, dietary imbalances and resistance issues. Balancing the merits and demerits of antivitamins is crucial for their safe and effective application.

Differences between vitamins and antivitamins

The primary difference between a vitamin and an antivitamin lies in their functions and effects on the body.

S. No.	Vitamins	Antivitamins
1.	**Definition:** Vitamins are organic compounds that are essential for normal growth, metabolism,	Antivitamins are substances that interfere with the function or utilization of

	and overall health. They are required in small quantities and must be obtained through diet because the body either cannot produce them at all or cannot produce them in sufficient amounts.	vitamins. They can block the absorption of vitamins, inhibit their biological activity, or accelerate their degradation.
2.	**Functions**: ○ **Metabolic Role**: Vitamins often act as coenzymes or cofactors that assist in biochemical reactions within the body. ○ **Health Maintenance**: They are crucial for maintaining the immune system, promoting healthy skin, aiding in wound healing, supporting vision, bone health, and blood clotting**.** ○ **Growth and Development**: Essential for proper growth and development, especially during childhood and pregnancy.	○ **Inhibition**: They counteract the effects of vitamins by inhibiting enzymes or pathways that depend on those vitamins. ○ **Research Tools**: Used in scientific research to study the role of vitamins in metabolic processes and disease states. ○ **Medical Applications**: Some antivitamins are used therapeutically to treat certain conditions by inhibiting vitamin-dependent processes (e.g., anticoagulants like warfarin).
3.	**Examples:** ○ **Vitamin A**: Important for vision and immune function. ○ **Vitamin B Complex**: Involved in energy production and red blood cell formation. ○ **Vitamin C**: Antioxidant that supports the immune system and collagen synthesis. ○ **Vitamin D**: Crucial for calcium absorption and bone health. ○ **Vitamin E**: Antioxidant that protects	○ **Avidin**: Binds to biotin (Vitamin B7), preventing its absorption. ○ **Dicoumarol and Warfarin**: Inhibit vitamin K recycling, affecting blood clotting. ○ **Thiaminase**: Destroys thiamine (Vitamin B1). ○ **Pyrithiamine**: Inhibits thiamine-dependent enzymes. ○ **Antifolates (e.g., Methotrexate)**: Inhibit the activity of folic acid

	cells from damage. ○ **Vitamin K**: Necessary for blood clotting.	(Vitamin B9).
4.	**Role in the Body**: Essential for health, growth, and metabolic functions.	Interfere with the action of vitamins, potentially leading to deficiencies or therapeutic effects.
5.	**Health Impact**: Deficiency leads to health issues (e.g., scurvy from lack of vitamin C, rickets from lack of vitamin D).	Can cause deficiencies if consumed excessively or improperly; however, they are useful in specific medical treatments (e.g., warfarin as an anticoagulant).
6.	**Occurrence**: Naturally present in food, essential for normal physiological functions.	Can be naturally occurring (e.g., avidin in raw egg whites) or synthetic (e.g., methotrexate for medical use).

Conclusion

Vitamins and antivitamins have opposing roles. Vitamins are crucial for supporting life and health, while antivitamins counteract the effects of vitamins, which can be detrimental or beneficial depending on the context. Understanding their differences is vital for both nutritional science and medical applications.

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TRICHODERMA: A POWERFUL BIOCONTROL AGENT

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Introduction

Trichoderma is a micro-worker that works in the root zone (rhizosphere) of plants.*Trichoderma* is a genus of fungi in the family Hypocreaceae that is present in all soils, where they are the most prevalent culturable fungi. This refers to the ability of several *Trichoderma* species to form mutualistic endophytic relationships with plant species.*Trichoderma* is mainly used to control soil-borne diseases in various plant and some leaf and spike diseases. These bioactive substances, including secondary metabolites and cell wall-degrading enzymes, can effectively improve crop resistance, reduce plant diseases, and promote plant growth.

*Trichoderm*a spp. can produce bioactive substances and have antagonistic effects on plant-pathogenic fungi and plant-pathogenic nematodes. *Trichoderma* sprays are also beneficial for controlling foliar diseases. But for that, it is necessary to have a favourable environment for the growth of fungi in the field.*Trichoderma* fungi remains in the soil for a long time, which is favourable for microorganisms.The characteristic of this fungus is that it grows very fast in soil and does notallow any other pathogenic fungi (e.g., *Phytophthora*, *Fusarium*, *Pythium*, *Rhizoctonia*, *etc*.) to grow.

Scientific classification

Domain: Eukaryota

Kingdom: Fungi

Division: Ascomycota

Class: Sordariomycetes

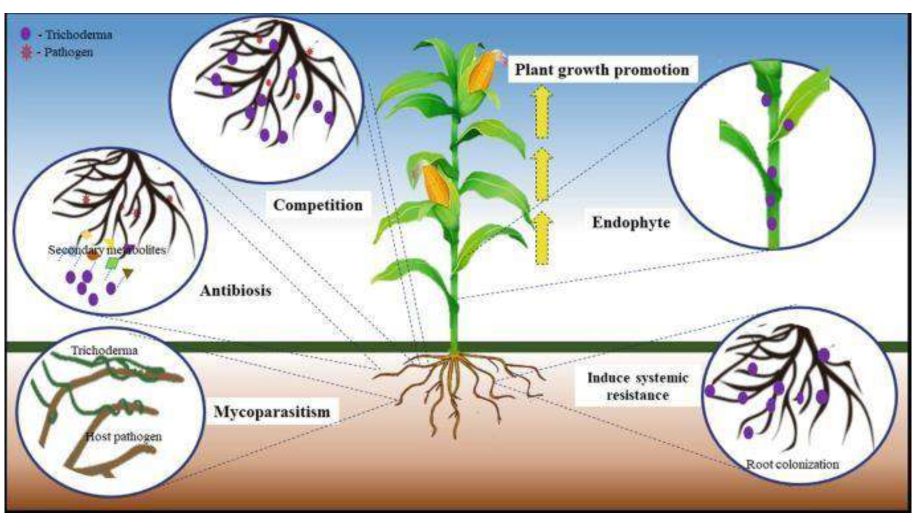
Order: Hypocreales

Family: Hypocreaceae

Genus: *Trichoderma* Pers. (1801)

Mechanism of *Trichoderma* in plant fungal disease control

- The prevention of infection or suppression of disease by Trichoderma is based on hyper parasitism, antibiosis, reduction of saprophytic ability, induced systemic resistance in the host plant, competition for nutrients and space.
- Hyperparasitism: It may feed on or in a pathogenic species which is known as parasitism.
- Antibiosis: A Biocontrol agent may excrete a compound that slows down or completely inhibits pathogens' growth in the surrounding area of such a compound called antibiosis. Among these antibiotics, the production of gliotoxin, viridin, pyrones, peptaibols, and others have been described extensively.



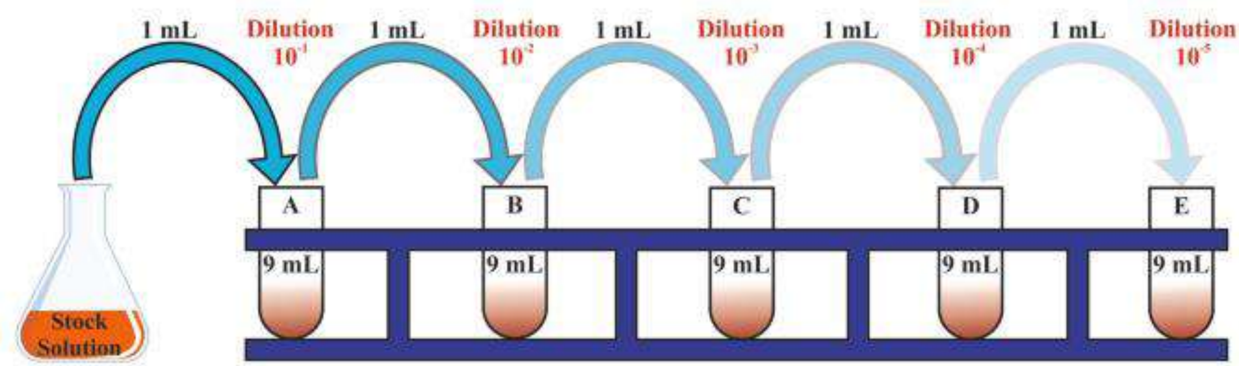
- Competition: It grows rapidly or uses its food source more efficiently than the pathogen, there by crowding out the pathogen and taking over, known as nutrient competition.
- It may promote a plant to produce chemical that protects it from the pathogen, which is induced resistance.
- They can grow endo-phytically in other species and support plant growth.
- Since chitin is the major component of most fungal cell walls, a primary role attributed to chitinases in the Biocontrol activity of *Trichoderma*.

Isolation of *Trichoderma* from soil

1. **Collection of rhizospheric soil samples**

Collection of soil sample was done from eight different locations, any leguminous plant's uprooted and soil is collected from rhizospheric area nearly ½ Kg soil was collected in plastic bags. Collected soil was air dried.

2. **Isolation of *Trichoderma* spp.**



Weigh the collected soil sample in the weighing balance and take 10 grams of soil

↓

Sterilize the laminar air flow and the instruments to be used in the laminar air flow

↓

Add 10 grams of soil to the conical flask

↓

Mix the soil thoroughly by constantly rotating and steering the conical flask for 15 minutes

Allow the soil particles to settle down

Use 1000 µl micropipette and transfer 1 ml of suspension from the conical flask to the first test tube. Discard the pipette tip (Use a new pipette tip every time) Label the first test tube as 10^{-1}. Now the volume of the first test tube is 10 ml

The dilution in the first test tube is mixed thoroughly

Now, 1 ml of mixture is taken from the 10^{-1} dilution and is emptied into the second tube and label it as 10^{-2}

The same process is then repeated for the remaining tube, taking 1 ml from the previous tube and adding it to the next 9 ml diluents

Label every test tube according to its dilution

With every dilution the amount of microorganisms in the test tube decreases which makes us easier to identify Trichoderma from the Petri plate

Use 100µl micropipette to transfer 0.1 ml dilution from test tube into Petri plate and spread the suspension uniformly on petri plate with the help of spreader.

Transfer the dilution from test tube 1,3,5 and 6 into the four different Petri plates

Seal the Petri plate with paraffin tape

Label the Petri plates with the dilution, date and roll number

↓

Keep the Petri plates under room temperature for 5-7 days that will allow microorganisms to grow.

Benefits of *Trichoderma*

1. Since *Trichoderma* grows slowly in the soil, it feeds on other harmful fungi and keeps their growth under control.
2. Being a natural ingredient, this fungus has no impact on the environment.
3. It helps to decompose organic matter in the soil and improves the soil.
4. Seed treatment with *Trichoderma* to increases the fertility and seed vigour.
5. Kills harmful pathogenic micro-organisms.
6. Improves nutrient utilization efficiency
7. Enhance the plant resistance

How to use?

1) Seed treatment: A common and useful method of using *Trichoderma* fungus is seed treatment at the time of sowing at the rate of 10 gm/ kg of seed with *Trichoderma* powder. Care should be taken to ensure that all the seeds are evenly coated. Seeds should be dried in the shade and sown immediately.

2) Soil Treatment: for control of soil borne pathogenic fungi. Mix 1 to 2.5 kg of *Trichoderma* powder with 25 to 30 kg of well-rotted cow dung, spread it over a one-hectare area, and mix it with soil and water if possible.

3) Drenching or spraying on plant: For control of soil borne pathogenic fungi 30-50 g/ 20 L water.

4) Foliar spray: For control of foliage diseases 20 g/ 20 L water.

5) Oil treatment: Apply 5 Kg of *Trichoderma* powderper hector after turning off the Sunhemp or Dhaincha into the soil for green manuring. Or Mix 1kg of Trichoderma the formulation in 100 kg of farmyard manure and cover it for 7 days with polythene. Sprinkle the heap with water intermittently. Turn the mixture in every 3-4 days intervals and then broadcast in the field.

Application of *Trichoderma* sp.

Crops	Diseases	Method of Application	Dose
Rice	Sheath Blight, Bacterial Leaf Blight, Sheath rot	Foliar Application	20 gm/ 20 liter
Potato	Damping off, Black scurf, Charcoal Rot	Tuber Treatment	20 gm/liter for 30 min.
Tomato	Stem rot, Damping off	Seeding treatment	20 gm/liter for 30 min.
Peas	Damping off	Soil treatment	1 kg powder +1000 kg compost
Soybean	Damping off	Soil treatment	1 kg powder +1000 kg compost
Egg plant	Collar rot	Seed treatment	8 - 10 gm/ kg
Banana	Wilt	Rhizome treatment	20 gm/liter for 30 min.
Tea	Collar rot, Black Root rot	Soil treatment	1 kg powder +1000 kg compost

Precautions:

1. Don't use chemical fungicide after application of Trichoderma at least for 4-5 days.
2. Don't apply *Trichoderma* in dry in soil moisture is an essential factor in its growth and survivability.
3. Don’t apply it on a sunny day when the soil surface is hot.
4. Don't put the treated seeds in direct sunrays.
5. Don't keep the treated FYM for a longer duration.

Conclusion

Trichoderma being a widely acceptable biofertilizer and a bio fungicide, can be used in almost all crops like Vegetables, Fruits, and Flowers etc. It's use not only protects the crops from harmful chemical fungicide but also improves soil texture and fertility by decomposing the organic matters. The effect of chemical control is good and helpful in increasing agricultural production, the unscientific use of chemical pesticides has caused serious pollution to the environment and enhanced pathogens' resistance to and chemical pesticides. Several experiments have proven that *Trichoderm*a has good biological control effects and can reduce the use of chemical pesticides.

However, its use is not limited to anti-pathogenic activity but also acts as bio fertilizer, plant growth promoter, bioremediation, and increase in crop yield both biological and economic yield. Thus, the use of *Trichoderma*should be promoted as it promises for sustainable agriculture by reducing the use of harmful chemicals in the agriculture field.

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LITTLE SPACES PROVIDE NUTRITION SECURITY FOR HOUSEHOLDS THROUGH KITCHEN GARDEN

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Introduction

Kitchen gardening is important for families with low incomes in including diversified, low-cost seasonal vegetables in their daily diet. Economic analysis revealed that kitchen gardens can be a panacea for vulnerable households by providing food security and nutritional diversity. Poor people more often pay a higher price for food as they buy small quantities of expensive food items as well as travel far to get to where the food costs are relatively lower, thereby losing that advantage on transport. It provides both direct and indirect income. Direct income is from the sale of surplus production, while indirect income is from the savings achieved by not buying the same products from the market.

Furthermore, kitchen gardens have proven to be an effective tool for education and community development. They provide an opportunity for individuals to reconnect with nature and learn about the basics of agriculture. Besides providing fruits and vegetables, gardening provides an aesthetic and therapeutic exercise that helps relieve stress. The physical activity involved in tending to a garden helps individuals stay active, reducing the risk of obesity and related health issues. By involving children in gardening activities, they can develop an appreciation for the environment and learn essential life skills. Moreover, kitchen gardens can serve as a platform for community engagement, fostering social interactions and promoting a sense of belonging among urban residents.

Despite the numerous benefits of kitchen gardens, establishing and maintaining one in urban areas can be challenging. Limited space, lack of sunlight, and soil quality issues are common obstacles that urban gardeners face. However, innovative solutions such as vertical gardening, hydroponics, and rooftop gardens have emerged to overcome these challenges. Vertical gardening is a light-framed, stackable planter for indoor and outdoor use. It utilizes trellises, fences, doors, balconies, decks, patios, and windowsills to grow flowers, herbs, and vegetables (e.g., peas, cucumbers, and tomatoes). It is well-suited to urban areas where space is limited. It doesn't have to be expensive; various repurposed materials can be used to build these simple structures. Hydroponics utilizes a water-based nutrient solution rather than soil and can include an aggregate substrate or growing media such as vermiculite, coconut coir, or perlite. This system fosters rapid growth, more substantial yields, and superior quality. These techniques allow individuals to maximize limited space and grow a variety of crops without relying solely on traditional soil-based gardening.

Need of Kitchen Garden

For people to stay healthy it's very important to have a healthy diet. A healthy diet means a balanced mix of rice, bread, pulses, vegetables, herbs, fruit etc. For energy and protection against disease, vegetables play an essential role. Growing of vegetables without the use of chemical inputs, it is beneficial for health of the body.

1. Grow healthy, fresh vegetables yourself.
2. Cultivation in a small area facilitates the methods of controlling pests and diseases through the removal Of affected parts and non-use of chemicals.
3. This will only facilitate successful production of our own requirement of vegetables.
4. To save the cost of buying vegetables and herbs.
5. Waste resources such as sweepings, kitchen scraps and dirty water can be recycled onto the garden.
6. Vegetables harvested from home garden taste better than those purchased from market.
7. Gardening gives dual benefits of food and income generation.
8. Gardens provide fodder for household animals and supplies for other household needs (handicrafts, fuel wood, furniture, baskets, etc.)

IMPORTANT STEPS KEEP IN MIND

1. **Site selection-** There will be limited choice for the selection of sites for kitchen gardens and the final choice is usually the backyard of the house. The area where sunlight comes from can be easily accessed from the house. This is convenient as the members of the family can give a constant care to the vegetables during leisure .When these are kept in mind, site selection can be done and making garden is easier
2. **Protection-** The kitchen garden area needs protection .It should not be possible for livestock to enter the area. A permanent fence should be made. Thorny plants can be cut and used to make a fence, but the best method is to plant a living fence to protect the garden.
3. **Land preparation**- Getting the right mix of soil is an important step as the nutrients in the soil determine how healthy the plants would grow. Use cow dung to keep all organic. Sweeping pit, liquid manure, mulching, Green manure must be used for fertility of the soil. Firstly a through spade digging is made to a depth of 30-40 cm.

   Stones, bushes and perennial weeds are removed. •

   100 kg of well decomposed farmyard manure or vermicompost is applied and mixed with the soil.

   • Ridges and furrows are formed at a spacing of 45 cm or 60 cm as per the requirement.

   • Flat beds can also be formed instead of ridges and furrows.

   Sowing and planting- The main objective of a kitchen garden is the maximum output and a continuous supply of vegetables throughout the year. Direct sown crops like bhindi, cluster beans and cowpea can be sown on one side of the ridges. Amaranthus (meant for whole plant pull out and clipping) can be sown by broadcasting in the plots. Small onion, mint and coriander can be planted/sown along the bunds of plots.

   Seeds of transplanted crops like tomato, brinjal and chilli can be sown in nursery beds or pots one month in advance after sowing and covering with top soil and then dusting with 250 grams neem cake so as to save the seeds from ants.

   • The perennial plants should be located on one side of the garden, usually on the rear end of the garden so that they may not shade other crops, compete for nutrition with the other vegetable crops.

- If seeds and seedlings are planted too wide apart, much of the space in between goes to waste, where weeds will grow. Weeds use precious water and compost, and cause extra work to keep clear.

4. **Irrigation management-** It is important to provide enough moisture for the kitchen garden. To make sure your plants get optimum water, check the moisture of the soil by pressing it with your fingers and then water the plant as per requirement. If there is no irrigation for main food crops, it is likely that there is also not enough water to irrigate the kitchen garden. But if the water conservation methods that is saving rain water are used, then more water is conserved and so less is needed. Collecting and using waste water from the kitchen can be enough to water the garden. In the hot season, irrigate in the evening or at night, and not in the daytime.


Nutrition and health Management

One of the easiest ways of ensuring access to adequate macro and micronutrients is to produce and consume different kinds of vegetables from the garden. Kitchen gardening is the easiest way of growing desirable fruits and vegetables on our own piece of land. It can be grown in the empty space available in the backyard of the house or a group of women can come together, identify a common place or land and grow the desired vegetables, fruits, etc. This can benefit the women and community as a whole.



Conclusion

Home-grown vegetables are natural, low cost and could be totally free from chemicals and pesticides. Kitchen garden is sometimes called backyard or home garden. These gardens have an established tradition and great potential for improving household food security and alleviating micronutrient deficiencies. Most importantly, it gives direct access to diverse nutritionally rich vegetables. It also increases the purchasing power through savings on food bills. This is especially important in rural areas where people have limited income-earning opportunities and poor access to markets. Gardens are also becoming an increasingly important source of vegetable supplies and an additional income resource for poor households in peri-urban and urban areas.

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MULCHING: A KEY COMPONENT OF NATURAL FARMING FOR RAINFED AGRICULTURE

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Abstract

Among the different natural resources soil and water are two most important in agriculture. Because, all plant growth depends on these natural resources. The soil provides the mechanical support and acts like a reservoir that holds water and nutrients that plants need to grow and water is essential for plant life processes. Present study demonstrates different mulching materials, its application method and how can mulch helps to water conservation and Soil Thermal Regimes and reduces soil deterioration by limiting runoff and soil loss. Under organic or biodegradable mulches was dominated by organic materials, while inorganic mulches are mostly comprised of plastic-based components.

Keywords: Biodegradable mulches; Soil thermal regimes; mulching Materials, water conservation.

Introduction

Agriculture sector is the largest water user in the world, accounting more than 70% of total consumption. Rainfed agriculture is becoming more popular in the world which accounts 80% of global cultivated land and provides 60–70% of the total globe's food. Under rainfed area, water scarcity due to climate change in which changing rainfall patterns affected the agricultural production in arid or semi-arid regions. As a result, water management and its conservation in the agriculture sector are now a challenge. The main limiting factors in agricultural output in semi-arid and dry areas are limited precipitation, restricted water accessibility and availability. This issue is becoming more serious as climate change has a significant impact on agricultural systems. The main reason for using less water in agricultureis the rising demand caused by the world's growing population. Water availabilityfor agricultural producers is steadily declining because urban populations' water needs areessentially increasing. Farmers are looking for novel approaches to enhance soil moistureto resolve both of these problems. Mulching is the component of the natural farming and its one traditional practice that can aid the solution to this issue. This article compiled information about mulching, different types of mulching materials, Comparison between organic & inorganic mulches and its role on water conservation and soil thermal regimes.

What is mulching

Mulching is a common practice that involves applying materials to the field before,during, or soon after sowing in order to support and spread over the soil surface, such asplastic material, crop residues, livestock manure, sands, rocks, and cement. The main goals of mulching are to limit evaporation or water erosion, boost soil temperature, improve the soil water supply capacity and suppress weeds.

2. Types of Mulching Materials

Organic, inorganic, and special materials are the three types of mulching materials. Agricultural wastes, wood industrial wastes, processed leftovers, and animal manuresare used to make organic mulching materials. Polyethylene plastic films andsynthetic polymers are examples of inorganic mulching materials.

Organic mulch

Inorganic mulch

Several innovativebiodegradable and photodegradable plastic films, as well as surface coating and biodegradablepolymer films for ease of implementation and flexibility, were also introduced as ecologically friendly materials.

2.1: Organic Mulches

Organic mulches are made from plant or animal matter. To get the most out of organic mulch, it is best used as soon as the crop germinates or when the vegetable seedlings are transplanted at 5 t ha^{-1}. Organic mulches are effective at minimizing nitrate leaching, boosting soil physical qualities, enhancing biological activity, balancing the nitrogen cycle, providing organic matter, controlling temperature and water retention, and reducing erosion. Natural ingredients are difficult to apply to growing crops and necessitate a lot of human effort. Organic mulch's application in horticultural crop production has been limited due to cost and logistical issues, with only a small amount of large-scale commercial utilization.

2.1.1. Straw

After harvesting, straw or crop remains are readily available. Straw mulch is a light weight material that is simple to apply and use. Paddy straw is now commonly utilized as field mulch, as it improves crop cultivation conditions. When straw is utilized as mulch, it might cause several issues. Straw mulches need to be replaced every year because they are extremely flammable and include grain seeds that could germinate and deplete soil nitrogen levels as they decompose (Goodman, 2020).

2.1.2. Bark Mulches

These are effective mulches as they hold more moisture for an extended time and prolong the availability of water to the crop. It is often used for landscaping and vegetation. However, because it is acidic, it should not be used in vegetable fields. On the other hand, this mulch is ideal for covering the walk ways between the beds (Kosterna, 2014).

2.1.3. Wood Chips

Reprocessed wood and a variety of tree species are used to make wood chips. Because wood chip mulches have a high C:N ratio, they may restrict the availability of soil nitrogen available for plant absorption while they decompose (Bantle *et al*. 2014).

2.1.4. Sawdust

Sawdust is popular mulch in locations where it is readily available. It is found during wood finishing procedures. It is lower in nutritional value than straw, with only half the nutrients. The breakdown is very slow due to the high C:N ratio. Its decomposition will result in N_2 deficiency in the soil, necessitating the use of fertilizer regularly. Because of its acidic nature, it should not be utilized in low pH soil. It does, however, retain moisture for an extended period of time (Tan *et al*. 2016).

2.1.5. Compost

Compost is an excellent mulch and soil conditioner that may be easily made at home using a variety of waste items such as leaves, straw, grass, and plant wastes, among others. Compost availability and utilization in agriculture is a long-standing tradition. It boosts the properties of the soil, as well as the carbon content, which improves the soil's capacity to retain water and improves soil health. Due to its higher N content, compost is not recommended for use in vegetable fields because of the greater chances of weed growth (Sofy *et al*. 2021).

2.1.6. Newspaper

Newspaper mulching is a cost-effective way to reduce weeds by reducing the chances of germination of weed seeds fallen from the previous season. The newspaper layers biodegrade quickly into the soil. Newspaper is preferable to plastic since it decomposes over time. It is less expensive and less time consuming (Haapala, *et al*. 2014).

2.2: Inorganic Mulches

Plastic mulch is an example of inorganic mulch; it comprises the majority of mulch used in commercial crop cultivation. Polyvinyl chloride or polyethylene films are the plastic materials used as mulch. It may raise the temperature around the plants at night in winter due to its higher permeability to long-wave radiation. As a result, polyethylene film mulch is recommended as a mulching material for horticultural crop cultivation.Throughout the 1960s, a variety of plastic films based on various types of polymers were examined for mulching purposes. The technical distinctions between flexible polyvinylchloride (PVC), high-density polyethylene (HDPE), and low-density polyethylene (LDPE) were minimal (Gao, *et al*. 2019). Because it is more cost effective to use, LLDPE makes up the over whelming majority of plastic mulch today. Black plastic mulch film application is growing in popularity and it has produced excellent results, especially in arid and semi-arid regions. Black polyethylene mulch achieved a greater crop yield and quality which increased the economic value for farmers. It also decreased soil evaporation, modified the microbial community, and increased soil moisture levels (Li, *et al*. 2014).

Fresh vegetables are progressively being produced through a practice known as "plastic culture", which involves using plastic as mulch in farming. Over one million tons of plastic film mulch is used each year in all parts of the world (Yu, *et al*. 2018). For instance, plastic film mulching was used in more than 60,000 ha of greenhouses in Spain in 2012, an increase of 5.7% (Transparency Market Research, 2016). According to estimates, China uses 0.7 million tons of plastic mulch annually, or 40% of the global total. China, Japan, and South Korea are currently the three countries that use plastic film mulch the most (80%) globally (Zhao, *et al*. 2022).

2.3. Photodegradable or Biodegradable Mulches

A kind of mulch that is simple to use and versatile is photodegradable and biodegradable. Sand, gravel, and concrete are specific sorts of mulch that are rarely utilized, leading to the absence of nutrients and being very expensive to integrate. Biodegradable plastic mulch is a more environmentally friendly alternative to polythene mulch. It was created to prevent the accumulation of LDPE and the pollution caused by plastic waste in the environment. Biodegradable plastic mulches are now composed of a variety of polymers or additives that are readily available in the global markets or are similar to LDPE mulches in terms of crop yield productivity. In organic farming, this form of mulch also minimizes the need for agrochemicals. Regular application of mulch may have negative effects on soil efficiency, crop productivity, contamination, and ecosystem services such as food and water processing, disease control, N_2 cycling, and O_2 formation, as well as cultural and aesthetic values. Complete and incomplete degradation are two different levels of degradation; photo degradation, water degradation, thermal oxidative degradation, and biological degradation are four different types of degradation mechanisms (Liu *et al*. 2022).

Starch, cellulose, polyhy droxyalkanoates (PHA), and polylactic acid (PLA) are typical bio based polymers used in BDMs. Poly (butylene succinate) (PBS), poly (butyl enessuccinate-co-adipate) (PBSA), and poly (butylene-adipate-co-terephthalate) (PBAT) are examples of polyesters derived from fossil sources and used in BDMs (Kasirajan and Ngouajio, 2012) . Ester bonds or polysaccharides, which are amenable to microbial hydrolysis, are found in the polymers used in BDMs. Theoretically, soil microorganisms should completely catabolize BDMs, converting them to microbial biomass, CO_2, and water [51]. In addition to the primary polymers, plastic mulches also contain trace amounts of organic (additives, plasticizers, etc.)and inorganic (Cu, Ni, etc.) elements, the effects of which are largely unknown. Traditional plant toxicity tests have not been modified to detect the effects of substances released by BDMs. First, as compounds degrade, they release various compounds at various times. Second, by concentrating only on germination, commonly used tests miss out on accounting for the shifting needs and responses throughout plant development (Bandopadhyay, *et al*. 2018).

Table 1: Comparison between organic & inorganic mulches

Subject	Organic mulch	Inorganic (plastic)mulch
Material type	Bio-based cellulose, chips, leaf, paper	Acetate, polyethylene, polymeric material
Durability	Temporary or decays over time	Long lasting, two–three crop seasons
Colors	Natural	Black, silver, white, red, blue etc.
Thickness	3–5 cm, controlled by application rates	15–20 µm; 15 µm is most effective
Cost	It has relatively low cost, especially if reusing farm waste and crop residues	It is much expensive than organic mulches
Availability	It is not easily available in large quantities	It is often available in large quantities at commercial centers
Fragments	Degradable to soil	Problematic or contaminated after one–two seasons
Weed control	Effective, but grass material grows weeds	High weed competition except transparent color
Pest management	Reduces thrips or fungal disease	Reduces thrips, spider mites, or whiteflies
Priority mulch	Straw (rice and wheat)	Black plastic

3: Methods of Application of Mulching Materials

In agricultural fields, a variety of mulching materials are used in a variety of ways and patterns but they are classified in flat and ridge shaped mulching.

3.1. Flat Mulching

A traditional type of mulching is called flat mulching, which involves covering the soil's top layer with organic, inorganic, or mixed mulching materials. In the case of organic mulching materials, flat mulching can keep the layer thickness based on the intended function. A type of flat mulch, where part of the topsoil is coated, is plastic mulching with holes. Compared with conventional flat mulching, this mulching improves soil aeration and rainfall infiltration.

3.2. Ridge Shape Mulching

In this type, the ridge is coated with a plastic film, which directs rainwater into furrows or lowers surface runoff, enhancing water use efficiency (WUE). Crops such as corn are typically grown on the ridge area of the field, which is mulched, but crops are also grown in the furrow, which can be mulched or not.

4. Mulching Material Selection

In general, the selection of a proper mulching material depends on the material type, the type of crop, environmental locations, and the availability of mulch, as well as their cost effectiveness.

5. Role of Mulching on Water Conservation

Crop output is proportional to the amount of accessible water and the efficiency with which it is used throughout the production period. Land that is not mulched loses more water than land that is covered with plastic. This is due to increased exposure to water-losing factors such as solar radiation, wind or heat (El-Ganainy *et al*. 2022). Plastic mulching has a better effect on plant production or water-use efficiency (WUE) than traditional tillage patterns. Black and white plastic mulching improves WUE in potato plants by 31% compared with the un-mulched ground.

6. Mulch effects on Soil Thermal Regimes

Mulches appear to be effective at changing water or heat balances on the soil's surface or improving the growing environment for plants. In general, organic mulches reduce maximum soil temperatures but boost minimum soil temperatures, whereas polyethylene mulches, enhance maximum or minimum soil temperatures compared with un-mulched soil (Ham *et al.* 1993).

7. Mulch effects on Soil Temperature

Sarolia and Bhardwaj (2012) recorded a temperature increase of 2–3^{0}C after treatment with wheat straw mulched soil, when compared with bare soil.

Effects of Mulch on Soil Temperature in different crops are presented in table-2.

8. Advantages of Mulching

1. Mulching in crop fields has numerous benefits, including reduced soil water loss, weed germination, soil erosion, and water droplet kinetic energy.
2. Mulch can help improve soil structure and increase earthworm movement.

3. After breaking down, organic mulch gives nutrients to the soil and boosts the availability of nutrients in the soil for a longer period of time.
4. Mulches control the temperature variation in the plants' root zones, causing soil to become colder in summer or warmer in winter.
5. Mulch prevents runoff or provides soil more time to absorb rainwater by lowering the kinetic energy of rain or by slowing the movement of rainwater .
6. Mulch protects soil from wind erosion

Table-2: Effects of Mulch on Soil Temperature in different crops

Type of Mulch	Impact on Soil Temperature	Crop	Reference
Straw mulch	Reduce soil temperature fluctuations	Alfalfa	Jun *et al*. (2014)
	Decrease soil temperature	Maize & Wheat–maize	Li *et al*. (2012)
Black plastic mulch	The soil temperature **increased more in black polyethylene** mulched plots than white polyethylene or bare ground plots	Maize Lettuce	Li *et al*. (2012) Gheshm *et al*. (2020)
Coupled plastic or straw mulch	Reduce soil temperature	Maize and wheat	Yin *et al*. (2016)
Transparent plastic mulch	The soil temperature **boosted in plastic film mulching**	Maize potato	Li *et al*. (2022) Zhao, *et al*. (2012)
Silver/black plastic mulch	Increase soil temperature	Cucumber	Torres *et al*. (2018)

9. Disadvantages of Mulching

1. Mulching has some drawbacks as well, such as increased labor needs, higher transportation costs, and difficult removal and disposal.

2. Weed growth and acid leakage are also major issues with some organic mulching materials such as straw and grass.
3. Mulched soil has better aeration and temperature that tends to support increased microbial activity in the soil, resulting in more thorough nitrification in mulched soil.
4. If mulching is done close to the stem, the surrounding moisture in the plant's stem can serve as a haven for a variety of microorganisms, pests, and diseases.

Conclusions

The hydrothermal regime of the soil is affected by various mulching materials that change soil moisture and temperature. These changes in the soil environment have an impact on soil microbiology, which is critical for creating a suitable environment for plant growth. Mulching materials have a substantial impact on water conservation in agriculture by altering the microclimate and lowering the soil evaporation. However, each form of mulch has its own set of advantages and disadvantages, making it appropriate for some conditions but not for others. The availability, durability, or pricing of materials are all key factors to consider when choosing mulching materials. However, minimizing the detrimental effects of mulching should be the main priority. One of the benefits of mulching, the soil surface reduces soil evaporation or erosion brought on by wind or water.

Straw mulch moderates soil temperatures in the hot summer by preventing topsoil temperatures from reaching levels that inhibit plant growth. In the early spring, when soil temperatures are low, plastic mulch encourages plant growth by increasing the topsoil temperature. As a result, farmers will employ this unique technology in the future to help them preserve moisture, eliminate weeds, and greatly increase soil health while producing more. This will also contribute significantly to the world's long-term food security.

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SPECIES OF HONEYBEES

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Introduction

Honeybees have been classified as follows namely True honeybees (the genus *Apis*) are a biologically well-defined group within the family Apidae which comprises, besides *Apis*, the *Euglossini* (orchid bees), *Bombini* (bumble bees) and *Meliponini* (stingless bees).

Systematic position of honeybees

Kingdom	- Animalia	
Phylum	- Arthropoda	
Class	-Insecta	
Order	- Hymenoptera	
Sub order	-Apocrita	
Super family	-Apoidae	
Family	- Apidae	
Sub Family	-Apinae	
Tribe	- Apini	Melliponii
Genus	- *Apis*	*Trigona*

Bee species

There are five important species of honey bees as follows.

1. *Apis dorsata: The rock bee*

2. *Apis cerana indica: The Indian hive bee*

3. *Apis florea : The little bee*
4. *Apis mellifera: The European or Italian bee*
5. *Melipona (Trigona) irridipennis: Dammer bee, stingless bee.*

1. *Apis dorsata:* The rock bee

The bees are the largest among the bee described and are highly temperament and ferocious. Constructs single large open comb of 5-7 ft long and 2-3 ft height at inaccessible places such as branches of tall trees, steep rocks, ceiling of neglected and uninhabited houses, water tanks and towers to protect themselves from direct sunlight, rainfall on the nest . The aggregation of more number of colonies on a single tree or building or rock can be seen commonly and numbers may go up to 250 in places, where food source is abundant.

Honey is normally stored in the top portion of the comb. It yield as high as 30-40per colony/year.The rock bees are highly ferocious and irritant in nature but they are sensitive to smoke. It is impossible to domesticate this species because of its ferocious and irritant nature, frequent deserting behaviour and habit of building only single comb. This species is hard working and efficient pollinator. The workers are light brown in colour. The queen is dark in colour and much larger than workers and drones. The drones are black in colour and as big as workers.

2. Little bee (*Apis florea*):

Commonly called as Kolujenu or Kaddijenu. Quite smaller than the ***Apis cerana indica*.** The workers are deep black in colour with white stripes on the posterior part of the bright orange abdomen. Queen is bigger and abdomen is golden brown in colour and drones are black with smoky brown hairs on the abdomen. Little bee colonies are highly migratory and even with slightest disturbance, desert the comb and migrate to other place. It builds single open small comb of 1 ½ ft. Long and 1 ft. ht. found in shaded places such as branches of bushes, hedges and trees with dense foliage and also found in piles of dried sticks and house chimmneys. It is a poor honey gatherer, yielding 500-1000 gm of honey per colony because of its short foraging distance. Honey is known to have special medicinal values. It is distributed only in plains and not in hills above 450M.

3) Indian honeybee (*Apis cerana*):

It is a domesticated species commonly known as Thuduvejenu / Potarejenu. It is smaller than *Apis mellifera* but larger than *Apis florae*. This is a medium sized domesticated species where the workers have dark coloured thorax with brown hairs and the brown coloured abdomen has dark bands. Queen has dark thorax and sparsely hairy. While the abdomen and legs are coppery brown in colour. The abdomen is big, distended and is without black bands. Drones are stout and slightly bigger than worker. It constructs many parallel combs in semi circular shape and are found in hollows of trees, rocks, old walls and internal galleries of termite mounds. It is less ferocious and easy to handle

It's quick absconding and swarming behaviour in certain periods are the main constraints for its successful beekeeping. The honey yield from single colony varies from 10-15 kg per year in plains and upto 20-25 kg per year in hilly areas. In Karnataka, there are two strains in *A. cerana*, one is the black/dark strain found in the Malnad areas and another is the yellow strain found in the plain regions

4) Italian honeybee (*Apis mellifera)*:

Europe (Italy) is the native of this species and it has been successfully introduced to many countries in the world during last five decades. It was introduced to India in 1960 and found successful in Northern states of Himachal Pradesh, Punjab, Jammu and Kashmir, Haryana, Uttar Pradesh, W.B. and Bihar. The efforts are on to study its suitability in the southern states of Kerala, Tamil Nadu and Karnataka. It is similar to *A. cerana* in both habits and habitats. Constructs many large parallel combs. It can yield 4 - 5 times more honey than Indian bee. It can be easily domesticated in hives. This species is less prone to absconding and is not susceptible to wax moth since it has a capacity to protect the colony form attack, it is called as the darling of bee keeping.

5) Stingless bee (*Trigona irridipennis*):

Another species of bees which differ in both appearance and size commonly called as Mujenti jenu or Nasuru jenu normally found in tropical parts of India. Build their nests in cracks in wall, ground, hollows of trees, bamboo, rocks and telephone poles.

The combs are built with dark material called ‘cerumen’ which is a mixture of wax and resin/ earth. The sting is vestigeal but defends their colony only by biting. It yields little honey about 60-180 ml per colony and the honey is highly valued in Ayurvedic medicine. No serious attempts have been made to domesticate these bees as the production of honey and wax is not economical, but they are efficient pollinators of different crops. It is small with 4 mm length and black in colour. Queen and drone are larger than workers.

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ENHANCING BLACKGRAM PRODUCTIVITY THROUGH NUTRIENT MANAGEMENT

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Introduction

Among the several grain legumes, black gram (*Vigna mungo* L. Hepper) is one of the most significant pulse crops. It is a high-protein food that, on a dry weight basis, has roughly 27% protein, 1.2% fat, and 55.6% carbs. It also has a high iron and calcium content. Pulses are typically produced on low-fertility soils or with little organic and inorganic plant-nutrient input, which has leads to a decline in the productivity and health of the soil. With a production of 18.79 lakh tons and a productivity of 451.60 kg ha-1, the states of Madhya Pradesh, Uttar Pradesh, Maharashtra, Rajasthan, Bihar and Karnataka in India cultivate the majority of the country's black gram. It covers 90.59 thousand hectares in Karnataka and produces 5.66 lakh tonnes of crop per hectare at a productivity of 1447.3 kg/ha.

The increasing global population puts more strain on natural resources, making it more challenging to provide food security. A balance between boosting crop productivity, preserving soil health, and upholding environmental sustainability is needed to ensure long-term food security. Food grain production of India increased dramatically from 52.1 million tons in 1951–1952 to 230 million tons in 2007–2008, largely due to efficient nutrient management

Effect and Impact of Macro Nutrients:

Nitrogen

With the incorporation of 20 kg N/ha, the attribution of growth towards height of the plant, number of branches/plant, and accumulation of dry matter were greatly increased. The administration of 20 kg N/ha resulted in a considerable increase in the number of pods/plant, pod length, grains/pod, and weight of 1000 grains as compared to no treatment of nitrogen (0 kg N/ha). When compared to no nitrogen, the use of 20 kg N/ha greatly boosted grain and straw yield productivity/day/ha; however, the harvest index did not rise when 20 kg N/ha was applied instead of 0 kg N/ha.

Phosphorus

The growth parameters such as height of plant, branches/plant, leaves/plant, and dry matter accumulation exhibited a significant increase with rising phosphorus levels, peaking at 60kg P2O5/ha. Similarly, yield attributes saw a marked improvement with phosphorus level up to 60kg P2O5/ha while contrasting with lower levels. Notably, grain and straw yield per hectare, harvest index, and overall productivity experienced significant enhancement with increasing phosphorus levels up to 60kg P2O5/ha, whereas no improvements were observed without the application of P2O5.

Potassium

The data concerning plant height indicates a significantly greater height at harvest (38.16cm) with the incorporation of 30 kg/ha of potassium. Both phosphorus and potassium application influenced the plant height of black gram. Regarding branches, a statistically increase in the number of branches per plant (5.92) was observed at harvest with the incorporation of 30 kg/ha of potassium. Additionally, a significantly higher number of nodules/plant (15.74) was recorded at harvest with the same treatment. Regarding dry weight, a significantly greater plant dry weight (8.62 g/plant) was observed at harvest with the application of 30 kg/ha of potassium. However, no other treatment was found to be statistically at par with 30 K kg/ha.

The numerical analysis revealed a significant impact on the number of seeds per pod. Treatment with 30 kg/ha of potassium resulted in a markedly higher number of seeds per pod. Additionally, the application of Phosphorous along with potassium also influenced the straw yield of black gram, ranging from 13.87 q/ha under control conditions to 19.00 q/ha with the incorporation of 30 kg/ha of potassium.

Sulphur

The incorporation of 30 kg/ha of sulphur effected in the highest values for plant height, number of branches/plant, number of leaves/plant, and number of root nodules/plant, reaching 40.09 cm, 9.98, 8.03, and 18.19 cm respectively. Sulphur, an essential component of proteins and various amino acids, as well as a structural constituent of cells, plays a significant role in influencing various physiological processes, including cell division and elongation.

The increased number of branches and leaves/plant observed with, phosphorus, nitrogen and potassium, along with sulphur, can be attributed to enhanced deeper root penetration of soil layers, leading to improved water and nutrient uptake in the treated plots. The association of sulphur with phosphorus contributed to heightened chlorophyll levels and increased phosphatase activity.

Effect and Impact of Micro Nutrients:

Various concentrations of four distinct micronutrients—zinc, boron, molybdenum, and cobalt—were administered individually as well as in various combinations. An early onset of flowering, occurring at 19.67 days, was observed when a combination of zinc sulphate at a rate of 25 Kg/ha and borax at 10 Kg/ha was applied to the soil. This was followed by an application of zinc chelate at 500 g/ha to the soil, coupled with seed treatment involving a mixture of ammonium molybdate at 5 g/Kg and cobalt nitrate at 1 g/Kg seed. In contrast, a delayed flowering stage, noted at 27.67 days, was recorded.

A favourable flowering response was additionally noted with the combined application of zinc and boron through soil treatment. This could be attributed to the application of zinc, which plays a vital role in plant nitrogen metabolism, alongside boron, known for its positive impact on initiating reproductive growth.Compared to the control group, all other micronutrient treatments significantly affected the plant height of black gram plants. Since zinc is recognized for its role in auxin biosynthesis, the increase in plant height could be attributed to enhanced auxin synthesis, ultimately contributing to the growth of both roots and shoots in plants.

Zinc and boron have a major role in the increased plant height by promoting early vigour, production of dry matter and crop growth. Furthermore, it was concluded that zinc's catalytic function in the electron transport processes of photosynthesis and respiration may be the cause of the increase in plant height. When zinc sulphate (25 kg/ha) and borax (10 kg/ha) were applied to the soil, it was found that the shortest time to blooming was achieved. All treatments, however, whether given singly or in combination, caused the plant's height to rise. Zinc sulphate applied alone at a rate of 25 kg/ha had the greatest effect, followed by zinc sulphate and borax applied together at a rate of 25 kg/ha and 10 kg/ha, respectively. The number of primary and secondary branches per plant was positively impacted by all treatments, but the soil application of zinc chelate at 500 g/ha had the biggest impact.

Ways to enhance nutrient uptake by roots:

Improving nutrient absorption in blackgram (*Vigna mungo*) involves specific strategies tailored to the crop's growth requirements and soil conditions. Here are practical ways to enhance nutrient uptake:

- **Soil pH Management:** Maintain soil pH between 6.0-7.0 to optimize nutrient availability, as blackgram thrives in slightly acidic to neutral soils.
- **Organic Amendments:** Apply organic matter such as compost or well-decomposed manure to improve soil structure, water retention, and microbial activity, which enhances nutrient availability.
- **Micronutrient Application:** Provide micronutrients like zinc, iron, and manganese through soil application or foliar spraying to address potential deficiencies and support healthy plant growth.
- **Water Management:** Maintain adequate soil moisture levels through efficient irrigation practices to facilitate nutrient uptake by blackgram roots.
- **Crop Rotation and Intercropping:** Rotate blackgram with non-leguminous crops or intercrop with compatible species to diversify root systems, improve soil health, and optimize nutrient utilization.
- **Inoculation with Rhizobium:** Use rhizobial inoculants to promote nitrogen fixation in blackgram, ensuring a sustainable supply of this essential nutrient.
- **Mulching:** Apply mulch around blackgram plants to conserve soil moisture, suppress weeds, and moderate soil temperature, which supports better nutrient absorption.

- **Regular Monitoring:** Monitor plant health and growth regularly to detect nutrient deficiencies or imbalances early, allowing timely adjustments in nutrient management practices.
- **Integrated Nutrient Management (INM):** Adopt INM approaches that combine organic and inorganic nutrient sources, tailored to local conditions, to optimize nutrient uptake efficiency in blackgram cultivation.

Conclusion

Key strategies for nutrient management include the balanced application of macro and micronutrients, timely incorporation of organic amendments, and the adoption of integrated nutrient management (INM) practices. These approaches not only improve crop yield and quality but also promote soil health and environmental sustainability.

In summary, optimizing nutrient management practices in blackgram cultivation is essential for achieving higher yields, maintaining soil health, and ensuring sustainable agriculture. By adopting balanced nutrient applications, leveraging organic inputs, and embracing site-specific management strategies, farmers can enhance productivity while minimizing environmental impact, thereby securing a resilient and profitable farming future.

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PHYSICAL METHODS FOR SEED INVIGORATION

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Introduction

To fulfil the growing need for food from a growing global population, one of the largest issues facing humanity today is enhancing the sustainability of agriculture while decreasing its environmental impact (Edmondson et al., 2014).The concept of agricultural sustainability is predicated on the requirement to create methods and technology that enhance food productivity without having a negative impact on environmental goods and services (Pretty et al., 2006). Sustainable productivity and crop establishment are proxied by high-vigor seeds. The EU seed market was valued at approximately €7 billion in 2012, making up 20% of the global market and placing it third behind the USA and China (Ragonnaud, 2013). Innovative biotech/molecular tools, treatments, or products are essential to accelerating the consolidation of the seed sector in this fiercely competitive economic environment

A tried-and-true method for improving seed quality during the brief activation of the pregerminative metabolism, which involves antioxidant activities and Procedures for DNA repair (Paparella et al., 2015). According to Ventura et al. (2012) and Hussain et al. (2015), seed priming has shown to be a successful method for boosting seed vigour and germination synchronisation, as well as seedling growth and field establishment in unfavourable climatic circumstances. There are several different ways to improve low-vigor seeds, some of which are well-known, such osmopriming and hydropriming. Physical techniques have demonstrated a number of benefits over traditional osmopriming protocols in the context of seed technology

(Bilalis et al., 2012). Based on the use of MFs, one of the most researched physical pre-sowing seed treatments in agriculture.

"Magneto-priming": An Appropriate Incubation Method

The impact of MFs on biological organisms have attracted a lot of interest.Concentrate. As Belyavskaya (2004) points out, the Earth's magnetic field (MF; 50 µT) is actually a natural component of the environment. It is known that one kilogramme $s^{-2}A^{-1}$, or the current flowing with one Coulomb of electric charge every second, is equal to one Tesla (T) unit of magnetic flux density. Krylov and Tarakanova published the first study on MFs' impact on plants in 1960. In their work, a definition of magnetotropism was defined in relation to the auxin-like influence that MFs have on germination-prone seedlings. In the context of seed research, the effects of MFs on seeds have been studied with the overall goal of understanding their relevance to develop new seed therapies.

Pre-sowing magnetic treatments has been shown to improve biomass accumulation and germination characteristics for a variety of plants (Table 1), and Teixeira da Silva and Dobránszki (2015) recently reviewed the literature on the subject. Several MF strengths, ranging from 0 to 300 mT, have been tested in these investigations. Improved germination rates, vigour, seedling biomass, and root growth were observed in magneto-primed seeds. The fact that MFs-treatments seemed to improve tolerance to biotic (De Souza et al., 2006) or abiotic (Javed et al., 2011; Anand et al., 2012) stresses is another intriguing aspect of them.

Predicated on the aforementioned supposition, there has been some focus on comprehending the physiological, biochemical, and molecular processes that underlie the enhanced performance.MFs-treated seeds to produce plants (Vashisth and Nagarajan, 2010; Baby et al., 2011; Javed et al., 2011; Anand et al., 2012). Vashisth and Nagarajan (2010) demonstrated that exposure to magnetic fields (SMFs) appears to function similarly to priming in sunflower (Helianthus annuus L.) seeds, with comparable benefits to seed performance. When compared to untreated seeds, these authors found that magneto-primed seeds had higher alpha-amylase, dehydrogenase, and protease activity during imbibition. The improved seed germination, seedling vigour, and rooting characteristics of seeds treated with SMFs were subsequently connected to the increased activities of hydrolyzing enzymes.

We still don't fully understand how plants sense MFs and control the signal transduction process. According to Ahmad et al. (2007), MF-perception and signalling in plants is mediated by cryptochromes, which are blue light photoreceptors.

Nonetheless, further research on both this area of magnetobiology and the possible genotoxic side effects of MFs is still warranted (Ghodbane et al., 2013). All of these investigations demonstrated the need for more research to broaden our understanding of the molecular mechanisms underlying the acceleration of seed germination, the enhancement of seedling vigour, and the magneto-primed plant's capacity for photosynthetic capacity. Light, humidity, and temperature are examples of environmental elements, often referred to as interdependent factors, that are known to modulate crop and horticulture seed performance. However, it is uncertain what effect their combined application with MFs will have.

This knowledge could be useful in creating novel seed treatments that are tailored to the local environment. Poinapen et al. (2013) investigated how, in a lab setting, the combined effects of MFs and interdependent factors influenced tomato (Solanum lycopersicum L. Var. MST/32) seed viability and performance. In magneto-primed seeds, relative humidity was found to be a critical element regulating seed performance, particularly in the early phases of seed germination and imbibition. These results have implications for optimising magneto-priming protocol development by identifying the best set of physical parameters.

MEDICATIONS USING IONISING RADIATION

Gamma Radiation Is a Potentially Invigorating Method in the fields of agricultural sciences and food technology, ionising radiation is a potent instrument that is widely used to solve concerns related to food microbiological safety and storability (Jayawardena and Peiris, 1988). High-energy infrared radiation with the ability to enter and interact with living tissues is called gamma (γ) radiation.

Cobalt-60 (60C) sources are typically used to provide it (Moussa, 2006). Units of Grey (Gy) are used to express the absorbed dosage of infrared radiation. One Gy dose is equivalent to one Joule of radiation energy adsorbed per kilogramme. The absorbed dosage of infrared radiation (IRs) while interacting with biological material (organism, organ, tissue) can alternatively be expressed in Sievert units (Sv). One Sv dose is equivalent to one Joule radiation energy absorbed per kilogramme of organ or tissue weight. Dose rate, or rate of energy deposition, is another important factor to consider while constructing infrared therapies. It is measured in Gy h^{-1}. Currently, situations requiring a high level of sterilisation are the main uses for γ-rays.

Treatments involving gamma radiation are frequently used to eliminate microbiological contamination or manage diseases and insect pests, thereby preventing disease.

In addition to its safety implications, γ-irradiation is employed to postpone the ripening of fruits and vegetables by obstructing the activation of crucial enzyme activities, therefore prolonging the shelf-life of crops (Mokobia and Anomohanran, 2005; Moussa, 2006). In an alternative agricultural environment plant breeders can effectively add new features to commercially valued crops and create new kinds by using γ-rays as a mutagenic tool (Irfaq and Nawab, 2001). The aforementioned research have collectively demonstrated the value of gammairradiation as a tool in seed technology, as low-dose treatments can effectively function as invigorating agents for seeds. To comprehend the molecular underpinnings of the enhanced growth/development response seen in irradiated seeds, additional research is necessary.

Notwithstanding the previously indicated advantages, gamma-irradiation treatments in the context of seed technology necessitate the proper installation of industrially scaleable γirradiation facilities. Before using this seed invigoration procedure, the ideal treatment conditions (total dose, dose rate), which depend on crop species, genotype, and environmental context, must be established.

The overall findings indicated that increasing the radiation dose did not significantly impair germination or the production of functioning leaves, suggesting that this cultivar may be somewhat radiation-resistant. Additionally, the Microtom cultivar's radio-resistance was reinforced by the mild structural alterations seen in leaves when high doses of X-ray radiation were applied, which resulted in a modest reduction in photosynthetic efficiency. Finding eligible species or seed lots that are resistant to radioactivity can be a significant development for the planning of space-oriented agriculture (Arena et al., 2014).

The current body of information regarding the effects of X-rays on plants is still limited, concentrates on a small number of physiologic features of plants, and requires expansion.Using global profiling methods (e.g., Omics), new information regarding the molecular and physiological mechanisms underpinning plant tissues' resistance to X-rays may become available.

"PRIMING" SEEDS WITH ULTRAVIOLET RADIATION: A DIFFICULT TASK

Even though UV-B radiation makes up only 1.5% of the spectrum, its detrimental effects on plant physiology are well documented. These include damage to DNA, proteins, and

Plant growth and photosynthesis are restricted by damage to membranes (Hideg et al., 2013; Choudhary and Agrawal, 2014). In mash-bean (Vigna mungo (L.) Hepper), the effects of UVB irradiation on seed germination, seedling growth, and plant development were studied (Shaukat et al., 2013). The authors noted a faster rate of germination, but the UV-B treatment had no effect on the ultimate germination percentage. Significantly, negative consequences were noticeable, namely a decrease in root and shoot growth. At the biochemical level, the UVB treatment led to a notable rise in the overall amount of soluble phenols and an improvement in the activities of tyrosine ammonia lyase and L-phenylalanine ammonia lyase. The dearth of knowledge regarding the potential application of UV-B radiation as a therapy for seed vigour may indicate that it is inappropriate for this use.

The electromagnetic spectrum range includes microwaves (MWs), which have the potential to be used in seed technology. Millimetre waves (MWs) are defined as radiation with a frequency range of 300 MHz (300 million cycles per second) to 300 GHz (300 billion cycles per second), or 1 m to 1 mm, in terms of wavelength. This information was reported by Banik et al. (2003). Despite the initial controversy, absorbed non-ionizing electromagnetic radiation, or MWs, is known to have both thermal and non-thermal effects in biological systems (Banik et al., 2003).

The findings demonstrated that the three plant species under study experienced both structural (such as smaller plastids and thinner cell walls) and chemical (such as increased emission of monoterpenes) changes as a result of the applied MWs treatments. It's interesting to note that, although having a larger radiation value, WLAN-frequency microwaves seemed to be more hazardous than GSM-frequency microwaves based on the previously observed characteristics.

ELECTRON METHOD USED TO EXPLAIN THE IMPACT OF PHYSICAL SEED INVIGORATION

A Case study of Paramagnetic ResonanceEPR, also referred to as electron spin resonance (ESR), is a method for both qualitative and quantitative investigation of free radical species with short half lives (10−9–10−1 s), including ROS. This potent instrument, which is currently thought to be among the most sensitive and particular for this use, originated from Zeeman's initial quantum mechanics research (1897). Following their interpretation of these findings, Ulenbeck and Goudsmit (1926) proposed the idea of "spin," or quantitized angular moment, as an inherent property of the electron. Even though Zavoisky published the first EPR spectrum in 1945, EPR was not widely accessible to researchers until the equipment became more affordable and widely available for purchase in the 1980s. This was necessary to support studies on biological systems with transition metals and organic-based radicals (Sahu et al., 2013).

At least one unpaired electron spin inside a molecular orbital is present in an EPR active system. There are two possible quantum states for the electron (M =±1/2). Without MF, the energy of the two quantum states is the same. Applying the MF causes the energy of the +1/2 state to shift and the energy of the −1/2 state to decrease, depending on the strength of the MF. Unpaired electrons have the ability to alter their spin states; these energy absorption-related events are tracked and turned into a spectrum (see to Weil and Bolton, 2006 for the basics of EPR). It remains to be completely explored how this method might be used for high-resolution profiling of radicals in seeds. Historical speaking, EPR made a substantial contribution toComprehend the part free radicals play in the demise of seeds by offering, for the first time, radical species spectra particular to individual seeds.

First identified in old soybean seeds (Priestley et al., 1985), an EPR signal matching to an unidentified organic radical was later verified in dried maize seeds (Leprince et al., 1990, 1995).EPR spectra from these early investigations also showed how temperature and oxygen levels affected ROS-mediated seed damage. One fascinating element of seed viability that EPR examines is the way that the cytoplasmic glassy state alters the mobility or viscosity of molecules, such as soluble carbohydrates.

The integrity of seed plasma membranes has been functionally analysed using electron paramagnetic resonance (Smirnov et al., 1992). These scientists examined the integrity of cellular membranes in wheat embryos using a nitroxide spin probe. The findings demonstrated that in seeds with a moisture level of at least 13%, the cell membrane was semi-permeable to nitroxide molecules. The EPR spectra obtained showed that the membrane function/permeability of the seeds was definitely affected when they were exposed to artificial ageing conditions. The effects of seed ageing on embryo membrane integrity were similarly confirmed by Golovina et al. (1997) in another investigation done with wheat seeds. The study not only showed that the permeability of the embryonic axis' plasma membrane grew more quickly as they aged than did other tissues, but it also established a correlation between the loss of germination and the integrity of the membrane. Using a nitroxyl spin probe approach, Researchers also looked at the vital role membrane permeability integrity plays during imbibition in neem (Azadirachta indica L.) seeds that are susceptible to chilling (Sacandè et al., 2001).

Conclusion

High vigour seeds serve as a stand-in for crop establishment and long-term yield. Physical ways of invigorating seeds offer an alternative to the existing chemical-based approaches for developing

Novel biotechnological approaches to the expanding global seed business.Physical approaches can be applied at a high throughput scale and have environmentally beneficial benefits when utilised to increase seed germination and seedling vigour. Using MFs, MWs, and IRs in treatment is one promising strategy.

As with chemical therapies, the effective use of priming treatments is hampered by the current information gap on pre-germinative metabolism in addition to the lack of facilities suitable for performing bodily remedies. Currently available information about the molecular mechanisms behind physical seed invigoration is shallow. Very little information was available about biochemical or gene expression changes that occurred, and the majority of the research were limited to evaluating the effects of various radiation treatments that were administered. The industry's attempt to deploy physical seed invigoration regimens is hampered by the lack of biomarkers linked to the optimal dose of radiation or the moment at which treatment should be discontinued.

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MANAGEMENT OF STORED PEST IN BLACK GRAM

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Abstract

Post- harvest losses and quality deterioration are mostly caused by various biotic and abiotic limitations. Rodents, fungus and insect pests are the most common biotic agents that impair storage of seeds. Insects cause direct or indirect damage to commodities by devouring the seeds. The primary economic loss caused by storage insect pests is grain consumption, as well as food contamination. Post-harvest damage caused by numerous insect pest is effectively minimized by integrated pest management which includes practising improved storage technologies, proper sanitation, using improved storage structures, various grain protectants and fumigants.

Introduction

Biological factors are the primary cause of postharvest crop losses in developing countrie s. In general, postharvest crop loss during storage in developing countries ranges from 5 to 10. In tropical countries, the worst damage to stored commodities and seeds occurs. However, Becauseof the high added value of seeds and the low economic injury level, serious economics damages may occur in developed countries. Stored seeds are susceptible to pests.

Seeds are marketed and moved over vast distances, resulting in the repeated introduction of invasive stored seed pests and their global expansion. Pests that infest stored grains are divided into two groups based on grain injury patterns: secondary pests and primary pests. "Secondary pests" are externally feeding groups of stored-product arthropod (mites and insects) pests that primarily injure the seed germ.

Major insect pests attacking seeds

S.No.	C. Name	Scientific Name	Family	Order	Host
1	Rice weevil	*Sitophilus oryzae S.zeamais, S.granarius*	Curculionidae	Coleoptera	Rice & Maize
2	Khapra beetle	*Trogoderma granarium*	Dermestidae	Coleoptera	Rice, pulses, oil seeds
3	Lesser grain borer	*Rhyzopertha dominica*	Bostrichidae	Coleoptera	Paddy, rice, wheat, maize.
4	Angoumois grain moth	*Sitotroga cerealella*	Gelechiidae	Lepidoptera	Paddy, maize, barley and wheat
5	Pulse beetle	*Callosobruchus chinensis, C.maculatus*	Chrysomelidae	Coleoptera	All whole pulses, beans and grams.
6	Tamarind bruchid	*Caryedon serratus*	Chrysomelidae	Coleoptera	Tamarind & Groundnut

Management

To effectively manage storage insect pests, an integrated pest management approach shou ld be used, which includes sanitation of the storage facility, seed cleaning prior to storage, pest in cidence monitoring, temperature and moisture control inside and outside the storage structure/are a, and the use of grain protectants as needed

Sanitation

Sanitation of the storage facility, both inside and outside, as well as neighbouring habitats, in order to eliminate pest stages and habitat. Sanitation helps to avoid pest population growth and further damage. When new seeds or storage commodities arrive in the facility, it is best to remove old or infested seeds. Always use pest-free storage containers (bins, jute bags, etc.). To avoid pest population spread, cracks and gaps in godown floors and walls, as well as other pest-infested areas, must be addressed. Before storing any commodities for an extended period of time, it is usually recommended to apply a preventive spray to warehouses or storage buildings. Insecticides such as deltamethrin 2.5 WP (40 g/l) and Malathion 50 EC (1% or 3 liter/100m2) can be used.

Sun drying of seeds

The most popular method used before storing any seeds is sun drying. By using this method, the amount of storage losses caused by mold, discoloration, respiration, and insect damage is reduced. The moisture content may change according on how long the storage period is kept. Ensuring equal aeration within the storage structure is ensured by properly cleaning the grains prior to storage. Aeration done correctly helps to lower the likelihood of fungus growth. Cleaning grains also aids in getting rid of weeds, pests, and unwanted seeds from other crops. Above all, seed washing improves the efficiency of management techniques like as fumigation.

Seed protectants

In order to eradicate insect pests from storage warehouses and buildings, grain protectants mostly employ contact insecticides. The insecticides can be applied as a preventative or remedial control strategy. To destroy cowling insect stages, prescribed quantities of insecticides such as Malathion 50% EC and deltamethrin 2.5% WP are applied to walls, floors, alleyways, and surface grain sacks. After 15 days, 3 litres of the diluted malathion 50% EC solution are sprayed on a 100 square meter surface area. The solution is diluted 1:100 with water. Similarly, after 90 days, 3 ltrs of an emulsion are sprayed on a surface area of 100 square meters after 40 grams of deltamethrin 2.5% WP has been dissolved in 1liter of water. Grain stacks or godowns can be fumigated with fumigants like phosphine at the recommended amount for curative control. Grain stacks should be covered with gas-proof fumigation coverings, or storage containers should be sealed airtight for optimal fumigation results. You can combine dried Neem/Margosa leaves with seeds and store them in bins or gunny bags. One kilogram of pulses can be combined with 200 grams of regular table salt to store for six to eight months. To ensure that the soil completely clings to the seeds, pour the red soil and water into a container, then add the seeds and stir well. Seeds can be saved for later and then placed in a gunny bag.

Storage structures

The fundamental idea behind storage structures is to keep moisture and air from migrating and preventing any living thing from getting access to oxygen while being stored. Grain storage structures are typically grouped according to factors like material availability, storage capacity, the structure's economics, etc. These factors allow the storage buildings to be categorized as either above-ground or below-ground, indoor or outdoor, bins or pots made of mud, wood or bamboo storage structures, iron drums, bins, or containers, or straw from wheat and paddy fields. In India, traditional storage systems made of bricks, bamboo, wood, mud, cow dung, or paddy or wheat straw are used to store between 59 and 70 percent of the country's grain. Here, storage is possible beneath, inside, or outside.

Conclusion

Proper maintenance of storage facilities, ongoing observation, and application of appropriate preventive and curative actions are crucial to preventing seed losses. To improve the nation's current storage pest management, it is imperative that public-private partnerships be formed in order to expand the country's current storage capabilities through various means, including building new ones. The implementation of novel grain storage solutions, such as silo storage, controlled environment storage, and integrated pest management strategies, can significantly lower preservation costs and increase the amount of contamination-free seed accessible.

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TEMPERATURE EFFECTS ON GREEN GRAM

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Introduction

Green gram, also known as mungbean (*Vigna radiata*), is a vital legume crop widely cultivated in tropical and subtropical regions. It is rich in high protein content and able to fix atmosphere nitrogen, enriching soil fertility. Understanding how temperature affects the growth, development, and yield of green gram is crucial for optimizing its cultivation and ensuring food security, especially in the context of climate change. Pulses are high in protein and have been identified as the primary protein source for Indian vegetarians. It is the second important component of the Indian diet, following cereals. Green gram, a significant pulse crop, is important in agriculture due to its low input requirements and capacity to carry out symbiotic nitrogen fixation in order to restore soil fertility. This crop is significant, especially for resource-constrained farmers, due to its short crop length and broad adaptation to various environments and soil types. It is a key pulse crop in India, accounting for more than 60% of global acreage and 50% of production. Crops such as green gram, which are farmed mostly on marginal areas and in rainfed circumstances, are thus more vulnerable. Under atmospheric stress by high temperature, improving agricultural productivity will be a huge challenge for the farming community. As a result, it is critical to gather information about the susceptibility of green gram genotypes to higher temperatures by screening and choosing acceptable genotypes.

Temperature Requirements for Green Gram

Optimal Temperature Range

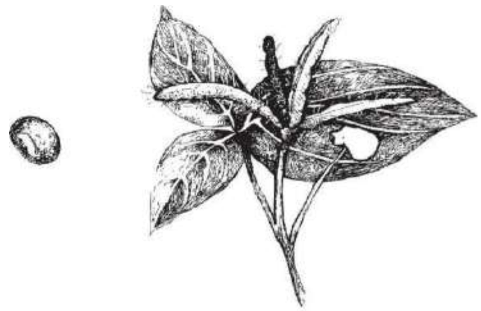
Green gram thrives in a temperature range of 25-35°C. The ideal temperature for possible green gram yield is 28-30°C. A temperature range of 27 to 32°C was found to be optimal for reproductive development in green gram, whereas higher temperatures during delayed planting significantly reduced pod number. Green gram seeds germinated 52% at 32°C, 43% at 21°C, and none at 10°C. Heat stress in nodules can influence nitrogenase activity, decreasing efficiency of fixing nitrogen accelerating senescence, leading to shorter nodule lifespan. This range supports optimal physiological and biochemical processes, including photosynthesis, respiration, and enzyme activities essential for growth and development.

Germination

- **Ideal Temperature:** 25-30°C
- **Effects of Suboptimal Temperatures:**
  - **Below 20°C:** Germination rate decreases significantly, leading to poor seedling vigor.
  - **Above 40°C:** Seeds may experience heat stress, reducing germination percentage.

Vegetative Growth

- **Optimal Growth Temperature**: 25-35°C
- **Effects of Temperature Variations:**
  - **Below 20°C**: Slower vegetative growth, reduced leaf area, and lower biomass accumulation.
  - **Above 35°C:** Increased transpiration rates, potential for water stress, and reduced photosynthetic efficiency.



Flowering and Pod Formation

- **Critical Temperature:** 25-30°C
- **Effects of Deviations:**
  - **Below 25°C:** Delayed flowering, reduced flower number, and poor pod set.
  - **Above 35°C**: Flower drop, reduced pollen viability, and poor pod formation due to heat stress.

Maturity and Yield

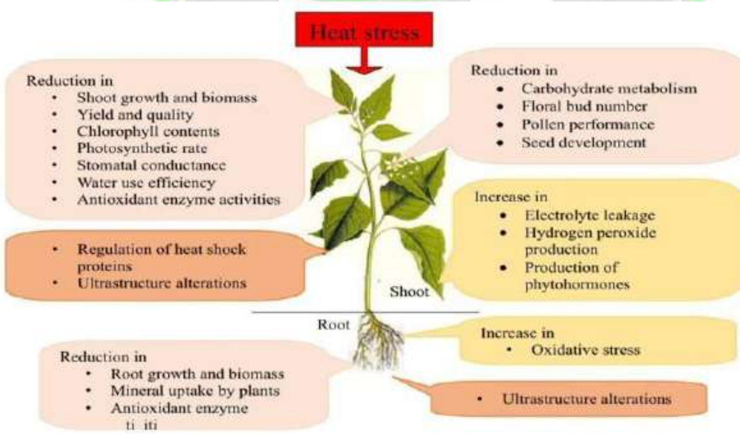
- **Optimal Temperature:** 25-30°C
- **Effects of Temperature Extremes:**
  - **High Temperatures (Above 35°C):** Accelerated maturity, leading to shorter growing periods and potentially lower yields. Extreme heat can cause seed abortion and poor grain filling.
  - **Low Temperatures (Below 20°C):** Prolonged maturity period, increased susceptibility to diseases, and potential frost damage in colder regions.

Physiological and Biochemical Impacts

Green gram's low production can be attributed to its short crop duration and susceptibility to several abiotic stressors. Temperature is a crucial factor influencing the productivity and quality of legumes, notably green gramme. High temperatures have a deleterious impact on photosynthesis, respiration, water relations, and membrane stability, as well as hormone and primary/secondary metabolite levels in field crops. High temperature stress cause floral loss and reduced yield. During the flowering phase in legumes, flower loss increases due to high temperatures, precipitation, or desiccating winds. The crops low production is owing to bud shedding and flowers, which results in limited pod development.

Photosynthesis

Temperature directly affects the rate of photosynthesis in green gram. Optimal temperatures (25-35°C) ensure maximum photosynthetic efficiency. High temperatures can lead to stomatal closure to reduce water loss, subsequently limiting CO_2 uptake and reducing photosynthesis.



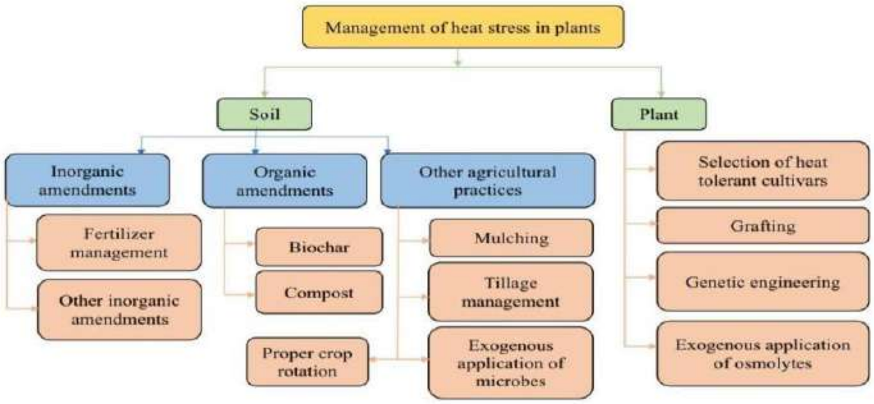
Respiration

Respiration rates increase with temperature. While moderate temperatures support growth by providing energy, excessive heat (above 35°C) can lead to a higher rate of respiration than photosynthesis, depleting energy reserves and affecting plant growth.

Water Relations

Temperature influences transpiration rates and water use efficiency. High temperatures increase transpiration, which can lead to water stress if not managed with adequate irrigation. Proper water management is crucial in high-temperature regions to maintain optimal growth.

Adaptation and Mitigation Strategies



Breeding and Selection

- **Heat-Tolerant Varieties:** Developing and selecting green gram varieties with enhanced heat tolerance and stress resilience can mitigate the adverse effects of high temperatures.
- **Early-Maturing Varieties:** Cultivating early-maturing varieties can help avoid exposure to peak summer temperatures and reduce the risk of heat stress during critical growth stages.

Agronomic Practices

- **Optimal Sowing Time:** Adjusting sowing dates to ensure that critical growth stages do not coincide with extreme temperatures.
- **Mulching**: Using organic mulches to regulate soil temperature and conserve moisture.
- **Irrigation Management:** Implementing efficient irrigation practices to maintain soil moisture and reduce heat stress.

Climate-Smart Agriculture

- **Agroforestry Systems**: Integrating trees with green gram cultivation to provide shade and reduce temperature extremes.

- **Crop Rotation:** Rotating green gram with other crops to maintain soil health and reduce pest and disease incidence, which can be exacerbated by temperature stress.

Conclusion

Temperature plays a crucial role in determining the growth, development, and yield of green gram. Understanding the temperature requirements and stress thresholds of green gram is essential for optimizing its cultivation, especially in the face of climate change. Implementing adaptive strategies, such as breeding heat-tolerant varieties and adopting climate-smart agronomic practices, can help mitigate the adverse effects of temperature fluctuations and ensure sustainable green gram production.

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SEED GERMINATION AND DORMANCY

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Abstract

Seed germination and dormancy are critical phases in the life cycle of plants, significantly influencing their survival and propagation strategies. Germination is the process by which a seed embryo resumes growth after a period of dormancy and emerges as a seedling, while dormancy is a state in which seeds are prevented from germinating despite the presence of favorable conditions. This abstract synthesizes contemporary research, highlighting the physiological, genetic, and environmental factors that regulate these processes, with insights from various authors.

Introduction

Seed germination and dormancy are pivotal to understanding plant ecology, evolution, and agricultural productivity. "Seed germination is a critical process involving the reactivation of metabolic pathways leading to the growth of the embryo." Dormancy, on the other hand, acts as a protective mechanism that allows seeds to withstand unfavorable conditions *(Finch-Savage and Leubner-Metzger (2006)),*. "Seed dormancy is an adaptive trait that synchronizes germination with optimal environmental conditions, ensuring seedling survival." (*Bewley et al. (2013*))

PHYSIOLOGICAL AND GENETIC REGULATION OF GERMINATION:

The germination process begins with imbibition, where water uptake reactivates the seed's metabolic machinery. Hormonal balance plays a crucial role in this transition. *Nonogaki*

(2014) notes, "The interplay between abscisic acid (ABA) and gibberellins (GA) is central to seed germination, with GA promoting and ABA inhibiting the process." *Koornneef et al. (2002)* further elaborate, "Mutants impaired in ABA synthesis or signaling demonstrate reduced dormancy and precocious germination, highlighting ABA's inhibitory role."

PHASES OF SEED GERMINATION

Seed germination is a complex, multi-phase process that involves the transition of a seed from a dormant state to active growth, culminating in the emergence of a seedling. This process is highly regulated and influenced by a variety of physiological, biochemical, and environmental factors. The phases of seed germination can be broadly categorized into three main stages: imbibition, lag phase (or metabolic activation), and radicle protrusion. This analysis integrates insights and quoted lines from various authors to provide a comprehensive understanding of each phase.

1). IMBIBITION PHASE

Water Uptake Dynamics: Seeds absorb water through osmosis, leading to an increase in seed volume. This process can be rapid and is influenced by the seed coat's permeability. *Bewley and Black (1994)*, "The rate of water uptake during imbibition is largely dependent on the seed's initial moisture content and the surrounding environmental conditions."

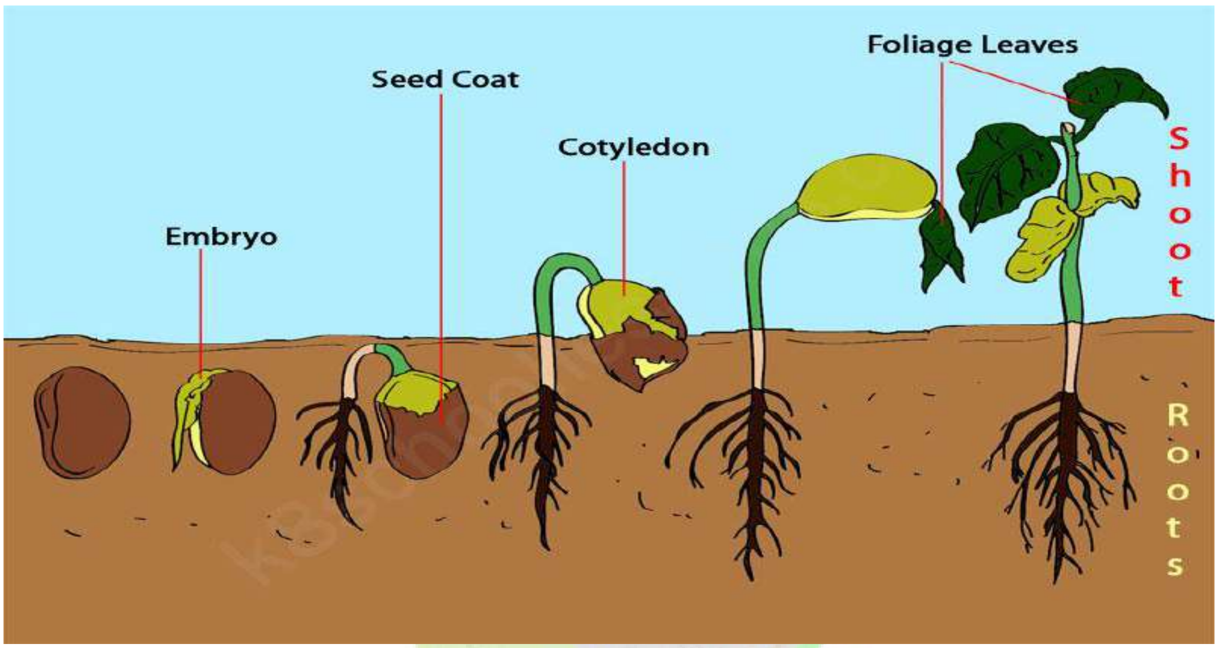
Biophysical Changes: Imbibition causes significant biophysical changes, including swelling of the seed and increased turgor pressure. *Finch-Savage and Leubner-Metzger (2006)* "The initial phase of water uptake can create mechanical stress on the seed coat, sometimes leading to its rupture, which is a critical step for germination."

2). LAG PHASE:

Metabolic Shifts: During the lag phase, the seed undergoes a series of metabolic shifts. "Respiration rates increase as mitochondrial activity is restored, leading to the production of ATP necessary for cellular processes," *Bewley (1997).* Mobilization of Reserves: Stored food reserves in the form of starches, proteins, and lipids are mobilized to support the developing embryo. *Bradford (1990)*"The hydrolysis of stored macromolecules provides the necessary substrates for the biosynthetic activities of the growing seedling. "Regulatory Mechanisms: Hormonal regulation is paramount during this phase. *Koornneef et al. (2002)* "The reduction in ABA levels and the increase in GA levels are critical hormonal signals that facilitate the transition from dormancy to germination."

3). RADICLE PROTRUSION:

Cell Wall Modification: Enzymes such as cellulases and pectinases modify the cell walls, allowing for cell expansion and radicle growth. *Nonogaki (2010)*, "Cell wall-loosening enzymes play a pivotal role in enabling the radicle to penetrate the seed coat." Energy Utilization: The energy derived from the breakdown of food reserves is utilized for the synthesis of new cellular components. *Taiz and Zeiger (2010)*, "ATP generated from respiration drives the biosynthetic activities necessary for cell division and elongation."



ENVIRONMENTAL INTERACTION:

Environmental conditions such as temperature, light, and soil moisture continue to influence the germination process. "Optimal environmental conditions are essential for the successful emergence of the radicle and subsequent seedling establishment," *Finch-Savage and Leubner-Metzger (2006).*

MOLECULAR MECHANISMS OF DORMANCY:

Dormancy involves complex molecular mechanisms, including hormonal regulation and epigenetic modifications. *Finkelstein et al. (2008)*, "ABA is a key hormone maintaining seed dormancy, controlling the expression of genes associated with desiccation tolerance and metabolic arrest." Furthermore, chromatin remodeling and histone modifications are significant.

Graeber et al. (2012), "Epigenetic regulation through histone modification and DNA methylation plays a crucial role in maintaining dormancy and regulating germination."

ENVIRONMENTAL INFLUENCES:

Environmental cues such as temperature, light, and moisture significantly impact seed dormancy and germination. *Baskin and Baskin (2014)*, "Temperature fluctuations serve as a primary signal to break dormancy, often mediated through changes in hormone levels." Light also plays a vital role, with phytochromes acting as sensors. *Debeaujon et al. (2000)*, "Phytochromes regulate seed germination by modulating ABA and GA levels, thus influencing the dormancy status."

ECOLOGICAL AND EVOLUTIONARY PERSPECTIVES:

Seed dormancy and germination strategies are crucial for plant adaptation and survival across diverse environments. These strategies ensure that germination occurs under optimal conditions, enhancing the likelihood of seedling survival. *Vleeshouwers et al. (1995)*, "The evolution of dormancy mechanisms is an adaptive response, allowing seeds to avoid germination during unsuitable conditions, thereby increasing species persistence and ecological success." Different species exhibit varied dormancy types, reflecting their evolutionary adaptations to specific ecological niches.

TYPES OF SEED GERMINATION

Seed germination can be classified into different types based on the growth patterns and emergence of seedling structures. The primary types of seed germination are epigeal and hypogeal. This detailed analysis integrates insights and quoted lines from various authors to elucidate these types and their characteristics.

EPIGEAL AND HYPOGEAL GERMINATION:

1). EPIGEAL GERMINATION:

Hypocotyl Growth: The hypocotyl elongates, raising the cotyledons above the soil. The cotyledons often turn green and become photosynthetically active. "The primary function of the hypocotyl elongation is to lift the cotyledons above the ground, where they can contribute to photosynthesis," *Fenner and Thompson (2005)*. Energy Source: Initially, the seed's endosperm or cotyledonary reserves provide energy for growth. As the cotyledons reach the surface and become green, they start photosynthesizing. Bewley and Black (1994), "The cotyledons transition from storage organs to active photosynthetic structures during epigeal germination."

Adaptation: This type of germination is advantageous in conditions where light is abundant, allowing the cotyledons to quickly start photosynthesis and support the young seedling's growth. Baskin and Baskin (2014), "Epigeal germination is often found in species adapted to environments with plentiful light, where rapid photosynthetic activity is beneficial."

2). HYPOGEAL GERMINATION:

Epicotyl Growth: The epicotyl elongates, pushing the plumule (the young shoot) above the soil surface while the cotyledons remain below. Esau (1977), "The epicotyl's elongation ensures that the plumule emerges first, protecting the delicate cotyledons."

Nutrient Storage: The cotyledons act as a nutrient source for the developing seedling, often remaining protected underground. Mayer and Poljakoff-Mayber (1989), "The subterranean cotyledons provide a sustained source of nutrients, supporting the seedling until it can photosynthesize independently."

Adaptation: Hypogeal germination is advantageous in environments where early photosynthesis is less critical, or where protecting the nutrient-rich cotyledons from herbivores and environmental stress is beneficial. Copeland and McDonald (2001), "This germination type is common in species where protecting the nutrient reserves is crucial for seedling survival.

TYPES OF SEED DORMANCY

1). PHYSIOLOGICAL DORMANCY:

Regulation by Hormones: Bewley and Black (1994), "The balance between ABA and GA is crucial in maintaining and breaking physiological dormancy."

Environmental Influence: Finch-Savage and Leubner-Metzger (2006) the environmental triggers, "Temperature and light are significant environmental cues that influence the breakdown of physiological dormancy through hormonal changes."

2). MORPHOLOGICAL DORMANCY:

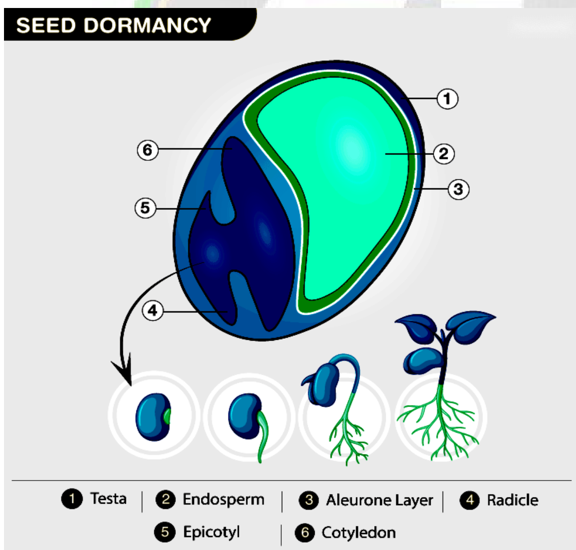
Embryo Immaturity: Baskin and Baskin (2004)the nature of morphological dormancy, "Seeds with morphological dormancy contain embryos that are not fully developed and require time to mature."Growth Conditions: Bewley et al. (2013) the role of environmental conditions, "Suitable temperature and moisture are critical for the growth of immature embryos in morphologically dormant seeds."

3). PHYSICAL DORMANCY:

Seed Coat Barrier: Mayer and Poljakoff-Mayber (1989)the impermeable nature of the seed coat, "Physical dormancy results from a hard seed coat that prevents water and oxygen uptake, essential for germination." Methods to Break Dormancy: Baskin and Baskin (2014) discuss scarification methods, "Mechanical and chemical scarification techniques are used to break physical dormancy by altering the seed coat structure."

4). COMBINATIONAL DORMANCY:

Dual Mechanisms: Fenner and Thompson (2005) the complexity of combinational dormancy, "Seeds exhibiting combinational dormancy require treatments addressing both physical and physiological dormancy mechanisms." Sequential Treatment Requirement: Bewley et al. (2013) describe the process, "Sequential treatments, such as scarification followed by cold stratification, are often necessary to break combinational dormancy." Seed dormancy is a natural mechanism that prevents seeds from germinating under unfavorable conditions.

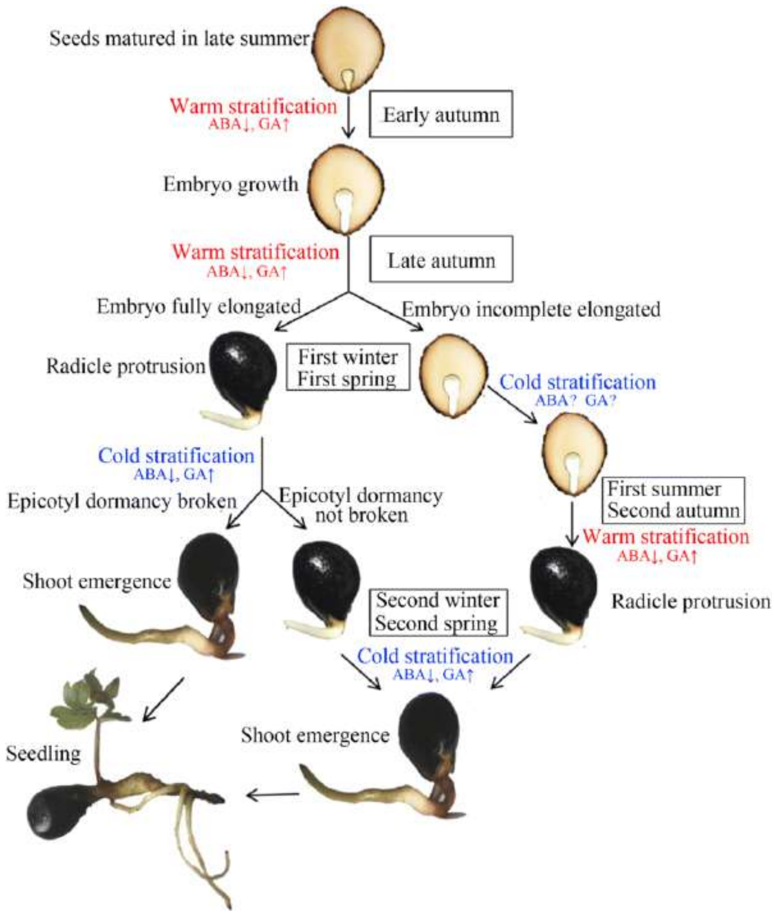


DORMANCY BREAKING METHODS

1. STRATIFICATION (COLD AND WARM)

Cold Stratification: Exposing seeds to cold temperatures for a specific period to simulate winter conditions."Cold stratification involves exposing seeds to moist chilling conditions, typically around 1-5°C, for several weeks to months, which helps in breaking dormancy by mimicking natural winter conditions." (Bewley et al., 2013)

Warm Stratification: Exposing seeds to warm temperatures before cold treatment to mimic seasonal changes."Warm stratification at temperatures of 20-30°C for several weeks, followed by cold stratification, has been shown to effectively break dormancy in species that experience both warm and cold periods before germination." (Finch-Savage & Leubner-Metzger, 2006)



2. SCARIFICATION (MECHANICAL, CHEMICAL, AND THERMAL)

Mechanical Scarification: Physically damaging the seed coat to allow water and gases to penetrate."Mechanical scarification, such as rubbing seeds with sandpaper or nicking the seed coat with a knife, can break physical dormancy by allowing moisture to enter and trigger germination." (Hartmann & Kester, 2014)

Chemical Scarification: Using chemicals like sulfuric acid to erode the seed coat. "Chemical scarification with concentrated sulfuric acid is a common method to break hard seed coats, as it effectively weakens the outer layers, allowing imbibition and germination." (Nikolaeva et al., 1985)

Thermal Scarification: Exposing seeds to hot water or direct heat to break the seed coat."Thermal scarification, involving brief immersion in hot water or exposure to direct heat, can crack or weaken seed coats, thus breaking physical dormancy in certain species." (Baskin & Baskin, 2014)

3.HORMONAL TREATMENTS

Gibberellic Acid (GA3): A plant hormone that promotes seed germination. "Application of gibberellic acid (GA3) has been widely used to break dormancy in various seeds, as it mimics the natural hormonal cues that trigger germination." (Khan, 1977)

Cytokinins: Another class of plant hormones that can promote germination. "Cytokinins have been shown to overcome certain types of dormancy, particularly in seeds that require light for germination, by promoting cell division and expansion." (Hilhorst & Karssen, 1992)

4.LIGHT TREATMENTS

Red Light: Certain seeds require light, especially red light, to break dormancy. "Exposure to red light can break photodormancy in some seeds, as it activates phytochrome, a light receptor that triggers germination processes." (Smith, 1982)

5. LEACHING

Water Leaching: Washing seeds to remove chemical inhibitors."Leaching seeds with water can remove inhibitory compounds that prevent germination, such as phenolics and abscisic acid, thus breaking dormancy." (Bewley & Black, 1994)

6. FIRE AND SMOKE

Heat and Smoke Compounds:** Simulating natural fire conditions that some seeds need to germinate. "Many species in fire-prone environments have evolved to require heat or smoke for dormancy breaking, with smoke containing chemicals like karrikins that stimulate germination." (Flematti et al., 2011). These methods highlight the diversity in seed dormancy mechanisms and the corresponding techniques to overcome them, as discussed by various researchers in the field.

Conclusion

Understanding the complex interplay between genetic, hormonal, and environmental factors that regulate seed germination and dormancy is vital for improving agricultural practices and conserving plant biodiversity. As Finch-Savage and Leubner-Metzger (2006) conclude, "Advancing our knowledge of the molecular and physiological basis of seed dormancy and germination will pave the way for the development of strategies to enhance seed performance and crop yields." The types of seed germination, primarily epigeal and hypogeal, exhibit distinct physiological and morphological traits that cater to different environmental adaptations and survival strategies. Understanding these processes provides valuable insights into plant development and can aid in optimizing agricultural practices. The process of seed germination is a highly coordinated sequence of events encompassing water uptake, metabolic activation, and radicle protrusion. Each phase is regulated by a complex interplay of physiological, biochemical, and environmental factors. As Finch-Savage and Leubner-Metzger (2006) summarize, "Understanding the intricate mechanisms underlying seed germination can provide valuable insights into plant biology and enhance agricultural practices." Understanding the various types of seed dormancy—physiological, morphological, physical, and combinational—is essential for optimizing germination processes in agriculture and horticulture. Each type of dormancy has specific mechanisms and requirements for breaking dormancy, reflecting the complex strategies plants use to survive and propagate in diverse environments.

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IOT BASED SEED SOWING

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Introduction

Over the last forty years, India's agricultural record has advanced fairly significantly. The growing need for food has been successfully met by the agriculture industry. Over the previous two decades, productivity gains have accounted for nearly all of the output increases, with increased land area under agricultural production contributing less and less to overall production growth. There has been a broad contribution of agricultural expansion to overall progress. Productivity growth has improved farm income, helped feed the impoverished, and opened up employment options for both direct and indirect workers. There are several factors that contribute to India's agricultural prosperity.

PROBLEM STATEMENT

The majority of nations currently lack enough skilled labor in the agricultural sector, which hinders the development of developing nations. As a result, modern technology must be used by farmers for all agricultural tasks (such as seeding, fertilizing, spraying, and digging).

Comparative Analysis of Seeding Devices against Traditional Sowing Methods: A Performance Evaluation":

Harvest yield: Due to improved plant establishment and appropriate input application, studies conducted across the nation have demonstrated that the

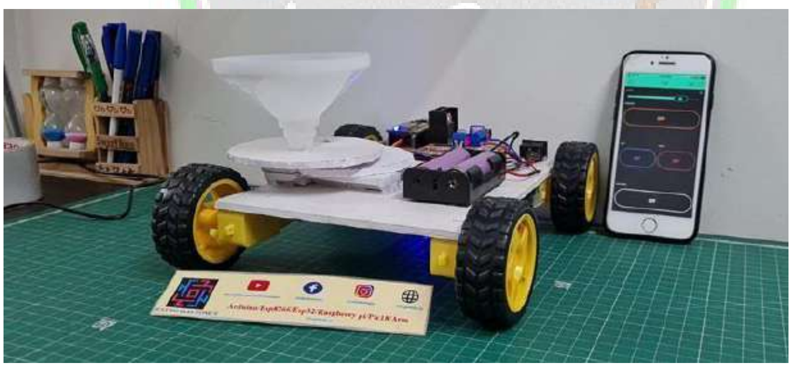
Comparing conventional seeding methods with the use of seeding devices in rainfed areas has increased agricultural yields by 10 to 20 percent.

Energy saving: Energy-conserving A study found that compared to sowing behind the plough, using a three-row bullock hauled ferti-seed drill for wheat crop reduced man hours and bullock hours by 76.37 percent and 59.92 percent, respective**.**

Line Sowing: This technique uses a seed drill or ferti-seed drill to plant seeds. This tool allows seeds to be dropped at a consistent depth, which promotes uniform germination and a steady stand. For the purpose of using a seed drill or ferti-seed drill, the seed bed has to be smooth, level, and free of weeds and clods.

Weed Mapping: The process of using machine vision algorithms to map the locations and, ideally, the biomass (density) of different plant species is known as "weed mapping." One method is to observe solely the increased leaf area in areas with patches of weeds and rows of crops**.**

Robot type Weeding : automated weeding There are several ways to eradicate, eliminate, or slow down these undesirable plants depending on the location and intensity of the weeds . One might employ several physical techniques that necessitate direct physical contact with the herb.

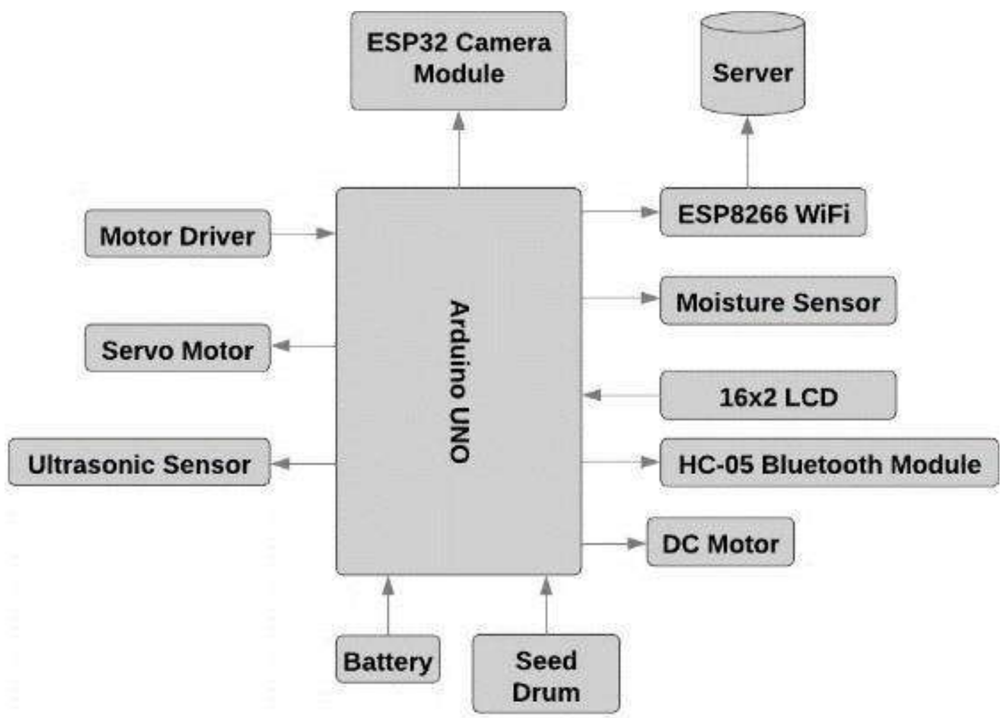


SELECTIVE HARVESTING:

Pick-and-Pull judicious harvesting The idea of is just gathering crop portions that satisfy specific quality standards. It may be seen asa particular kind of presorting depending on sensory perception. Examples include picking and harvesting fruits and vegetables that fit a size requirement, combining grain that is sufficiently dry (and letting the remainder dry out), and harvesting barley only when it has a specified protein level.

RAIN SENSOR:

An automatic irrigation system can be equipped with a rain sensor or rain switch, which is a rain-activated switching device. The rain sensor has two primary uses: first, it can be connected to a water-saving device and used to trigger the system's shutdown when it rains.



Block Diagram of IoT-Based Automatic Seed Sowing and Plant Nutrition System**.**

Advantage

1. Not required more skill to operate .
2. Automated Seed Sowing, in conjunction with RF technology, interfaces with the Warehouse Control System or Warehouse Management System to enhance accuracy and efficiency, greatly simplifying installation.
3. Reduction in labor requirements Transportation flow optimization based on mission, traffic, and vehicle fleet.

Disadvantage

1. The extreme temperature and vibrations are too much for electronics components to withstand.
2. Because of the clod and dirt, accuracy should be reduced.

Conclusion

This system's automatic method of seeding is its primary feature. The correct order in which the seeds are sown ensures effective seed germination. This robotic method of autonomous seed planting lowers the need for manpower. In this case, there has also been a significant decrease in seed waste. This technology was created to automatically plant seeds. Here, a robot is used to help disseminate the seeds in the soil in a suitable order, decreasing the amount of seeds wasted. The Seed Sowing V robot has been utilized to implement the autonomous planting operation for the onion crop. The farmers will be able to farm more effectively with the assistance of this robot. Any other type of crop, including fruits, rice, sugarcane, etc., might be added to the project. An alternative to using regular wheels for the robot's design is to use a chain roller. It can thus be used in the real-time agriculture industry.

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QUALITY SEED PRODUCTION TECHNIQUES IN BLACK GRAM

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Abstract

Black gram is a legume crop, which is one important staple food crop of India. The production of quality Black gram seed production has been improved in more scientifical way than the primitive, which produces increased yield for a fine seed production. We require good land preparation, water resource, optimum seed rate for optimum population. Standard dosage application of fertilizer (20:40:40). Rouging of off types, voluntary crops, weeds. Required plant protection activities for several pest and diseases. Harvesting the crops when the plant shows harvesting index of drying of plant and pods. Dry the seeds up to optimum moisture content of 8 to 10 percent for storage.

Introduction

Black Gram (*Vigna mungo)* is popularly cultivated in India. It was introduced from southern united states. It is a leguminous pulse widely cultivated for its rich great source of protein (20.8 to 30.5%), so, we must expand the production of black gram cultivation for healthy life. Which has wide variety of nutrients like vitamin B1, 2,3,6,9. It was cultivated as sole crop or inter crop. It was popular for fermenting actions.

SOIL REQUIREMENT:

It may be grown in a range of soil types, including heavy cotton soil and sandy soil. The ideal soil was a well-drained loam with a pH of 6.5 to 7.8.

PREPARATION OF LAND:

The land utilized for seed production ought to be devoid of any volunteered plants. Use a tractor or animal drawn plow the land to a depth of 15-20 cm, breaking up soil clods and improving soil aeration. The land should be prepared well by harrowing to ensure uniform water distribution and proper drainage. Create raised bed or ridges for soil tends to retain excess moisture.

METHOD OF SOWING:

Pests and diseases should not be present in seed. It should be bought from accredited seed firms, universities, KVKs, and agricultural research stations. For spring and summer crops, the seed rate is 25 to 30 kg per hectare; for kharif and rabi season crops, it is 15 to 20 kg per ha. Black gram seeds can be sown either by broadcasting or line sowing methods.

. Broadcasting: Spread the seeds evenly across the prepared field by hand or using mechanical seed broadcasters. After broadcasting, cover the seeds lightly with soil by running a harrow or by light ploughing.

2. Line Sowing: Create furrows or lines using a plough or tractor. Drop the seeds uniformly along the lines at the recommended spacing. Cover the seeds lightly with soil using a harrow or by hand. spacing for line sowing has been mentioned below,

A) season of kharif and rabi crop:

- Row to Row - 30 to 45 cm
- Plant to plant- 7 to 10 cm

B) season of spring and summer crop:

- Row to Row- 20 to 25 cm

- Plant to plant-7 to 10 cm

ISOLATION:

Keep a 5-meter buffer between the same crop variety and various types throughout the field in order to produce certified, high-quality seed.

FERTILIZER MANAGEMENT:

Use 15-20 kg of nitrogen, 40–50 kg of phosphorous, and 30–40 Kg of potash per/ha and 20 kg/ha of sulphur during the final ploughing for a solitary crop. Calcium and sulphur would be readily available at reasonable rates if gypsum was used at a rate of 100 kg/ha.

IRRIGATION:

Irrigation is especially needed for the spring and summer crop. Irrigation is usually not needed for kharif crop. There may be need for one or two irrigations, if the dry period is prolonged.

WEED MANAGEMENT:

Depending on the strength of the weed, 1-2 hand weeding should have been done up to 40 days after seeding. Herbicides, such as Fluchloralin (Basalin), can be used to control weeds. Apply 1 kg / ha in 800-1000 litres of water prior to planting.

PROTECTION OF PLANTS:

For control a flea beetle with a characteristic of shot hole symptoms we can spray chloropyrifos 50%+ cypermethrin 5% pesticide. Apply Emamectin benzoate 5% for control the leaf webber. Spray a systemic insecticide to control the spreading of mosaic virus spread by white flies. Dust sevin (10%) or 25 kg/acre of folidol dust is effective against caterpillars and pod borers. To reduce cercospora and anthracnose Apply 1.25 kg to 2.50 kg of COC to 625 L of water, when first signs appear. dry root rot, treat the soil with 5 kg of COC per hectare in 250 litres of water. Apply 25 kg of fine sulphur per hectare, for controlling the powdery mildew. Use 2.5 kg of wettable sulphur per acre or 2.5 kg of fine sulphur dust every 15 days to reduce rust.

ROGUING

Periodically, if needed, the severely diseased and off-type plants should be removed.

HARVESTING:

When the beans grow firm and dry and the pods and plants have dried, black gram cultivation is harvested. During harvesting it should have atleast 20 to 22% of moisture required.

Black gram pods should harvested immediately, when it matures. To protect the seeds, threshing can be done by hand.

YIELD:

A Well managed crop can produce 10 to 15 qtl of grains per ha.

STORAGE:

1. Save the seed for 8–9 months of short-term storage in gunny or cloth bags with an 8–9% moisture content.
2. Save the seeds for 12 -15 months of medium term storage in polylined gunny bags with an 8–9% seed moisture content.

Save the seeds more than 15 months of longer term storage in 700 gauge polythene bags with a seed moisture level of less than 8.

Conclusion

By adapting the above mentioned production technology for seed production with adequate care, healthy viable and vigorous seed can be produced. Which yields higher income and higher quality seeds for sowing.

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SEED CERTIFICATION

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Introduction

As a standard practice to preserve high-quality seeds, seed certification is in fact an essential step in the production and selling of seeds. Standards and making them available to farmers in order to preserve a high-quality yield. Under this technique, different crop kinds are often produced with the goal of verifying the seed's physical identification, qualities, viability, and purity.

SEED CERTIFICATION

As a means of upholding high standards for seed quality and providing farmers with access to them for the maintenance of high yields, certification of seeds is undoubtedly an important stage in the production and selling of seeds. Aiming to verify the purity, viability, physical identity, and attributes of seeds, different crop kinds are typically produced using this approach.

This system, which is governed by law, verifies the quality of seeds produced and the methods used in their multiplication

OBJECTIVES OF SEED CERTIFICATION

The process of certifying seeds has various goals, the primary one being the maintenance of seed standards such as vigor, purity, genetic composition, and seed health and quality index. Three goals should be achieved by an effective seed certification system, and they are as follows:

1. A methodical growth in the cultivation and commercialization of superior cultivars or varieties.
2. The identification, generalization, and rapid proliferation of recently released elite types under appropriate and widely recognized names.
3. By giving seed material a steady and consistent supply through careful upkeep.

CERTIFICATION AGENCIES

The Seed Certification Agency, registered under Section 5 of the Seeds Act of 1966, is the appropriate body to certify seeds.

Eligibility requirement for seed certification

Only appropriate variety seeds that have previously received certification under Section 8 of the Seeds Act of 1966 are accepted for the certification process.

The variety in question must strictly adhere to the requirements given below in order to be approved for certification:

1. Fundamental requirements: A variety must strictly be registered under Section-5 of the Indian Seed Act of 1966. It ought to be included in the production chain. The variety's pedigree record needs to be correctly traceable.

2. Field Standards: Field standards include choosing a good site, keeping an isolation distance, maintaining spacing, checking the planting ratio, maintaining border rows, and so on.

3. Specific requirements: Different types of pollen-shedders, such as those found in sunflower, bajra, and sorghum crops, must be present in any seed crop. Tassel shedding in maize crosses, disease-affected and dead plants, unappealing weed plants, etc., should all fall below the upper bounds permitted for seed certification.

4. Quality Seed Standards: Crop-wise minimum certification standards for seeds have been devised.

Process followed in seed certification in India

The processes and procedure for seed certification procedures are as follows:

A supervisory examination of the source of the spreading content:

The first and most important phase in the seed certification program is seed confirmation. Seed should be obtained from reputable sources in order for it to be accepted by an authorized source and by a legal class certification organization. Therefore, while planting seed crops, high-quality, true-to-type seed should be used.

Investigative Study:

An evaluation of the crop growing in the field should be conducted to ensure that the prevalent diseases are not spreading and that weed plants and other weeds are present, as well as to verify the authenticity of the variety, maintain isolation distance, physical additives, and disease circulation.

Sample examination:

This involves a range of laboratory tests, evaluations, and assessments of the seeds' planting value. These tests include germination and other purity tests to confirm the varietal purity and viability of the seeds.

Control plot testing:

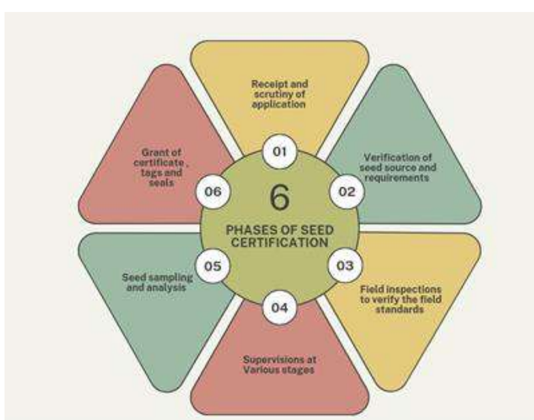
One of the most important processes in the process is the control plot testing, where standard quality samples of the variety's seeds are developed alongside a side-by-side comparison of specimens obtained from the location of origin. It is determined that the health, varietal purity, and seed purity obtained from field examination are equivalent to the findings.

Grown-out test:

This test looks for diseases or infections that may be present in the seeds, as well as species or varietal authenticity. The specified samples/varieties are cultivated in the field alongside the common check varieties after being collected from the seed lots. For the varietal purity and seed purity index, growing plants are the subject of observations.

PHASES OF SEED CERTIFICATION

The six procedures that make up the Seed Certification process are as follows:



1. Carefully reviewing the field conditions to ensure that they adhere to the recommendations for the various field grades.

2. Post-harvest stages of administration that include additional packing and processing.

3. Gathering specimens to be analyzed in order to determine the quality status and standards for seed quality.

4. Following all the procedures, a certificate, certification labels, labeling, tagging, close-up, etc., ought to be provided.

VALIDITY OF SEED CERTIFICATION

The seed certification has a validity span of approximately nine months from the testing day when the initial certification is completed. Any certification's validity period may be extended by an additional six months if the seed is retested to ensure that it complies with purity standards that are advised regarding physical purity, inborn purity, seed sprouting, damage caused by insects and pests, and loss caused by any of these factors. In this case, the vast majority of the seeds will need to be retested for purity and grade standards, which are characterized by crop selection. The seed lot that is produced will be eligible for the validity period provided that it complies with the stated requirements and conditions.

IMPORTANCE OF GOOD QUALITY SEED

- The crops under consideration must to possess both genetic and physical authenticity.
- Seed should provide the necessary number of plants.
- Acquired seedlings exhibit stronger natural traits, rapid growth, and a certain degree of tolerance and resistance to pest and disease attacks.
- Capacity to endure unfavorable weather conditions.
- A larger root system will allow for higher nutrient absorption, leading to an abundance of good output and good production.
- If you add extra fertilizer and other inputs, it will respond well.
- Improved seed varieties with pure quality standards and grades ensure a greater yield of up to 10%–12%.

Major seed quality parameters : The ability of a seed to have the required genetic and physical clarity to match its physical characteristics and fitness status is known as major seed quality.

The following is a list of the most significant seed quality dispositions:

Physical quality

Physical quality is a measure of a seed's purity; in this sense, there should be no internal matter, impurity status, diseased seed, or insect-damaged seed. A healthy seed should be of uniform size, weight, and color; it should also be devoid of other stems, branches, flowers, debris, stones, leaves, fruit walls, dust, and other inert materials or crop seeds. Additionally, the seeds shouldn't be damaged, rotted, sick, moldy, shriveled, or entirely empty. The seed ought to be easily identified as a species belonging to a particular class and category of species. When this crucial component is absent, the field's ability to deposit and sow seed is typically impacted.

1.Genetic purity

The true to type identification of the seed germplasm can be deduced from the requirement that each seedling per plant per tree be an exact replica of the mother in every area of quality traits.

These quality traits are required to raise the crops' production, resistance, or other necessary quality aspects, or to obtain the appropriate seed quality traits.

2.Physiological quality

In terms of subsequent generation and multiplication, this is how seeds actually appear. Seed germination, seed quality, and seed vigor-like performances should make up standards based on the physical quality characteristics of the seed. A seed's action based on performance is referred to as the seed's viability. The term "germinability" refers to a seed's ability to remain viable long enough to produce a healthy seedling with normal roots and shoots in the right environment. A seed's vigor refers to its capacity or ability to produce the best seedlings of superior quality. It is the sum of all the attributes and seed credit that allow it to regenerate in any given situation.

Nuclear seed

Nucleus seed is the foundation for seed multiplication in all kinds and hybrids that have been reported.

Typically, four to five classes of seeds are observed, which are listed below:

1. **Breeder seed**

Additionally, breeder seed is completely pure genetically and physiologically for the generation of foundation seed. The producing breeder or workers produce a golden yellow certificate for this kind of seed in the case of breeder seed.

2. **Foundation seed**

Foundation seeds are the progeny of breeder seeds that are developed and approved by public and private seed production organizations. They are overseen by seed certification organizations in a manner that ensures their quality requirements are upheld in compliance with specified field and seed standards. The relevant seed certification organizations give foundation seed with a white certificate.

3. **Registered seed**

This seed is the progeny of the foundation seed, which is designed to maintain its purity and genetic recognition in accordance with the standards set forth for the particular crop undergoing certification. At this stage of seed development, a purple color certificate is awarded.

4. **Certified seed**

It is the offspring of foundation seed, produced by certified seed growers following the management system of seed certification agencies, ensuring seed quality meets the minimum standards for seed certification. A blue certificate is issued by the seed certification agency for certified seed. Certified seeds and foundation seeds can be produced at stages 1 and II, but they cannot be reproduced beyond three generations after the breeder seed stage.

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CAUSES AND EFFECTS OF WATER STRESS ON PLANTS

Article ID: AG-VO4-I07-45

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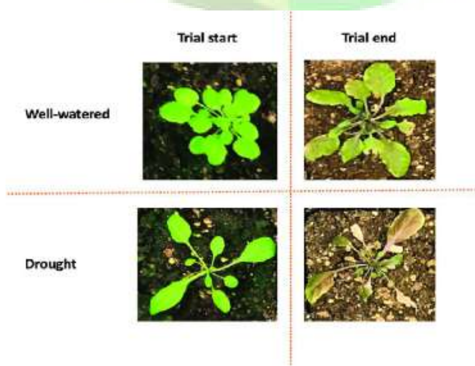
Introduction

The natural balance of the environment is constantly challenged by various abiotic stressors like salt, drought, chemical toxicity, and extreme temperatures. These stressors disrupt plant development and yield, leading to significant agricultural challenges such as famine. Stress alters plant morphology, physiology, biochemistry, and molecular makeup, resulting in substantial reductions in crop yields. However, plants have evolved natural responses to counteract these stressors through physiological and biochemical adjustments.



Water Stress:

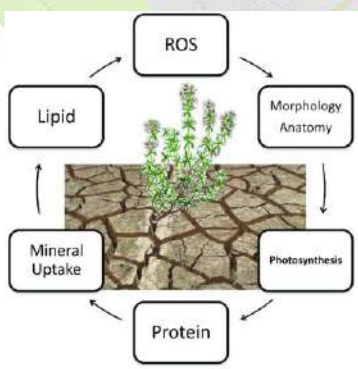
Water is vital to all physiological activities in plants, comprising 80-90% of non-woody plant biomass. Drought, a significant form of water stress, reduces the water potential and turgor pressure of plant cells, hindering normal physiological processes. While many plant species struggle to survive extended periods of drought, some have developed mechanisms to withstand desiccation in their mature life cycles.

Effects of Water Stress on Plants:

Drought presents a multifaceted challenge to plants, affecting them at various structural and physiological levels. Prolonged water scarcity leads to desiccation and eventual death in many plant species. Reduced water potential and turgor pressure in plant cells impede cell expansion, growth, and reproductive processes. This response involves the accumulation of substances like abscisic acid (ABA) and osmolytes, triggering wilting. Additionally, the production of reactive oxygen species (ROS) increases, exacerbating damage, although radical-scavenging compounds help mitigate these effects.

Beyond affecting water-related parameters, drought alters mineral nutrition, nutrient uptake, and transport, influencing leaf area and assimilate distribution among organs. Changes in cell wall flexibility and disruptions in cellular homeostasis further characterize the impact of water stress. Drought also induces the synthesis of proteins and mRNA molecules associated with drought response mechanisms.

While water stress inhibits plant development and cell proliferation, it disproportionately affects cell expansion over division. Moreover, drought alters essential physiological processes such as photosynthesis, respiration, ion uptake, and hormonal regulation, impeding overall plant growth and development.



Photochemical Synthesis:

The text highlights the negative impact of water scarcity on photosynthesis in plants, leading to modifications in metabolism and structural changes in the photosynthetic machinery. It mentions the decline in photosynthesis with decreasing leaf water potential and relative water content, though it indicates uncertainty about whether metabolic impairment or stomatal limitation is more significant.

The text discusses how C3 and C4 plants respond differently to water stress, with C4 plants being more vulnerable, and it explains the physiological and biochemical changes affecting photosynthesis under water stress. It also touches upon the role of reactive oxygen species (ROS) and the inhibition of chlorophyll synthesis under water stress, along with the differential responses of carotenoids compared to chlorophyll.

Protein Synthesis:

The text describes the changes in plant proteins under drought conditions, including quantitative and qualitative alterations. It discusses the reduction in protein synthesis in plant leaves during water shortages, particularly in C3 plants, and highlights the production of various stress-responsive proteins such as LEA proteins, proteases, cold regulation proteins, and enzymes involved in detoxification and osmoprotection. Additionally, it mentions the regulation of gene expression and signal transduction through the production of proteins like transcription factors and protein kinases in response to water stress.

Lipid Response to Water Stress

Water stress profoundly affects lipid-protein interactions in membranes, enzyme functionality, and membrane permeability, with fatty acid composition varying notably during drought.

Plant Responses to Water Stress

Plants undergo morphological changes such as altered leaf architecture, stomatal submersion, and root-to-shoot ratio adjustments to cope with water scarcity. Additionally, drought triggers hormonal responses, including increased ABA levels, leading to stomatal closure and gene expression changes to mitigate water loss.

Nutrient Dynamics under Water Stress

Water stress disrupts ion homeostasis, decreasing calcium and potassium levels, which are crucial for membrane integrity and stomatal regulation. Furthermore, nitrogen metabolism is impaired, affecting nitrate reductase activity and nutrient absorption.

Oxidative Stress in Drought Conditions

Oxidative stress induced by drought generates reactive oxygen species (ROS), damaging membranes and macromolecules, hindering cellular metabolism. Plants respond by activating antioxidant systems and stress-related genes to counter ROS accumulation.

Plant Responses to Dehydration

Plants exhibit a range of physiological, biochemical, anatomical, and morphological adjustments to combat drought, including alterations in gene expression. The response to drought stress is intricate, involving a combination of positive and adaptive changes influenced by factors such as plant diversity, soil water depletion dynamics, atmospheric water demand fluctuations, and plant growth stage.

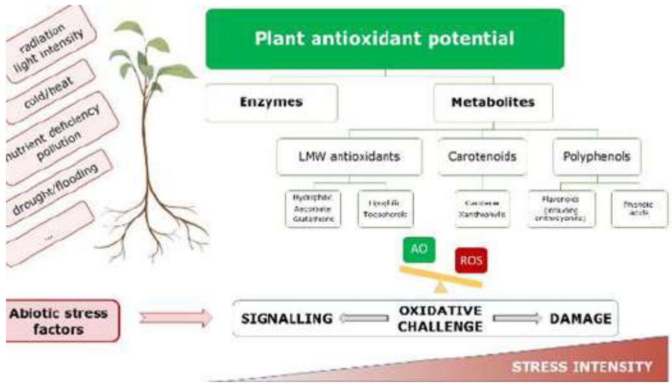
Plants typically employ both stress avoidance and tolerance mechanisms to cope with drought, with early adaptation often conferring temporary advantages. The synthesis of specific metabolites tailored to enhance plant function under drought conditions reflects plant adaptation. Primary processes involved in plant water stress response include growth regulation and recovery, defense against damage and rapid repair, and maintenance of homeostasis through ionic balance and osmotic adjustment.

Plant Resistance to Water Stress

During drought, plants optimize cellular and organ morphology, physiology, and metabolism to maximize productivity. Responses to water stress vary across plant species, developmental stages, and stress intensity and duration, categorized into stress avoidance and tolerance mechanisms. Morphological modifications such as reduced stomatal conductance, decreased leaf area, and enhanced root systems aid in drought avoidance, while physiological, biochemical, and molecular mechanisms, including gene expression and protein accumulation, contribute to drought tolerance. Drought-tolerant plants undergo fundamental alterations in water-related processes, biochemical and physiological functions, membrane structure, and subcellular organelle ultrastructure to maintain regular activities even under low tissue water potentials.

Activation of Antioxidant Systems

Plants employ enzymatic and non-enzymatic antioxidant systems to mitigate the effects of reactive oxygen species (ROS) generated under environmental stress. Enzymes such as glutathione reductase, ascorbate peroxidase, peroxidases, catalases, superoxide dismutase, and monodehydroascorbate reductase, along with antioxidant substances like carotenoids, anthocyanins, flavanones, glutathione, ascorbic acid, and tocopherols, scavenge ROS to protect cellular components. Antioxidant activity fluctuates significantly under drought stress, influenced by species variation, cultivar diversity, growth state, stress duration.



Accumulation of Compatible Solutes

Osmolytes play a crucial role in plant response and adaptation to water stress by aiding in osmotic adjustment and turgor regulation. Accumulation of compatible solutes enhances plant resistance to various environmental stressors, including drought, high temperatures, and salinity. These solutes act as water substitutes, maintaining cell turgor and osmotic potential, thereby improving water uptake and retention. Compatible solutes also protect membrane structures and enzymes, stabilize protein conformation, scavenge free radicals, and stabilize cellular macromolecules. Their accumulation is influenced by genetic factors, stress severity, and species-specific responses, contributing to enhanced plant resistance to osmotic stress.

Biotechnology Approaches to Mitigate Water Stress

To bolster plant resilience against water stress, various methodologies have been explored, combining traditional genetic techniques with advanced breeding methods. Among these is the selection of genotypes exhibiting higher yields in arid regions, though implementation faces hurdles due to erratic rainfall patterns and the complex genetic underpinnings of drought tolerance. Conventional genetic approaches, involving gene transfer from wild relatives to crop plants, have yielded inconsistent results. Key targets for plant breeding include enhancing traits such as water-extraction efficiency, water-use efficiency, hydraulic conductance, osmotic and elastic adaptations, and leaf area modification. While genetic modifications predominantly focus on genes involved in maintaining cell functionality and integrity, controlling genetically complex responses to abiotic stress remains challenging.

Current engineering approaches predominantly entail transferring stress-responsive genes, albeit achieving significant enhancements is hindered by the intricate nature of abiotic stress tolerance mechanisms and potential side effects.

Concluding Remarks

Climate change-induced phenomena like water shortages, floods, and waterlogging have profoundly impacted plant ecosystems by depriving them of water. Plants have evolved intrinsic mechanisms to combat water stress, with varying degrees of tolerance and response strategies. While highly tolerant species exhibit morphological adaptations to water scarcity, these may compromise biomass yields due to reduced photosynthetic activity. Plant genetic machinery produces a range of compounds to withstand water deprivation, while endogenous biomolecules counteract oxidative stress triggered by drought. Biotechnological interventions strive to enhance drought adaptation in less resilient species, drawing upon research on the origins, consequences, and responses to water stress. Nonetheless, our comprehension of plant water stress remains limited, underscoring the imperative for sustained research endeavors to address this pressing issue.

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THE IMPACT OF WATER STRESS ON BLACK GRAM

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Introduction

Unbalances in the typical condition of the environment are brought about by the continuous abiotic stress exposure of the biosphere such as salt, oxidative stress, chemical toxicity, severe heat, drought, and so forth. An annual famine is caused by stresses on arable plants that disrupt agriculture and the food supply in many locations across the globe.

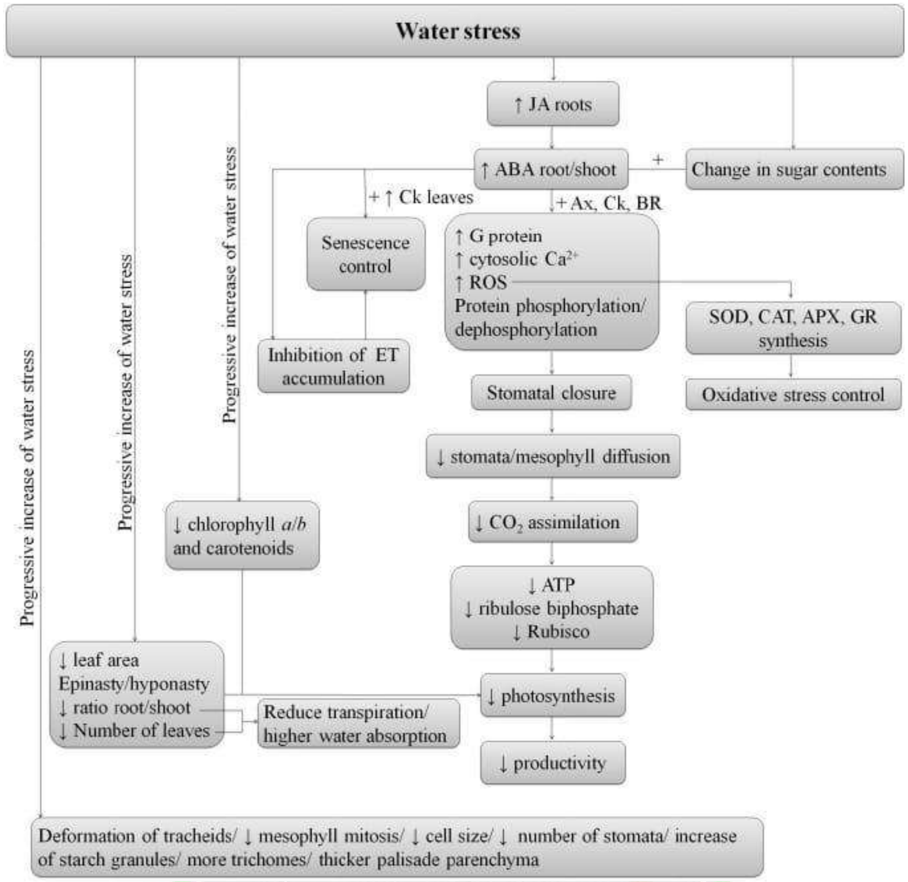
When there is insufficient water available for the roots of the plant or when transpiration rates rise sharply, the plant experiences water stress. The main causes of water stress are water shortages, such as droughts and highly salinized soil. There is water in the soil solution in circumstances of high soil salinity, as well as additional circumstances, such as flooding and chilly soil, but plants are unable to absorb it. Water stress tolerance is present in all plants, however it varies by species.

IMPACT OF WATER STRESS

As an abiotic stressor, drought, has multiple dimensions and affects plants at different levels of organisation. Indeed, many plants will dry and die if the drought lasts long enough. Water stress decreases the water potential and turgor of plant cells, increasing solute quantities in the extracellular space and cytosol matrix. Cell enlargement consequently decreases, preventing growth and leading to infertility.After then, abscisic acid (ABA) and other appropriate osmolytes, such proline, build up and cause wilting. This is where the overproduction of reactive oxygen species (ROS) and the emergence of compounds that scavenge radicals, including glutathione and corbate, intensify the detrimental effects. Drought affects plant water relations in a number of ways, including stomatal closure, gaseous exchange limitations, transpiration reduction, and slowed rates of carbon absorption (photosynthesis). It also lowers water content, turgor, and total water. Reduced leaf area and alterations in assimilate partitioning among organs are the results of detrimental effects on mineral nutrition (nutrient uptake and transport) and metabolism. Changes within the cell wall of plants ,flexibility, as well as disruptions in the cell's ion distribution and homeostasis have been explained. New proteins and mRNAs associated with the drought response in plants are also created as a result of water stress. Cell expansion slows or stops when exposed to water stress, slowing plant growth. However, Cell expansion is more severely affected by water stress than cell division. Changes in photosynthesis, respiration, translocation, ion uptake, carbohydrates, nutrient metabolism, and hormones are a few of the methods by which that drought influence plant growth.

MECHANISM OF WATER STRESS IN PLANTS

- Osmotic stress : A lack of water throws off the osmotic equilibrium, which makes cells shrink and lose their turgor pressure.
- Hormonal imbalance : Abscisic acid, a stress hormone that controls stomatal closure and water conservation, is produced in response to water stress.
- Stomatal closure : Water stress results in stomata closing, which lowers photosynthesis and CO_2 intake.
- Reduced water uptake : Water stress reduces water transfer to leaves by compromising root water intake.
- Oxidative stress : Reactive oxygen species (ROS) produced by water stress cause damage to biological components.
- Disrupted Nutrient uptake : Transport and absorption of nutrients are hampered by water stress.
- Cell membrane damage :Water stress changes the shape and functionality of cell membrane
- Denaturation of Proteins : Proteins under water stress unravel and stop working.
- Decreased division and proliferation of cells:Cell growth and division are impeded by water stress.
- Programmed cell death : Extreme water stress may cause cells to die on schedule.



- Source : Zingaretti et al (2014)

EFFECT ON BLACKGRAM

Stages	Impact	References
Water Stress	Decreases the rate of photosynthesis	K Pavithra et al (2021)
Water Stress	Decreases the number of pods	K Pavithra et al (2021)
Water Stress	Decreases the shoot length.	Swati Shahi et al(2019)
Water Stress	Reduces the number of leaves.	Swati Shahi et al (2019)
Water Stress	Reduces the fresh weight of the seed.	Swati Shahi et al(2019)
Water Stress	Reduces the seed protein content.	Swati Shahi et al (2019)

Conclusion

Water stress can significantly affect the growth and output of black Gram throughout its reproductive phase. Among the outcomes are reduced proline accumulation and nitrate reductase activity,decreased cell membrane stability,decreased yield potential, decreased chlorophyll and carotenoid content, decreased net assimilation rate and leaf area index.Insufficient rainfall, elevated temperatures, and low soil moisture levels can all lead to water stress. Drought-tolerant cultivars, irrigation, and conservation agriculture are effective ways to handle it.

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MAXIMIZING YIELD AND SUSTAINABILITY THROUGH INTEGRATED PEST MANAGEMENT IN BLACKGRAM

Article ID: AG-VO4-I07-47

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Introduction

Black gram, scientifically known as *Vigna mungo*, is a highly versatile legume that holds significant importance in agriculture, nutrition, and culinary traditions across the globe. Also referred to as urad dal or black lentil, originally indigenous to the Indian subcontinent, it is presently grown in diverse tropical and subtropical regions across the globe.The black gram plant is an annual legume that belongs to the Fabaceae family. It typically grows in warm and humid climates, thriving in well-drained soil with good moisture retention. The plant features small, elliptical leaves and produces clusters of tiny, pale-yellow flowers that eventually give way to cylindrical pods containing the edible seeds.

Regarding nutrition, black gram is celebrated for its abundant protein content, rendering it a valuable reservoir of plant-based protein for individuals adhering to vegetarian and vegan diets.Moreover, it boasts substantial dietary fiber, along with essential vitamins like folate and vitamin B, and minerals such as iron, magnesium, potassium, and calcium, all enhancing its nutritional significance.Culturally, black gram holds a prominent place in the culinary traditions of South Asia, particularly in Indian cuisine.

It is a staple ingredient in a wide array of dishes, including dals (soupy lentil preparations), curries, snacks (such as vadas and papads), and desserts. Its versatility in cooking, along with its distinctive earthy flavor, has made it a favorite among chefs and home cooks alike.

The issue plaguing blackgram:

In India, the cultivation area for black gram spans approximately 3.25 million hectares, yielding a production of 1.91 million tonnes and boasting a productivity of 463 kg per hectare.Madhya Pradesh holds the leading position in the country for black gram cultivation. In Tamil Nadu, black gram is cultivated across 3.41 lakh hectares, resulting in a production of 1.21 lakh tonnes and an average productivity of 354.88 kg per hectare. Black gram faces numerous significant insect pests that result in severe damage and yield reduction. About sixty different insect species can be found on black gram. 34 of these insects posed a significant threat to one or more of the pulse crops.

The impact of pests on blackgram:

In several Indian states, the average losses attributed to insect pests in black gram crops were calculated to be 28.7 percent. On average, an annual loss of around 2.5 to 3.0 million tonnes of pulses occurs due to pest-related issues. In addition to sucking the sap from the plant(such as aphids and whiteflies) and weakening its vigor, these insect pests also spread disease and interfere with photosynthesis. Damaged seeds have lower market value, affecting the economic return for farmers. Additionally, infestations can impact seed quality, making them less viable for future planting. Farmers often need to invest in pest control measures, including chemical pesticides, biopesticides, and cultural practices, increasing production costs.

Even though integrated pest management (IPM) is the best method for crop production, farmers are unable to use this practice in their fields. The rate at which farmers are implementing IPM techniques is not particularly encouraging. It is important to study how black gram growers are implementing integrated pest management techniques in light of the aforementioned point.

Important pest of blackgram:

- Aphids (*Aphis craccivora*):

Symptoms: Yellowing and curling of leaves, stunted growth, and honeydew secretion leading to sooty mold.

- Whitefly (*Bemisia tabaci*):

Symptoms: Yellowing and curling of leaves, transmission of viral diseases.

- Thrips (*Caliothrips indicus, Ayyaria chaetophora, Megalurothrips distalis*):

Symptoms: Silvering of leaves, distorted flowers, and pods.

- Pod Borers (*Helicoverpa armigera, Maruca vitrata*):

Symptoms: Larvae bore into pods and feed on seeds, causing direct damage.

- Leafhoppers (*Empoasca* spp.):

Symptoms: Yellowing and crinkling of leaves, hopper burn.

- Spotted Pod Borer (*Maruca vitrata*):

Symptoms: Larvae feed on flowers and pods, causing webbing and pod damage.

- Bean Weevil (*Callosobruchus maculatus*):

Symptoms: Larvae bore into seeds, causing internal damage.

- Root-Knot Nematodes (*Meloidogyne* spp.):

Symptoms: Knots or galls on roots, stunted growth, and yellowing of leaves.

- Blister Beetles (*Mylabris* spp.):

Symptoms: Defoliation of leaves, causing reduced photosynthesis.

Management strategies through integrated pest management:

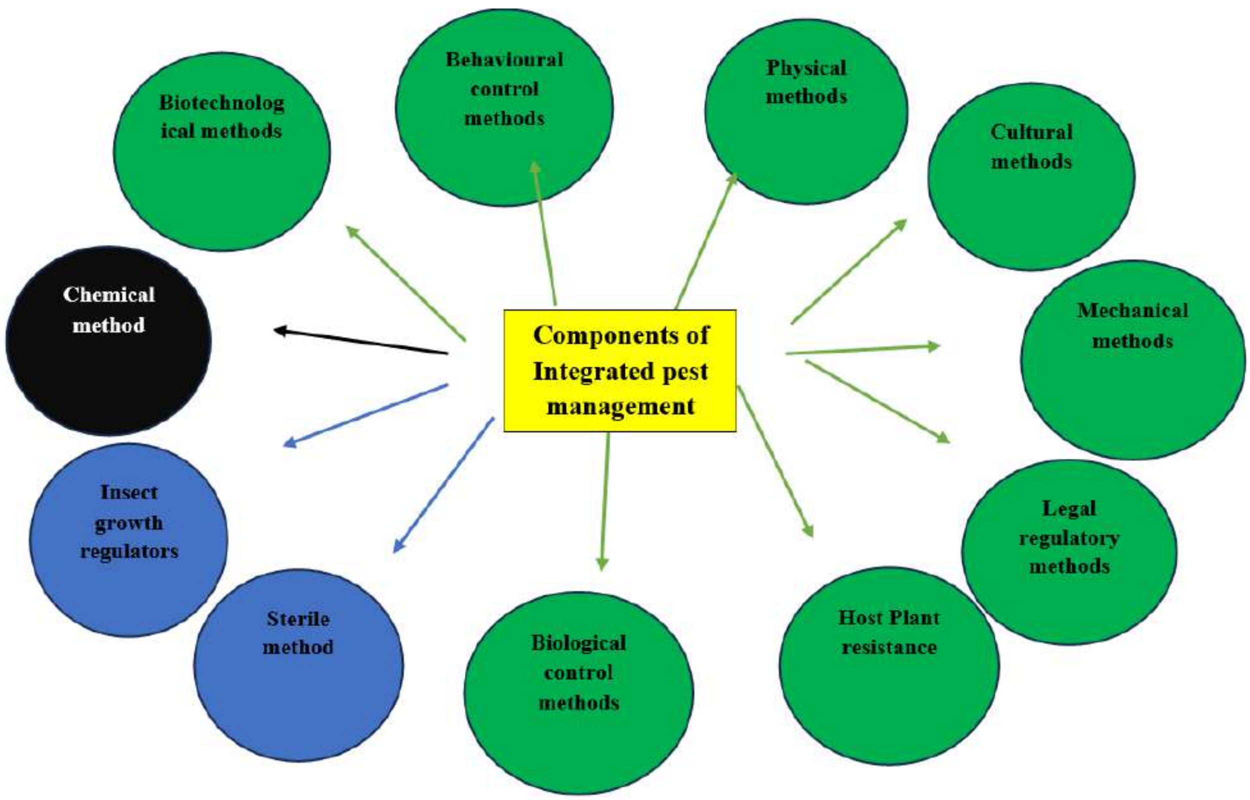
Integrated Pest Management (IPM) is a comprehensive pest control approach that considers the environment and pest population dynamics. It incorporates a variety of techniques and methods in a harmonious manner to keep pest populations below the economic injury level.

Cultural practices:

- Appropriate seed rate utilization. Adopting clean cultivation practices aids in decreasing the occurrence of insect pests.
- Optimal timing of sowing aids in minimizing the prevalence of insect pests.
- Deep ploughing during summer decreases the occurrence of insect pests.
- Utilizing an even distribution of fertilizer, especially potash, aids in minimizing the occurrence of insect pests.

- Crop rotation assists in reducing the occurrence of insect pests.
- Clearing and disposing of the stubble from the previous crop.

Tools or components of integrated pest management:



Mechanical practices:

- Sticky traps are employed to lure sucking pests.
- Light traps are employed to attract adult insects. Handpicking and eliminating larvae/eggs.

- Removing the infected plant parts aids in reducing the occurrence of stem fly infestation.
- Digging trenches around the field perimeter. Rouging. Pheromone traps are utilized to lure male moths.

Biological control:

- Applying a 2% Neem oil spray aids in decreasing the prevalence of insect pests.
- Treating seeds with Trichoderma viride at a rate of 4-5g per kilogram of seed.
- Applying NPV (Nuclear Polyhedrosis Virus) spray, followed by either Bacillus thuringiensis or Beauveria bassiana bio-pesticides were applied 15 days subsequent to the application of chemical insecticide. The bio-pesticide is applied 15 days after the chemical insecticide.

Chemical control:

- Soil treatment with Phorate 10G at a rate of 15 kg per hectare during sowing aids in reducing the occurrence of stem fly. Spraying Trizophos 40EC at a rate of 800ml per hectare or Chloropyriphos 20EC at a rate of 1500ml per hectare during the flowering stage. Seed treatment with 2gm Thiram+1gm Carbendazim per kg seed should be done.
- Seed treatment with Thiomethaxone at a rate of 3-4 grams per kilogram of seed.

Use of resistant varieties:

These varieties are bred to possess natural defenses against specific pests, reducing the need for chemical pesticides and contributing to sustainable agriculture. By planting pest-resistant blackgram varieties, farmers can achieve healthier crops, more stable yields, and lower production costs.

Some pest resistant blackgram varieties:

- VBN (Bg) 6
- Resistance: Highly resistant to mungbean yellow mosaic virus (MYMV) and moderately resistant to leaf crinkle virus.
- Characteristics: High yielding variety with good seed quality and drought tolerance.
- PU 31
- Resistance: Resistant to MYMV and Cercospora leaf spot.
- Characteristics: High yield potential, early maturity, and good seed quality.
- IPU 02-43
- Resistance: Resistant to MYMV and powdery mildew.
- Characteristics: High yield, early maturity, and adaptability to different agro-climatic conditions.
- IPU 94-1
- Resistance: Resistant to MYMV and Cercospora leaf spot.
- Characteristics: Early maturing, high yielding, and suitable for both kharif and summer seasons.
- LBG 645
- Resistance: Resistant to MYMV.
- Characteristics: High yielding, good seed size, and suitable for both rainfed and irrigated conditions.

Monitoring and surveillance:

Monitoring and surveillance are crucial components of an effective Integrated Pest Management (IPM) strategy for crop cultivation. These practices help in early detection, accurate identification, and timely intervention, thereby reducing pest-related damage and improving crop yields.

Conclusion:

In conclusion, the implementation of Integrated Pest Management (IPM) techniques represents a pivotal step towards achieving sustainable blackgram cultivation. By adopting a multifaceted approach encompassing cultural, biological, mechanical, and chemical methods, farmers can effectively manage pest populations while minimizing adverse impacts on the environment and human health.

IPM not only promotes economic stability by reducing production costs and safeguarding yields but also fosters environmental resilience and enhances the well-being of farming communities. Through collaborative efforts among stakeholders and the promotion of education and training initiatives, the widespread adoption of IPM practices can be realized, ensuring a future where blackgram cultivation thrives in harmony with nature.

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A DETAILED COMPARISON OF CONVENTIONAL AND ORGANIC SEEDS

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Introduction

The foundation of human civilization has always been agriculture, which has developed over millennia to satisfy the world's expanding food needs. The selection of seeds is an important factor in modern farming as it affects crop quality, yield, and environmental effect. The market is dominated by two main types of seeds: conventional and organic. Conventional seeds frequently include the use of synthetic fertilizers, pesticides, and genetic alterations, whereas organic seeds are produced without synthetic chemicals and follow the guidelines of organic farming. This article explores the distinctions between conventional and organic seeds and looks at how they affect farming operations, the environment, and human health. Natural Seeds Synthetic fertilizers, herbicides, and pesticides are not permitted in the rigorous cultivation practices for organic seeds. The organic farming method used to grow these seeds promotes soil health, biodiversity, and ecological balance.

1. Health and Safety -

Chemical-Free Production: By avoiding synthetic chemicals during production, organic seeds lower the possibility of chemical residues on crops. Customers now have a safer option because of the reduced exposure to dangerous chemicals.

Nutritional Benefits: Research indicates that foods grown organically might have higher concentrations of specific nutrients, such antioxidants, than crops farmed conventionally.

2. Environmental Impact -

Soil Health: By using compost, green manure, and crop rotation, organic farming techniques improve the fertility and structure of the soil. These techniques encourage the cycling of nutrients and microbial activity, which improves soil health.

Biodiversity: By avoiding synthetic pesticides and herbicides, organic farming promotes a varied ecosystem. This aids in keeping beneficial insects, birds, and other species in balance.

Reduced Pollution: Because organic farming doesn't use synthetic chemicals, there is a lower chance of soil and water contamination, safeguarding nearby ecosystems and human populations from pollution.

3. Heirloom and Open-Pollinated Varieties -

Seed Variety and Resilience: Heirloom and open-pollinated seed kinds, renowned for their genetic richness, are frequently the source of organic seeds. Crops that are more resistant to regional pests, illnesses, and weather conditions may arise from this diversity.

Adaptation to Local Conditions: Organic seeds are more adaptive and require less outside inputs, such as fertilizer and water, because they are usually bred to flourish in particular local conditions. Customary Seeds Conventional seeds, sometimes referred to as non-organic seeds, are made with the use of genetic engineering and contemporary agricultural methods, such as

the use of artificial chemicals. These seeds are frequently created with a high yield and pest and disease resistance in mind.

1. Yield and Efficiency -

High Productivity: In order to increase yields, conventional seeds are frequently subjected to genetic selection or modification. This may result in a more economical use of resources and land, which could lessen the strain on natural ecosystems.

Disease and Pest Resistance: A lot of conventional seeds have been genetically modified to fend against particular pests and illnesses, which can reduce crop losses and increase food production stability.

2. Chemical Dependency -

Use of Pesticides and Fertilizers: To preserve crop health and productivity, conventional farming mainly relies on synthetic pesticides and fertilizers. These substances have the potential to raise yields, but they also carry dangers to the environment and public health.

Soil Degradation: Constant use of artificial chemicals can cause soil to deteriorate, making it less able to sustain crops over time. This may eventually lead to a decline in soil fertility and an increase in reliance on chemical inputs.

3. Genetically Modified Organisms (GMOs) -

Genetic Modification: Genetically engineered organisms intended to improve specific qualities, including herbicide resistance or nutritional value, are frequently found in conventional seeds. While there are many advantages to genetically modified organisms (GMOs), like higher yields and less need for pesticides, there are also worries about the long-term impacts on the environment and human health.

Intellectual Property Rights:

Large agribusinesses patent a lot of GMO seeds, which raises questions about farmers' rights and seed sovereignty. Instead of conserving seeds from their harvest, farmers that use these seeds frequently have to purchase fresh seeds every season.

Financial Aspects

1. **Price of Seeds -**

Sustainable Seeds : Because their cultivation involves labor-intensive procedures, organic seeds can generally be more expensive. On the other hand, by lowering the requirement for artificial inputs, they might ultimately lower expenses.

Conventional Seeds: Although these are usually less expensive up front, they may end up costing more in the long run because they require chemical inputs and may require environmental remediation.

2. **Market Demand**

Consumer Preferences: Due to consumer concerns about sustainability and health, there is a growing market for organic produce. Growing organic crops could result in higher market pricing for farmers.

Market Access: Conventional seeds might make it simpler to obtain subsidies and access to major agricultural markets, which would be advantageous economically for large-scale production.

Conclusion

In conclusion Selecting between conventional and organic seeds requires weighing a number of considerations, such as agricultural efficiency, environmental sustainability, and health. There are many advantages to using organic seeds, including lower chemical exposure, environmental protection, and genetic variety preservation. They might, however, present difficulties like greater expenses and poorer yields. Conventional seeds, on the other hand, offer more efficiency and productivity but at the cost of greater chemical use and possible environmental harm. In the end, the choice should be based on the particular objectives and principles of the farmer as well as the requirements and preferences of the customers. The future of agriculture will depend on striking a sustainable and healthy balance between these two strategies as the world's population continues to rise.

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IMPACT OF CARBONDIOXIDE ON PLANT PERFORMANCE

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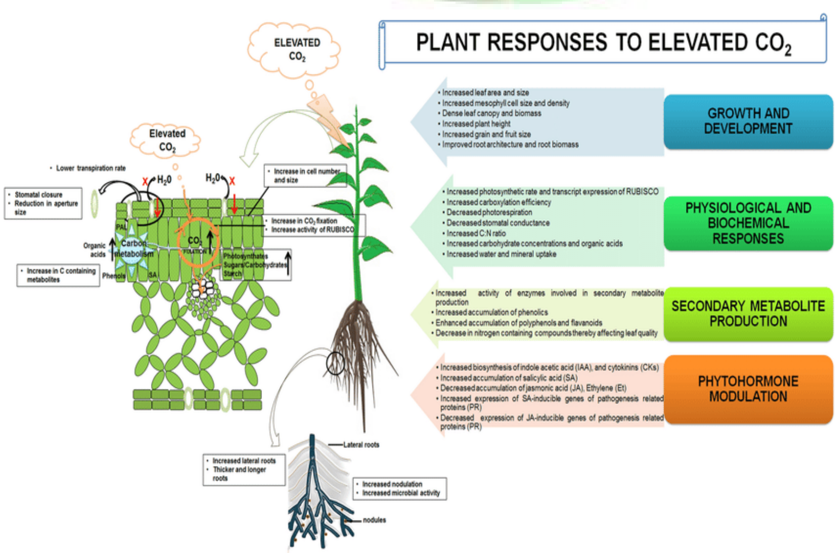
Introduction

Climate change is expected to cause the concentration of carbon dioxide (CO2) in the atmosphere to increase from its current range of around 370–550 ppm by 2050 to a potential range of 730–1010 ppm. It is predicted that this would result in a rise in global mean temperatures of 1-4 °C, in addition to other atmospheric changes. Climatological elements are major characteristics that influence the many stages of a plant's life cycle, beginning with seed germination and continuing through development. As the level of CO_2 increases and it would drastically reduce the whole world food protein upto3%.



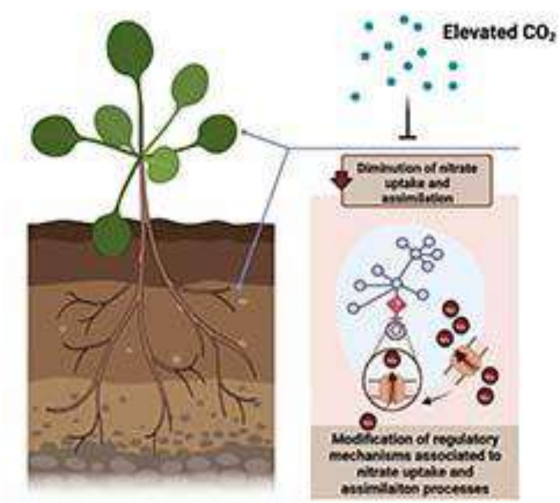
If the increase in atmospheric CO_2 concentration will be accompanied by an increase in air temperature, crops may shorten their growing cycle, which may offset the advantages of an increasing CO_2 concentration. Therefore, the interacting effects of CO_2 concentration and temperature on plant growth is complicated.

Impact on Seed Germination

In reaction to stress in their surroundings, plants exhibit alterations in their physiology, morphology, and ecology. Negative correlations have been observed between the quantity of CO_2 in soil and physiological characteristics of plants, including photosynthetic rate, stomatal conductance, and transpiration rate. Elevated soil CO_2 concentrations have also been shown to limit several plant bioactivities, including transpiration rate, leaf wetness, stomata conductance, and root respiration. Because reduced root activity slows root uptake of water and nutrients and forces plants to close their stomata, inhibition of root respiration in response to elevated soil CO_2 levels can lead to reduced stomatal conductance. The lack of carbon dioxide inside the leaf due to stomatal closure can further slow down photosynthetic respiration.

As plants have been shown to be more susceptible to anaerobic factors during their early development, elevated soil CO_2 concentrations also have an effect on plants during their germination period.

Soil properties: Increased CO_2 levels have the potential to modify soil characteristics, including pH and nutrient availability. If these changes are detrimental to rice seed germination, they may have an adverse effect on seed germination.



Competitive Pressure: Raised CO_2 levels may also benefit weeds and other plants, boosting competition for resources like nutrients and water, which may have an indirect impact on rice germination.

Pest and Disease Pressure: When pathogens or pests attack rice seedlings, changes in the environment brought on by high CO_2 levels can have a detrimental effect on pest and disease pressure.

Impact of Seed Yield

The phase of reproduction is extremely vulnerable to environmental stressors because rising temperatures and CO_2 can change the physiological processes involved in blooming, which can eventually result in delayed development and inability to set seeds.

While high temperatures shorten crop duration by hastening anthesis, lower temperatures during the crop phase of growth may lengthen crop duration. It has been discovered that plants cultivated in high CO_2 environments exhibit increased photosynthesis and photosynthetic accumulation, resulting in more resource allocation towards flower development and seed setting. Furthermore, by boosting their respective growth rates, growing plants during the time of blooming, and raising tissue sugar levels, the higher temperatures and CO_2 levels have an impact on the physiology of flowering.

Eg; Wrinkled seeds of lentils and chickpeas were considered to have faster seed filling. Higher carbon dioxide affects the overall growth rate of the plant, which is mainly seen when it reaches the reproductive stage.

Different plants respond differently to changing environments, either delaying or hastening growth processes. In reaction to elevated CO_2 , species evolution may halt or remain identical. Those that evolved faster either acquired the minimum size necessary for reproduction or changed the size at which growth began. Anticipation of reproductive time affects plant-pollinator interactions and reduces final seed production or yield.

Impact on Plant Growth

The elevate CO_2 will improve the photosynthesis which will increase the carbon content uptake and assimilation which will improve the growth. The additional stimulation of photosynthesis will also facilitate the distribution of photosynthesis below the ground, that is it will improve the root-to-shoot ratio.

Higher atmospheric CO_2 increases the seed output of C3 plants, such as cotton, soybean, rice, and peanuts, while decreasing the seed yield of C4 plants, namely as maize and sugarcane. The nitrogen (N) content of non-gum seeds may decrease with an increase in seed weight. Elevated temperature has the potential to decrease seed weight because of faster development and shorter seed filling time; however, decreased seed weight does not always imply decreased germination or vigour. Declared reactions of seed germination to increased CO_2 differ, much like seed weight.

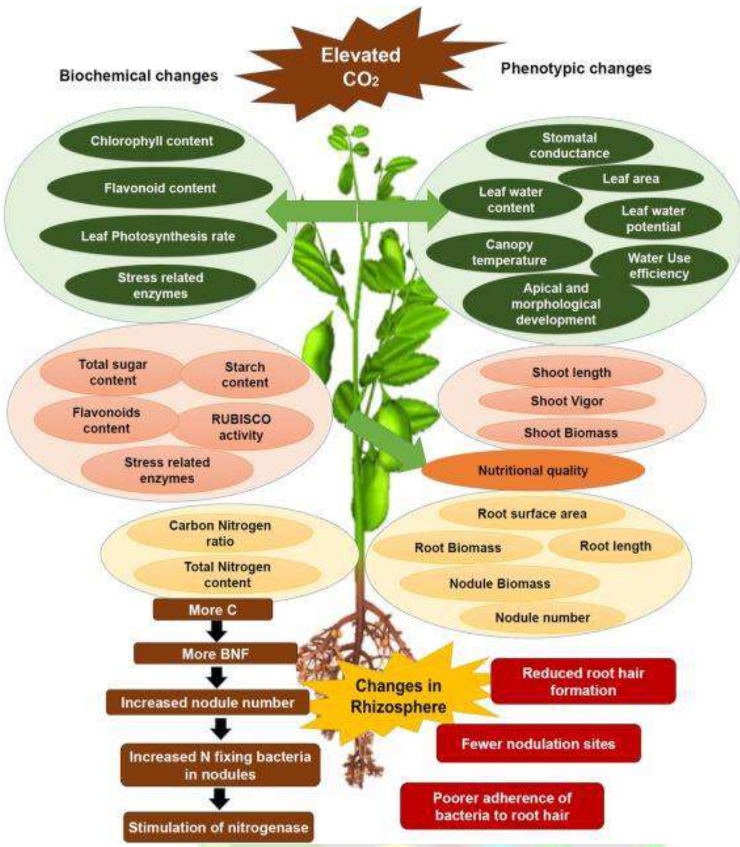
Impact on Seed Quality

Many biochemical and physiological reactions are impacted by high temperatures, including the requirement for oxygen during seed absorption. In India, where pulses make up almost 60% of the cultivated area, rainfall is significantly impacted by climate change. There are several ways that climate change may impact seed yield. A modest increase in temperature during the peak of seed development can significantly diminish seed yield due to reduced photosynthetic accumulation in seeds. It will have an impact on the pace, time, and duration of seed filling.

- Diminished activity of essential enzymes implicated in starch build up, such as soluble/granule-bound starch synthase and sucrose synthase. Lower the pollen viability, stigma receptivity and fertilization.
- Increased CO_2 levels can impact seed properties such as size, shape, color, uniformity, health, physiological condition, and biochemical composition, affecting their capacity to germinate.
- The biological and physical change in seeds, a decrease in metabolic activity, reduced storage, an abnormal number of seedlings (such as protease and amylase), and lowered hydrolytic enzyme activity are the contributing factors.

An increase in temperature significantly affects the rate, duration and timing of seed filling, leading to a decrease in seed weight. Prolonged extreme temperatures during germination and seedling development period impairs the germination potential of seed, resulting in irregular germination damaging plant stand.

Heat shock proteins (HSPs) keep the seed in a folded state which limit the germination until the favourable conditions, which are related to dormancy. Limiting pollination and/or inducing early pod rupture, heat stress during flowering reduces canola yield, whereas heat stress during seed filling and maturation impacts the quantity and quality of seed storage compounds, resulting in alterations in seed quality.



Conclusion

Changes in environmental signals caused by global climate change can lead to increased, delayed or prevented germination, as seen in certain cases. Precipitation, temperature, and Soil moisture is expected to affect various aspects of seeds, including their ability to withstand changes that have occurred in recent years. Increasing temperatures can alter distributions of species and influence seed germination, development, and fitness, with far-reaching ecological and economic repercussions. It will also affect the country's food production and security.

It is imperative to conduct a systematic survey and assessment of the situation, as well as modify management practices to ensure sustainability in the global seed supply chain. The studies focused on introducing quality of seed as a criteria for plant breeding. The study of larger germplasm for better and more stable seed qualities is very important. It is imperative to use the latest technology to improve seeds through priming, coating, nanotechnology and molecular techniques. The resumption of traditional seed production and conservation practices is crucial to the development of new technologies adapted to the needs of smallholders.

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PRIORITIZING SEED QUALITY AND ENHANCEMENTS TECHNIQUES IN MODERN AGRICULTURE

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Introduction

Seed technology aims to optimize germination rates and minimize germination losses, which are crucial for effective seed utilization. High-quality seeds are valued for their exceptional genetic and physical purity, and their ability to produce robust seedlings with strong roots and shoots. (Hay, 2019) this can lead to successful crop establishment and growth in various climatic situations, resulting in maximum yield. Genetic improvement through conventional breeding and biotechnological interventions can accomplish desirable traits including tolerance to major biotic and abiotic stressors. 'Seed augmentation' technology can improve the planting value of a seed by complementing its genotype across different growth environments. The main goal of seed enhancements is to maximize the seed's innate physiological potential, which often remains unrealized under typical sowing and cropping conditions (Black and Peter, 2006; Patel and Gupta, 2012).

BENEFITS ANTICIPATED FROM AUGMENTATION

When used by itself or in conjunction, seed enhancement therapies should provide one or more of the following benefits:

- A lower seeding rate.
- Early and consistent emergence brought about by enhanced germination and quick seedling development.

- Improved nursery oversight.
- Better stand establishment due to protection from pests, particularly weeds.
- Simplicity in handling and planting with accuracy.
- Provision of additional nutrients and growth promoters required for improved post-sowing performance.
- Elimination of weak or underperforming seeds through the use of unconventional upgrading methods.
- Marking seeds for traceability and identification retention using visible pigments or other marker materials.

DIFFERENT SEED QUALITY ENHANCEMENT TYPES

There are several ways to improve the quality of seeds to different degrees. These can be grouped according to the mode of application.

a) **Physical methods:** Seed preparation and conditioning aim to improve overall seed quality. However, certain physical activities can directly impact planting value or further enhance seed quality by employing various imaging techniques, such as near-infrared spectroscopy, sorting by chlorophyll fluorescence, imaging by magnetic resonance, multispectral analysis, thermal imaging and scanning electron microscopy. Additionally, methods like X-ray separation, colour sorting, gravity and liquid density separation, brushing and scarifying, and size grading can be utilized.

b) **Pelleting, encrusting and film coating:** Several methods are predicated on applying one or two or more thin layers of an polymer which is inert in nature, either alone or in conjunction with active ingredients, to completely or partially cover the seed for a variety of uses. This process may or may not result in a notable increase in the size or weight of the seed. Included among these are coatings for the slow release of active chemicals, coatings to improve flow ability, coatings for binding pesticides or micronutrients, coatings for embedding biological, branding on the seed surface, pelleting and encrusting in the inert substances which is water soluble.

c) **Treatment of seeds to prevent insects and diseases**: The oldest and most fundamental method for enhancing seed performance after sowing is treating seeds with insecticides. In addition to these basic techniques, the field has progressed significantly, now employing various environmentally friendly and highly precise physical and chemical processes. Among them are: Virus removal treatments, Chemical seed dressing, Dry heat treatment, Plasma treatment, Hot water treatment, Radiation treatment, Magnetic treatment, and Electromagnetic treatment.

d) **Enhancement of seeds in physiological manner:** The metabolic development of seed, which gives it a better start upon sowing, is the foundation of physiological therapies aimed at enhancing the quality of seed. These are referred to as "seed priming" collectively; Heydecker (1974); Heydecker and Coolbear (1977) popularized the phrase, which was first used by Malnassy (1971). Numerous priming technologies are suitable for different applications and are currently in commercial use. They are: Priming in pre sowing period, correction during mid-storage, other Technologies, etc.

SEED ENHANCEMENT METHODS

1. **Physical enhancements: Seed quality upgradation, cleaning and processing**

Pre-cleaning, cleaning, and grading are vital processing steps that enhance seed quality by boosting their vigour, purity and appearance. Depending on the equipment being utilized, different grading and upgrading procedures apply. However, the main focus is always on the physical characteristics of the seeds, including their shape, size, length, colour, density and texture. One key machine, the grader, evaluates the size and shape of the seeds, a process known as basic cleaning. Patil and Bansod (2014) note that various machines utilize specific characteristics for separation: the indented cylinder relies on length, the spiral separator on shape, and the gravity separator on density.

2. **Film coating**

Commercial seed lots are often coated to facilitate handling and incorporate active ingredients (ai) for specific seed protection and stimulant-assisted germination promotion (Pedrini et al. 2018). This method reduces the total amount of pesticides used in agriculture and is especially beneficial for targeted pesticide application (Hay 2019).

3. **Seed pelleting**

"Seed pelleting" involves encasing seeds in an inert substance to form uniformly sized globules, enabling precise seeding. This technique is particularly useful for mechanized sowing, lowering the amount of seeds used compared to conventional planting methods and ensuring even distribution of small seeds. Seed pelleting is commonly used for small, expensive, lightweight, and delicate vegetable and flower seeds, as well as those that are difficult to handle. Frequently pelleted plant species include forage grasses, flowers, leeks, celery, onions, lettuce, carrots, monogerm sugar beets, and chicory.

4. **Seed encrustation**

Encrustation is beneficial for seeds with irregular surfaces, as it fills grooves and cavities with a specific material, resulting in a smoother, more uniform shape and more manageable weight (Pedrini et al. 2018).

5. **Hot water treatment**

Hot water treatment is a traditional method for eradicating diseases that affect both the surface and interior of seeds. The treatment involves a temperature high enough to destroy pathogens while maintaining the seed's viability.

6. **Steam treatment**

Forsberg et al. (2015) explain that steam treatment is developed to eliminate seed infections. This thermal seed treatment method involves briefly exposing seeds to hot, humid air to disinfect or disinfest them of seed-borne bacteria.

7. **Dry heat treatment**

One popular physical technique for curing bacterial and fungal infections in seedlings is dry heat therapy. Moreover, it is a long-term and efficient method of rendering seed-borne viruses inactive. Seeds from vegetable crops are the main use for this technology. For example, *Didymella bryoniae*, *C. orbiculare*, and *Cladosporium cucumerinum* are successfully removed from cucumber seeds by a 90-minute dry heat treatment at 70°C (Shi et al. 2016). Similarly, Falconi and Viviana (2016) found that disease transmission from seeds to seedlings was decreased by up to 85%. To preserve the vigor and germination potential of the seeds, caution must be used when applying this treatment.

8. **Other potential treatment**

A variety of potential chemical and physical treatments have been suggested to improve seed performance. They are:

- **Electromagnetic and magnetic Treatments for Seed Enhancement:** Exposing seeds to varying magnetic field flux densities can accelerate germination, provide a uniform crop stand, increase yield, and strengthen the seeds' resilience to disease. For a predetermined amount of time, the magnetic seed therapy acts as a non-invasive physical stimulant to cause physiological changes in the seed (Pietruszewski and Martinez, 2015).

- **Radiation treatment:** In addition to other seed treatments targeting microbial infections, small doses of gamma radiation, high-energy electrons, ultrasonic radiation, microwave radiation, and UV radiation are utilized (Brown et al. 2001).
- **Electron treatment:** It is a promising technique known as "electron treatment of seeds" leverages the biocidal effects of low-energy electrons with wavelengths shorter than 100 nm. This method employs the Braun tube principle to generate accelerated electrons. Because of the charge difference, electrons are forced toward the electron exit window when high electrical voltages are applied between a cathode and anode. During seed treatment, the amount of medication given and the amount of electron energy are closely watched. The electron energy is adjustable by changing the acceleration voltage, and the dose is controlled by regulating the current strength.

Conclusion

Enhancement technologies, employing physical, pharmacological, or physiological methods, can be used individually or in combination to significantly improve seed performance. However, the success of any technology largely depends on its cost-effectiveness. Since seeds are considered an efficient distribution method and a carrier for new technologies, it is logical to implement the most suitable and affordable quality enhancement treatments through seeds.

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CASTANOPSIS INDICA: A KEYSTONE SPECIES IN THE HIMALAYAN FORESTS

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Introduction

The mighty oak, a magnificent and bountiful indigenous tree, epitomizes the beauty and abundance of Himalayan forests. These towering climax species serve as microcosms of the forest, providing habitat for numerous floral and faunal species. *Castanopsis indica* (Roxb. ex Lindl.) A.DC. commonly known as Dhalne katus or Indian chestnut, is a tall evergreen broadleaf tree species belonging to the family Fagaceae.

Description of the plant

Grows upto 8- 14 m (26- 46 ft) in height with a broadly rounded crown; it can grow up to 30 metres tall. The straight bole can be up to 100cm in diameter. The tree is harvested from the wild for its timber and edible seed.

Distribution

North East India, Nepal, Bangladesh, Laos, Myanmar, Bhutan and Thailand. In India it is found in Sikkim, Assam and Arunachal Pradesh. It grows primarily in the wet tropical biome in east Himalayan wet temperate forest or evergreen oak forest at an altitude of 1700-2800m.

Habitat

Scattered in primary and secondary forest formations in Vietnam. Broad-leaved evergreen forests

Phenology

Flowering: Monoecious; March–May and is yellow in color and has a bell-like shape. Male flowers in racemes.

Fruiting: September–November of following year. It takes two years to produce an acorn. Nut-ripening periods are from March to June.

Fruits: densely clustered with 3-4 seeds and covered completely by long slender straight sharp spines of 2.5-4 cm lengths. Fruits completely enclosed by cupule (4 cm), containing 1-2 nuts, splitting into 4 parts, cupule covered by spines of up to 1.5 cm long.

Leaves: alternate, simple, up to 20 by 10 cm, widest point above the center, lower surface whitish, whole margin clearly toothed.

Trees: slightly fissured bark. Twigs densely hairy. Stipules long, slightly curved, rounded tip (5 mm). Petioles short (5-10 mm).

Wood

Growth rings distinct. Wood semi ring porous, vessels solitary and arranged in diagonal and radial rows, Parenchyma apotracheal diffuse, diffuse-in-aggregate and paratracheal scanty, T.L.S. Uniseriate rays (mostly) parenchyma strands 2–3 celled (3), R.L.S. Homogeneous ray made up of procumbent cells only and Heterogeneous ray made up of procumbent cells with marginal square/or upright cells (4 and 5). Density is 619 kgm-3. A very attractive wood, of a yellow-brown or pinkish-brown colour, with a lustrous surface and hardy grain, the wood is hard (moderately hard) and heaviness is moderately heavy and generally used for construction and furniture making due to its resistant nature to termites and insects.

Bark: Rough and grey

Castanopsis indica

Leaf: Thick, leathery, serrated, short petiole

Fig. 1& 2. Different parts of *C. indica*.

Need for restoration

Oak woods make up roughly 17–18% of Sikkim's total forest cover, and about 25% of these forests require restoration. Due to human activities and development, the canopies of these forests have opened up, allowing bamboo species like *Arundinaria* and *Yushania* to take over. If the disturbance is significant and the canopy remains open, the ecosystem can shift permanently to this new state, making it difficult for the oak forests to recover. Another major problem is climate change, because oaks have a high calorific content, they burn easily, increasing the risk of forest fires. The challenging terrain makes it difficult to control these fires once they start. Therefore, restoring oak forests should be given top priority as an important measure to combat climate change. The restoration approaches includes consultation with experts and organization of workshops, piloting of Oak rehabilitation in Sikkim under GIZ CCA-NER project and preparation of oak manual underway jointly with ATREE and funded by TNC-India.

Challenges for natural regeneration

- Pest and insect like weevils attacks often damages acorns;
- Mature oak trees produce poor quality seeds;
- Single acorn can take years to germinate;
- Competitive pressure from secondary species such as Symplocos, Eurya, Bamboo, Viburnum etc.;

- Less penetration of sunlight because of closed canopy.

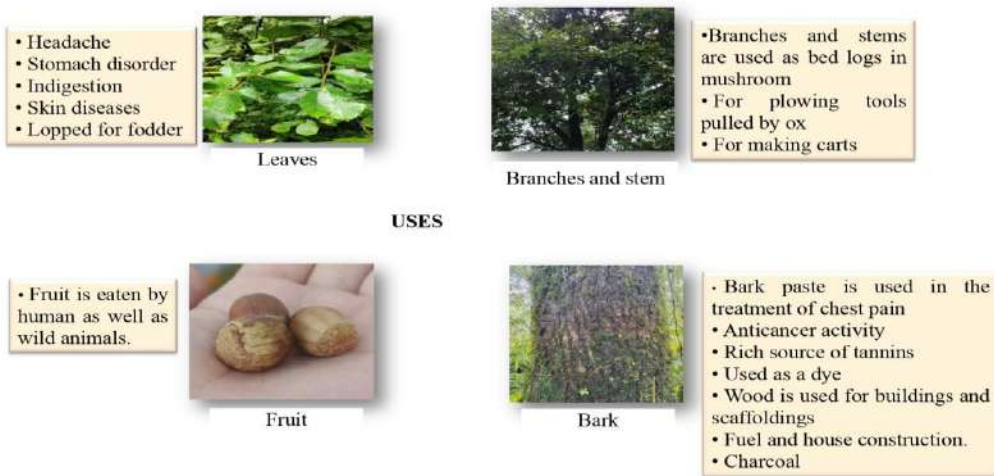

Fig. 3. Important uses of *C. indica*.

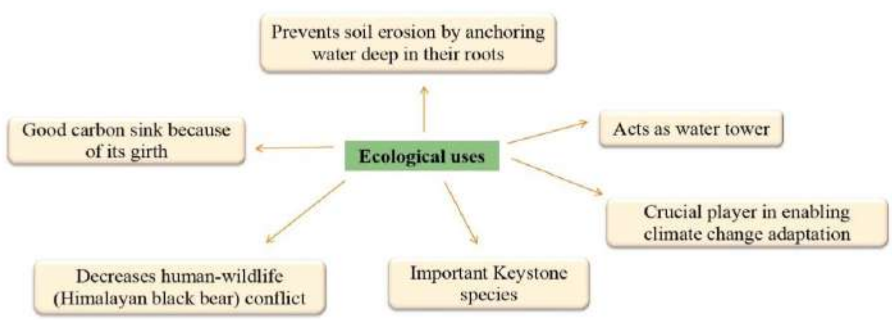

Fig. 4. Ecological uses of *C. indica*.

Reproduction and propagation

(i) The Acorns are collected, screened and sown in nursery during may and June then the plantlets are transplanted and fenced to safeguard young saplings from grazing and herding. The seedlings are thin and delicate. It is best grown in full sun to partial shade and prefers well-drained, moist soil.

(ii) Propagation is done by seed or semi-hardwood cuttings taken in late summer or early fall.

(iii) Sandpaper rubbing at the distal end established as the best pre-sowing procedure followed by soaking in 10% concentrated HCl acid for 5 minutes treatment and water treatment at room temperature for 48 hours.

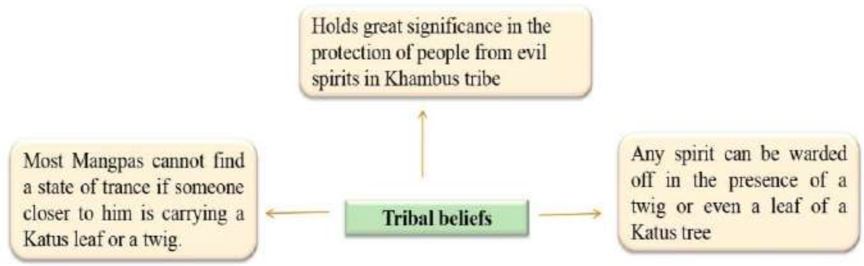

Fig.5. Uses of *C. indica* in tribal beliefs.

Conclusion

In conclusion, despite the multitude of benefits offered by *Castanopsis indica*, it remains relatively unknown to the wider public. This remarkable tree holds immense potential to enhance human life across various spheres, from nutrition and medicine to environmental conservation. By raising awareness and encouraging the propagation of *C. indica*, we can harness its full potential and contribute to a healthier, more sustainable future.

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BIOPLASTICS: THE GREEN ALTERNATIVE REVOLUTIONIZING SUSTAINABILITY

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Abstract

Bioplastics are a growing sustainable substitute for traditional plastics, made from renewable biological sources. The widespread usage of plastics derived from petroleum has serious environmental problems, which are addressed by this green breakthrough. Since bioplastics break down more quickly in the right environments, they have the added advantage of lowering carbon footprint and reducing reliance on fossil fuels. Technology developments have increased the number of uses for bioplastics, ranging from packaging to car components. Although there are obstacles to overcome, such increased production costs and a lack of industrial composting facilities, bioplastics have the potential to completely transform sustainability. Overcoming these obstacles and increasing output depends on ongoing research and development as well as supporting policy. In line with the increasing demand, the introduction of bioplastics into the worldwide market promises a more environmentally friendly future.

Key words: Plastic pollution, Sustainability, Renewable resources, Environmental impact

Introduction:

Plastic pollution has triggered a global environmental disaster, threatening oceans, wildlife, and human health. Every year, millions of tons of plastic waste enter the oceans, generating massive garbage patches that threaten marine life. Animals frequently ingest or become entangled in plastic trash, resulting in harm or death. Microplastics, or small plastic particles, have contaminated ecosystems and the food chain, endangering both wildlife and humans. Plastic manufacture and disposal add to greenhouse gas emissions, which exacerbates climate change. Reducing plastic use, better waste management, and encouraging recycling are all critical measures in addressing this issue. Public awareness and international cooperation are critical in driving policy reforms and solutions for a sustainable future. Addressing plastic pollution demands a collaborative effort from governments, companies, and citizens.

Bioplastics are a sustainable alternative to traditional plastics made from renewable sources such as plants, algae, and microbes. Bioplastics, as opposed to regular plastics, are designed to have a lower environmental impact. They can be biodegradable or compostable, which means they degrade organically and contribute to trash reduction. Bioplastics also have a lower carbon footprint during production. As the need for environmentally friendly materials develops, bioplastics present a viable alternative for lowering reliance on petroleum-based plastics and minimizing plastic pollution, so contributing to a more sustainable future.

Bioplastics are important in reducing plastic pollution and climate change because they are environmentally friendly. They are made from renewable resources, reducing reliance on fossil fuels and lowering greenhouse gas emissions during manufacture. Unlike traditional plastics, many bioplastics are biodegradable or compostable, which helps to minimize waste and pollution in oceans and landfills. By incorporating bioplastics into common items, we can drastically reduce the environmental impact of plastic use. Their adoption promotes a circular economy, sustainability, and resilience to the negative effects of climate change, making them critical to our environmental preservation efforts.

What are Bioplastics?

Bioplastics are plastics made from renewable biological sources like plants, algae, and microbes. Unlike traditional petroleum-based plastics, bioplastics seek to lessen environmental impact by incorporating renewable resources. They can be biodegradable, meaning they break down naturally over time, or compostable, which means they decompose into non-toxic components under composting conditions. Bioplastics are utilized for a variety of purposes, including packaging, agriculture, and consumer products. Bioplastics, by providing an environmentally favourable alternative, help to reduce reliance on fossil fuels and plastic pollution, so promoting a transition toward more sustainable production and consumption habits.

Bioplastics differ from ordinary plastics in terms of their biodegradability and environmental impact. Bioplastics, which are derived from renewable sources such as plants, frequently decompose or compost spontaneously, decreasing long-term waste. Traditional petroleum-based plastics, on the other hand, can remain in the environment for hundreds of years, contributing to pollution and damaging wildlife. Bioplastics often have a lower carbon footprint since their manufacture produces less greenhouse gases. While ordinary plastics are durable and versatile, their environmental impact is enormous. Adopting bioplastics can help reduce plastic pollution and reduce reliance on fossil fuels, supporting a more sustainable and environmentally friendly future.

Types and ways to prepare bioplastics:

Type	Description	Source Materials	Biodegradability	Common Applications
PLA (Polylactic Acid)	Made from fermented plant starch (e.g., corn, sugarcane)	Corn starch, sugarcane	Biodegradable	Packaging, disposable tableware
PHA (Polyhydroxyalkanoates)	Produced by bacterial fermentation of sugars	Sugars, vegetable oils	Biodegradable	Medical implants, packaging
Starch Blends	Composed of starch mixed with other biodegradable polymers	Corn, potato, tapioca starch	Biodegradable	Packaging, agricultural films
PHB (Polyhydroxybutyrate)	A type of PHA, produced by bacterial fermentation	Sugars, vegetable oils	Biodegradable	Packaging, medical applications
Bio-PET (Bio-based Polyethylene Terephthalate)	Similar to conventional PET but made from bio-based materials	Sugarcane, corn	Non-biodegradable	Bottles, textiles
Cellulose Acetate	Derived from cellulose, a component of plant cell walls	Wood pulp, cotton	Biodegradable	Film, cigarette filters
Lignin-Based Bioplastics	Made from lignin, a	Lignin, cellulose	Biodegradable	Packaging, automotive

	byproduct of paper manufacturing			parts
Chitosan	Derived from chitin, found in the exoskeletons of crustaceans	Shellfish shells	Biodegradable	Medical applications, water treatment
Algae-Based Plastics	Made from algae, a rapidly renewable resource	Algae biomass	Biodegradable	Packaging, films
Soy Protein Isolate Plastics	Made from soy protein isolate, derived from soybeans	Soybeans	Biodegradable	Packaging, adhesives
Casein Plastics	Made from casein, a protein found in milk	Milk protein	Biodegradable	Packaging, adhesives

How bioplastics are made?

Bioplastic manufacture is a multi-step process. First, renewable raw resources such as corn, sugarcane, or algae are gathered and processed to yield sugars or starches. These sugars are subsequently fermented by microorganisms to yield bio-based monomers like lactic acid and polyhydroxyalkanoates (PHAs). Polymerization of the monomers produces lengthy biopolymer chains. These biopolymers are then converted into pellets or granules that can be molded or extruded into a variety of bioplastic goods. The entire process is intended to be more environmentally friendly than typical plastic production, lowering dependency on fossil fuels while limiting environmental effect.

Applications of Bioplastics:

- **Packaging:** Bioplastics are gaining popularity in packaging due to their environmental benefits. They are used to make compostable bags, food containers, and wraps that disintegrate organically, hence minimizing landfill trash. This move enables businesses to accomplish sustainability targets while also appealing to environmentally sensitive customers. Furthermore, bioplastic packaging can help to lessen the carbon footprint associated with conventional plastic manufacture.

- **Agriculture:** Bioplastics are used as mulch films in agriculture, degrading into the soil without the need for disposal. This not only lowers labour expenses, but also eliminates plastic contamination in fields. Biodegradable plant pots constructed of bioplastics can be put directly in the ground, where they decompose, enriching the soil and encouraging healthy plant development.
- **Consumer goods:** Bioplastics are utilized in disposable cutlery, plates, and cups, reducing plastic waste and promoting compostability. Bioplastic shopping bags and fabrics are an environmentally beneficial alternative to traditional counterparts, reducing the environmental impact of common items and encouraging sustainable consumer behaviour.
- **Medical and pharmaceuticals:** Bioplastics are used in new medical and pharmaceutical applications, including biodegradable sutures, stents, and drug delivery systems. These materials are intended to dissolve safely in the body, minimizing the need for additional procedures to remove medical devices while improving patient care. Bioplastics also contribute to the creation of environmentally friendly medical packaging, reducing hazardous waste.

Benefits of bioplastics:

- **Environmental Impact:** Bioplastics have a substantially lower carbon footprint than regular plastics because they are made from renewable resources such as plants, which absorb CO_2 as they grow. Their biodegradability and compostability allow them to degrade organically, as opposed to traditional plastics, which can endure for millennia. This helps to reduce plastic waste in oceans and landfills, thereby protecting species and ecosystems. Bioplastics help to reduce greenhouse gas emissions, which aids in climate change mitigation efforts.
- **Economic benefit:** The bioplastics industry has the ability to reduce costs while also creating job opportunities in sustainable areas. As demand for environmentally friendly products rises, investments in bioplastic research, production, and recycling infrastructure can help to drive economic growth. Farmers benefit from providing raw materials, while new jobs are created in the bioplastic production, waste management, and recycling industries. Companies can also save money by reducing waste disposal prices and increasing brand loyalty among environmentally conscientious customers.

- **Social benefits:** Bioplastics serve an important role in encouraging sustainable practices and minimizing plastic waste, which benefits society as a whole. By using bioplastics, communities may reduce their environmental effect and contribute to a cleaner, healthier Earth. This shift promotes ethical consumption and enhances public knowledge of sustainability. The shift to bioplastics contributes to worldwide efforts to battle pollution, maintain biodiversity, and create a more sustainable future for everybody.

Challenges and limitations of bioplastics:

- **Technical challenges:** Technical challenges for bioplastics include mechanical strength and breakdown rates. Some bioplastics may not be as durable and flexible as standard plastics, restricting their application range. Furthermore, breakdown rates can vary, with some bioplastics necessitating specific conditions to biodegrade successfully, which may not be present in all locations.
- **Economic Barriers:** Bioplastics are more expensive to create than conventional plastics due to smaller manufacturing scales and higher raw material costs. This price gap may prevent manufacturers and consumers from using bioplastics, particularly in cost-sensitive regions. Production must be scaled up and processing processes improved to increase bioplastics' economic competitiveness.
- **Consumer awareness:** Raising consumer awareness and acceptance is vital for widespread use of bioplastics. Many people are still unfamiliar with the benefits of bioplastics and how to dispose of them properly. Raising knowledge about the environmental benefits and advocating clear labeling can assist consumers in making educated decisions, increasing demand for bioplastic goods and aiding a transition toward sustainable practices.

The future of bioplastics:

- **Innovations:** Current research in bioplastic technology aims to improve durability, flexibility, and biodegradability. New bio-based polymers, improved microbial fermentation methods, and hybrid materials with enhanced performance are all examples of advancements. Innovations in feedstock use, such as agricultural waste and algae, aim to further reduce prices and environmental impact.
- **Market growth:** The bioplastics industry is expected to rise rapidly due to increased environmental consciousness and regulatory pressures. According to industry forecasts,

the worldwide bioplastics market might approach $7 billion by 2025, with packaging, agriculture, and consumer goods seeing significant growth. Investments in manufacturing capacity and technical developments will continue to drive this growth.

- **Sustainability goals:** Bioplastics support sustainability and circular economy aims. They help to minimize reliance on fossil fuels, lower greenhouse gas emissions, and promote waste reduction through biodegradability and compostability. Bioplastics help to create a more sustainable, circular economy by aligning with sustainable practices and encouraging innovation.

Conclusion

Bioplastics are a sustainable alternative to traditional plastics, created from renewable sources and with a lower environmental impact. They biodegrade or compost naturally, reduce plastic pollution, and contribute to climate change goals by lowering carbon emissions. Adopting bioplastic products and practices is critical for achieving a sustainable future. We have to support companies that use bioplastics, fight for policies that encourage their use, and educate others about their benefits. As bioplastic technology advances and market demand rises, bioplastics have the potential to transform the plastic industry. Choosing bioplastics helps to preserve ecosystems, conserve species, and reduce our carbon footprint. Together, we can create a world in which plastics no longer hurt the environment but instead contribute to its health and sustainability. Join the bioplastics movement to ensure a cleaner, greener future for generations to come.

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RNA EDITING

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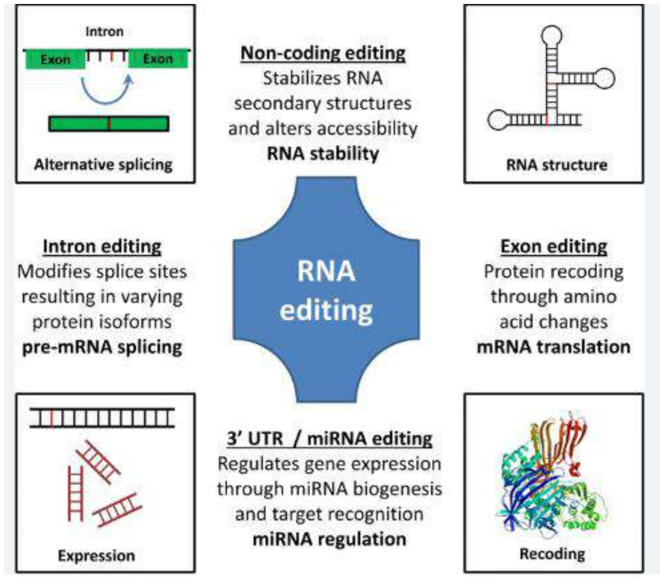
Introduction

RNA editing is a post-transcriptional modification where a precursor mRNA (pre-mRNA) nucleotide sequence is changed by base insertion, deletion, or modification. The extent of RNA editing varies from a few hundred bases, in mitochondrial DNA of trypanosomes, to a just single base, in nuclear genes of mammals. Even a single base change in the pre-mRNA can convert a codon for one amino acid into the codon for another amino acid or a stop codon. This type of re-coding can significantly affect the structure and function of a protein and may lead to the production of multiple variants of a protein from a single gene.

RNA editing is also known as RNA modification through which some cells can make discrete changes to specific nucleotide sequences within an RNA molecule after it has been generated by RNA polymerase. It occurs in all living organisms and is one of the most evolutionarily conserved properties of RNAs. RNA editing may include the insertion, deletion, and base substitution of nucleotides within the RNA molecule. RNA editing is relatively rare, with common forms of RNA processing (e.g. splicing, 5'-capping, and 3'-polyadenylation) not usually considered as editing. It can affect the activity, localization as well as stability of RNAs, and has been linked with human diseases.

RNA editing has been observed in some tRNA, rRNA, mRNA, or miRNA molecules of eukaryotes and their viruses, archaea, and prokaryotes. RNA editing occurs in the cell nucleus, as well as within mitochondria and plastids. In vertebrates, editing is rare and usually consists of a small number of changes to the sequence of the affected molecules.



In other organisms, such as squids, extensive editing (*pan-editing*) can occur; in some cases the majority of nucleotides in an mRNA sequence may result from editing. More than 160 types of RNA modifications have been described so far. RNA-editing processes show great molecular diversity, and some appear to be evolutionarily recent acquisitions that arose independently. The diversity of RNA editing phenomena includes nucleobase modifications such as cytidine (C) to uridine (U) and adenosine (A) to inosine (I) deaminations, as well as non-template nucleotide additions and insertions. RNA editing in mRNAs effectively alters the amino acid sequence of the encoded protein so that it differs from that predicted by the genomic DNA sequence.

Insertional and Deletional RNA Editing

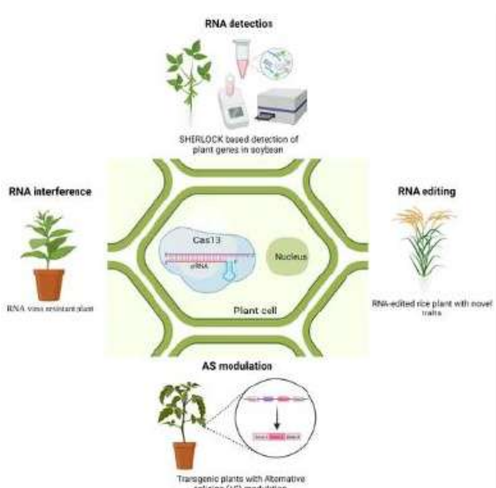
Insertional and deletional RNA editing involves the addition and deletion of specific nucleotides or sequences of nucleotides from pre-mRNA. In RNA editing in the mitochondria of some pathogenic trypanosomes, hundreds of noncoding uridines are added and specific uridine residues are deleted from the pre-mRNA. These additions and deletions are performed by an enzyme complex, called the editosome. The editosome is guided by a special RNA transcript known as guide RNA (gRNA). gRNA attaches to the target pre-mRNA region with the help of a complementary anchor sequence, which is 10-15 nucleotides long. gRNA also has a template sequence that instructs the editosome as to the location and number of uridine residues to be added or deleted in the pre-mRNA. More than 50% of the mitochondrial RNA of some trypanosomes is formed by the addition of uridine residues.

Substitutional RNA Editing

Substitutional RNA editing by base modifications is observed In higher eukaryotes, where the base is modified without changing the length of the pre-mRNA. In vertebrates, deamination reactions involving adenosine and cytidine are the most common type of RNA editing. Adenosine is deaminated to inosine by a single enzyme known as adenosine deaminase acting on RNA (ADAR). To recognize the editing site, ADAR needs a double-stranded RNA structure formed between the target region and the downstream complementary intron region of the pre-mRNA. There are three types of ADAR enzymes found in vertebrates. ADAR1 and ADAR2 enzymes are found in various tissues whereas ADAR3 is specific to the brain of some species. Another less common type of RNA editing is observed in the ApoB gene of mammals where cytidine is modified to uridine. This is accomplished by a complex of enzymes including apolipoprotein B mRNA editing enzyme catalytic polypeptide 1 (APOBEC1). Though RNA editing is a relatively rare phenomenon in vertebrates, defects in the process can cause several diseases associated with the central nervous system, such as amyotrophic lateral sclerosis, epilepsy, depression, and schizophrenia.

RNA editing in plants

Plant RNA editing was first described in 1989 as a C-to-U conversion in mitochondrial transcripts . There are approximately 500 and 30 RNA editing events in the mitochondria and chloroplasts, respectively, recorded in a diverse list of plants such as *Arabidopsis thaliana*, *Oryza sativa*, *Brassica napus Beta vulgaris*, *Vitis vinifera*, and *Nicotiana tabacum*. Recent analysis showed that numerous nuclear transcripts are also differentially edited.



Most C-to-U substitutions are found in the protein-coding regions safeguarding evolutionary codons. Therefore, the RNA editing should be considered a corrective mechanism at the post-transcriptional level against C-to-T (or T-to-C) changes, which possibly support less favorable changes. RNA editing events have also been identified in introns and untranslated regions; these events affect mRNA stability or splicing as the secondary structure or regulatory element is modified.

In the case of some lower plant families, in addition to the extensive C-to-U, "reverse" U-to-C RNA editing has also been identified in plastids and mitochondria. Recent studies have demonstrated the molecular mechanism by which the target sequence recognition and the catalysis of C-to-U and U-to-C editing of organellar RNAs are conducted by pentatricopeptide repeat (PPR) and the auxiliary DYW domain, respectively. The nuclear transcriptome of *A. thaliana* revealed the presence of A-to-I RNA editing events, possibly caused by a plant homolog of ADAR, similar to the mammalian RNA editing . Additionally, recent transcriptomic studies have reported nine different RNA editing patterns in nuclear encoded RNAs of *Arabidopsis* and *Salvia;* these events are all intra-base substitutions (C-to-U, U-to-C, A-to-I, A-to-C, A-to-U, G-to-A, G-to-C, U-to-A, and U-to-G). The molecular mechanism of these peculiar RNA editing of nuclear encoded RNA is completely unknown.

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UNLOCKING THE POTENTIAL: THE IMPACT OF SILICON ON AGRICULTURAL CROP RESILIENCE AND PRODUCTIVITY

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Abstract

Silicon, a prevalent element in the Earth's crust, has emerged as a critical factor influencing the growth and performance of agricultural crops. Silicon supplementation positively impacts crop growth parameters, including biomass accumulation, root development and yield. Silicon enhances plant's ability to withstand biotic and abiotic stresses; such as pests, diseases, drought, salinity and heavy metal toxicity. Mechanistically, silicon uptake and deposition in plant tissues, particularly in cell walls, fortify structural integrity and induce biochemical changes that underlie stress tolerance mechanisms. Furthermore, silicon-mediated alterations in plant defense pathways contribute to enhanced disease resistance and pest deterrence. The application of silicon-based amendments in agricultural practices holds promise for sustainable crop production by improving resource use efficiency, reducing chemical inputs and mitigating environmental stresses. Integrating silicon management into agronomic practices presents an avenue for enhancing crop resilience, productivity and sustainability in the face of escalating global challenges.

Key words: Nano-particle, reactive oxygen species, silicon, stress tolerance, sustainability

Introduction

It has been documented that silicon uptake increases plant's tolerance to water stress through a variety of processes[1]. Increased antioxidant defence, increased net CO_2 assimilation of leaves during drought, lowering transpiration by forming a double layer of cuticle-Si on the surface of epidermal cells that affects the permeability of the cell and giving plant tissues structural support to avoid lodging are a few effects of Si. Given the predictions of reduced water availability under climate change[2] and the potential of Si application in mitigating the impacts of drought on crop performance[3], the ability to accumulate Si as a mechanism to alleviate the adverse effects of drought on crops is of increasing interest. Besides providing resistance to pathogens, Si is also known to offer resistance response to insect pests in plants. When plants are exposed to abiotic stress, they release an excessive amount of reactive oxygen species (ROS), which harms the cells. The advantageous impact of using Si has been noted in reducing the effects of abiotic stressors such salt, drought, metal toxicity, radon etc. The reduction in stress linked with Si is seen in both the low Si accumulators and the high Si accumulating plants.

Uptake

Through the transpiration stream, silica is drawn up from the soil as silicic acid, which is then collected by plant tissues at varying concentrations based on a range of parameters such as plant species and variety as well as the availability of Si in the soil. It is well recognized that variations in the distribution of root biomass among various rooting zones and in root architecture have an impact on plant uptake of Si. The genetic predisposition to absorb silicic acid determines a plant's capacity to absorb Si. Si has been found to have a variety of effects, such as resistance to disease, tolerance to drought stress, high temperatures, heavy metal stress and damage from herbivores. Moreover, Si is known to promote many physiological processes in plants, which in turn promotes plant development.

Both passive absorption through the transpiration stream and aquaporin channels as well as active efflux transporters are involved in the process. Although it is currently known that variations in Si uptake and accumulation between plant species and varieties affect differences in stomatal density and conductance, as well as in transporter abundance and expression, the relative contributions of passive and active processes to Si uptake and transport remain unclear[4]. Reduced transpiration rates during dry spells will lower soil water availability, which may restrict the benefits of silicon by reducing the plant's ability to absorb and transport the mineral.

Bio-availability in soil

Three distinct fractions of silicon are found in soil: the liquid, adsorbed phase, and solid phase. There are four types of silicon present in solid phase: crystalline, microcrystalline, weakly crystalline and amorphous. The main and secondary silicates that make up a significant portion of Si in the solid phase are the primary types of silica. Biogenic and litho or pedogenic formations are among the amorphous forms. It is believed that the Si found in plant waste and microbe remnants is biogenic.

Soil Bacteria's Capability to Solubilize Silicon

It is believed that bacteria contribute significantly to the silicate biogeochemical cycle by facilitating the breaking of siloxane (Si–O–Si) bonds that are necessary for Si solubilization and mobilization. By a variety of processes including the synthesis of extracellular (i) cation ligands, (ii) organic and inorganic acids, (iii) alkali (amines or ammonia), and (iv) polysaccharides, bacteria break down silicate complexes. The most common process among them is thought to be the generation of acids, which solubilizes silica[5]. Numerous bacterial species emit organic acids such as fumaric, succinic, acetic, gluconic, tartaric, and maleic acids, which also aid in the solubilization of Si from multiple silicate sources.

Nano silica

The production of nanomaterials and their application in plant nutrition have garnered significant interest in recent decades. Nutrient loss can be reduced by using fertilizers at the nanoscale range, which enables the controlled release of nutrients based on crop requirements. Numerous crop plants have also been investigated for the application of silicon nanoparticles, or Si-NPs (Table 1). Si-NPs have distinct characteristics from their bulk counterparts, including small size, high surface area to weight ratio, and varied morphologies. Nanoparticle’s solubility and surface reactivity are enhanced by their larger surface area. Because of their smaller size than the bulk material, nanoparticles are able to pass through cell walls and plasma membranes more readily, which facilitates their efficient absorption[6].

Effects on Stress Tolerance

Silica-mediated enhancement of stress tolerance is particularly significant in barley cultivation. Silicon supplementation has been shown to mitigate the adverse effects of diverse stressors, including drought, salinity, and heavy metal toxicity. By strengthening cell walls and activating defense mechanisms, silica confers resilience to environmental challenges, thereby safeguarding barley productivity and quality under adverse growing conditions.

Impact on Disease Resistance

Barley is susceptible to various pathogens, including fungi, bacteria, and viruses, which can cause significant yield losses. Silica supplementation has been demonstrated to bolster barley's resistance against such pathogens by inducing systemic acquired resistance (SAR) and priming defense responses. Additionally, silica deposition inhibits pathogen penetration and colonization, reducing disease severity and enhancing crop health.

Implications for Agricultural Practices

The integration of silica-based amendments in barley cultivation holds promising implications for sustainable agriculture. By optimizing nutrient uptake, enhancing stress tolerance, and bolstering disease resistance, silica supplements offer a cost-effective strategy for improving barley yield, quality, and resilience. Furthermore, the eco-friendly nature of silica-based interventions aligns with the principles of organic and low-input farming systems, promoting environmental sustainability and resource efficiency.

Table 1. Effect of silica on different crops

Crop	Si supplementation	Particle size	Effect	Reference
Maize (*Zea mays*)	10 µM	20-40	Application of Si-NP resulted in noticeably increased resistance to *Aspergillus niger* and *Fusarium oxysporum*.	7
Wheat (*Triticum aestivum*)	10 µM	20-40	Si-NP and Si shielded seedlings against UV-B radiation. Si-NP was shown to be more efficient than Si at reducing UV-B stress.	8
Fenugreek (*Trigonella foenum-graecum*)	0, 0.5, 1, 1.5, 2 and 2.5 mM	20-30	The application of SiNP and sodium silicate increased the thickness of the xylem cell wall, lignifications in the cell wall, and the uptake and accumulation of Si.	9
Strawberry (*Fragaria ananassa*)	50, 100, mg L^{-1}	10-20	Si-NP spraying reduced the detrimental effects of salt stress on strawberry plants.	10

Conclusion

The influence of silicon on agricultural crops presents a compelling narrative of potential benefits for global food security and sustainability. Through an array of mechanisms, silicon supplementation enhances crop growth, stress tolerance, and disease resistance. By fortifying cell walls, optimizing nutrient uptake, and priming defense responses, silicon fosters resilient crop phenotypes capable of thriving under diverse environmental conditions. Furthermore, the eco-friendly nature of silicon-based interventions aligns with the principles of sustainable agriculture, offering a pathway towards reduced chemical inputs and enhanced resource use efficiency. While substantial progress has been made in understanding silicon-crop interactions, further research is essential to unlock the full potential of silicon in optimizing crop production systems. Integrating silicon management strategies into agronomic practices holds promise for addressing the challenges of climate change, pest pressure, and soil degradation. As we navigate towards a future of increasing agricultural demands and environmental uncertainties, harnessing the benefits of silicon represents a tangible opportunity to bolster crop resilience, productivity and sustainability on a global scale.

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LAND USE LAND COVER MAPS

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Introduction

A map is a symbolic representation of selected characteristics of a place, typically on a flat surface. It visually presents information about the world, including country sizes, shapes, locations of features, and distances. Maps can show distributions such as settlement patterns and exact locations in a city. Cartographers, or mapmakers, create maps for various purposes: vacationers use road maps, meteorologists use weather maps, and city planners use maps to decide on infrastructure placement. Land Use and Land Cover data sets provide global and regional information on land forms and uses, highlighting potential development threats and human modifications. These data sets include details on urban expansion, anthropogenic stressors, mangrove land cover from Landsat imagery, and Central American vegetation from AVHRR imagery.

Important considerations during LULC mapping are

- Purpose- scientific studies, policy, planning or management purposes.
- Thematic content - needed for few cover types or for all cover types of Scale - locally, regional scales, or continental to global scales.
- Data- RS data limit type and accuracy of information that may be extracted.
- Methodology – visual or digital or automatic or semi-automatic.

Land use

Land use refers to the human activities and purposes for which land is used, such as residential, commercial, industrial, agricultural, recreational, and natural areas. It's essential for land management and planning, helping to understand how society utilizes different land areas.

Land use maps, along with land cover maps, offer a comprehensive view of the landscape. While land cover describes the physical characteristics of the land (like vegetation, water bodies, and buildings), land use focuses on human activities on the land. Combining land use and land cover in maps helps researchers, planners, and policymakers analyze patterns, changes, and trends in land use and cover. This information is valuable for urban planning, environmental management, natural resource planning, and other applications requiring knowledge of land characteristics and activities.

Land cover

Land cover refers to the physical characteristics of the Earth's surface, including natural and artificial features. Unlike land use, which focuses on human activities and purposes for which the land is utilized, land cover categorizes the surface into different types based on the physical attributes. Land cover maps help in understanding the physical composition of a landscape, providing valuable information for environmental monitoring, ecological studies, and land management. When combined with land use data in LULC maps, they offer a more comprehensive view of how both human activities and the natural environment interact and contribute to the overall landscape composition. These maps are crucial tools for urban planning, biodiversity conservation, climate change studies, and sustainable resource management.

SOURCES OF LAND USE COVER INFORMATION:

Conventional

The conventional method for collecting Land Use and Land Cover (LULC) information in the country involves revenue records compiled by the Directorate/Bureau of Economic and Statistics (DES/BES) of respective states. This data, based on agricultural inventory at the plot level, uses a nine-fold classification system and is available as statistical records without spatial references. Another source is topographical maps from the Survey of India, which use ground information but are outdated and lack current land use changes. Soil Survey organizations generate land use maps based on soil mapping units, but these are limited to specific project areas and lack coordination with other agencies, leading to duplication and irrelevant data. Local planning agencies use detailed information from ground surveys. Problems with these data sets include changes in category definitions, incomplete coverage, varying data age, and incompatible classification systems, making it hard to aggregate data. Modern approaches like remote sensing have partly overcome these limitations.

Remote sensing

Land cover mapping is a product of the development of remote sensing, initially through aerial photography. Remote sensing technology, because of the benefits it offers (wide area coverage, frequent revisits, multispectral, multisource, and storage in digital format to facilitate subsequent updating and compatibility with GIS technology) proved very practical and economical means for an accurate classification of land cover.

METHODOLOGY:

Data collection

Satellite imagery, from platforms like Landsat and Sentinel, provides a broad, detailed view for large-scale land cover mapping. High-resolution aerial photos from aircraft or drones offer up-to-date details for smaller areas. Ancillary data, such as topographic maps, climate info, and soil maps, add context. Ground truthing with field surveys validates the observed land cover types.Geographic Information System (GIS) datasets, including administrative boundaries and transportation networks, enhance understanding. Land use planning documents, zoning maps, and historical records from local authorities provide insights into existing land use patterns. Open data platforms like OpenStreetMap offer community-driven contributions. Weather and climate data help understand seasonal land cover changes. Historical satellite imagery is useful for analysing trends over time. Combining these data sources creates accurate, current LULC maps useful for environmental monitoring and urban planning.

GEORFERENCING OF SATELLITE DATA:

Georeferencing involves aligning the pixels of satellite imagery with real-world geographic coordinates, allowing for precise mapping and interpretation. This process ensures that the mapped features correspond accurately to their locations on the Earth's surface. Ground control points, identifiable landmarks with known coordinates, are used to anchor the satellite imagery spatially. Through techniques like polynomial transformation or image-to-image registration, the satellite data is transformed to fit the chosen coordinate system.

Georeferencing not only facilitates the integration of different datasets within a Geographic Information System (GIS) but also enables the overlay of mapped information with other spatial layers, enhancing the overall utility of LULC maps. This spatial accuracy is crucial for decision-making in applications ranging from urban planning and environmental monitoring to disaster management.

Classification

In LULC mapping, image classification is crucial for identifying different land cover types in satellite or aerial imagery. The process starts with preprocessing to correct atmospheric distortions and improve image quality. Then, training data is selected by labeling representative samples of each land cover class. Features are extracted from this data, such as spectral and textural characteristics. A classification algorithm (e.g., Maximum Likelihood, Support Vector Machines, Random Forest, Neural Networks) is chosen based on the data and objectives. The algorithm is trained to distinguish between land cover classes using these features. The classifier is applied to the entire image, assigning each pixel to a land cover class. Post-classification processing refines the results, and accuracy is assessed using ground truth data. The final LULC map provides detailed land cover classifications for various applications, from urban planning to environmental monitoring.

Supervised Classification Maps

Supervised classification is a key method in LULC mapping, involving the selection and labelling of training data. This data guides a classification algorithm (e.g., Maximum Likelihood, Support Vector Machines, Random Forest) to distinguish land cover classes based on spectral and textural features. The trained classifier categorizes each pixel in the image. Post-classification processing refines results, and accuracy is validated with ground truth data. The resulting LULC map offers a detailed representation of land cover types, useful for urban planning, environmental monitoring, and resource management.

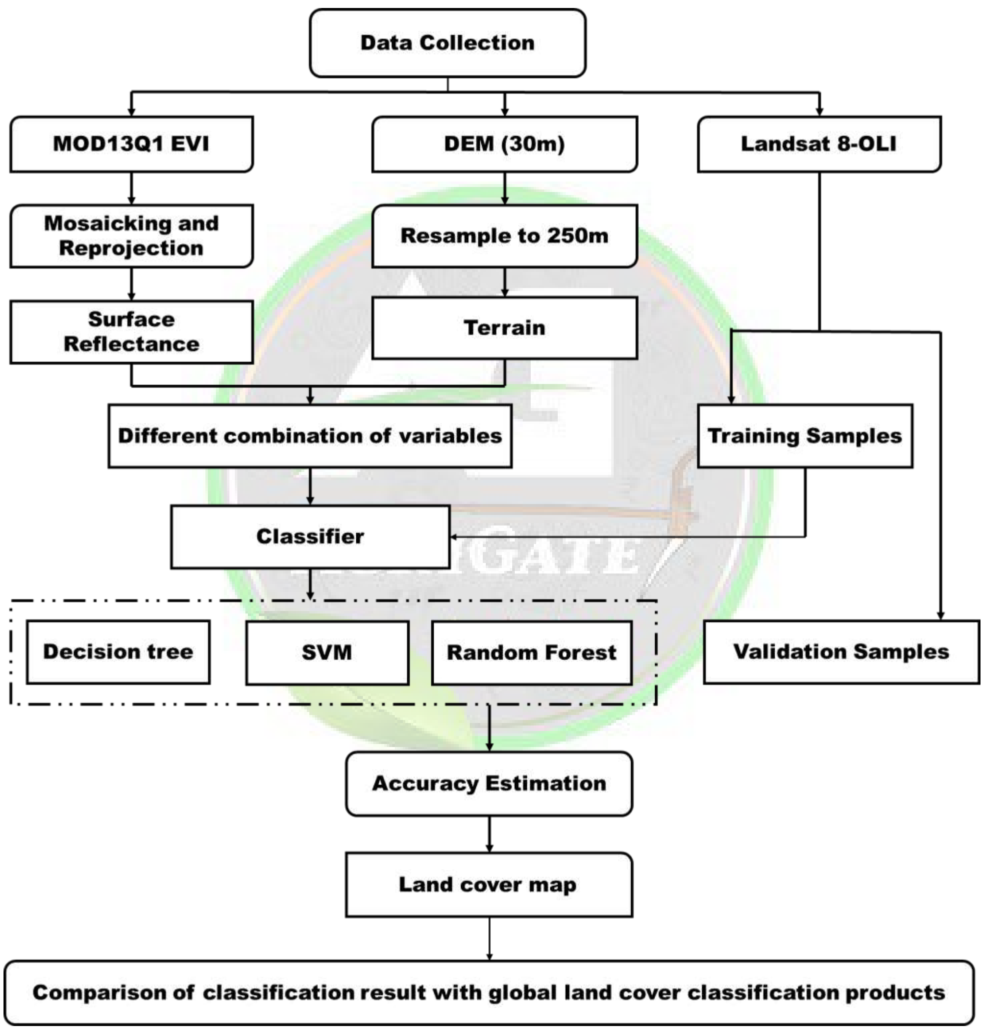
Assigning Signatures

Assigning signatures in LULC mapping involves characterizing the spectral fingerprints of different land cover classes. Training data is collected to represent the spectral variability of each class. Spectral signatures are created by compiling reflectance values across spectral bands. These signatures are validated with additional data or ground truth information and adjusted as needed. Once validated, the signatures guide classification algorithms (e.g., Maximum Likelihood, Support Vector Machines) in categorizing pixels. Post-classification refinement and validation ensure accuracy, resulting in a detailed LULC map.

Digital Classification

Digital classification in LULC mapping uses computational algorithms to categorize pixels in remote sensing imagery. Training data represents the spectral characteristics of each land cover class. Algorithms (e.g., Maximum Likelihood, Support Vector Machines, Random Forest) learn from this data to create decision rules for classification. The trained classifier is applied to the entire image, assigning pixels to land cover classes. Post-classification processing refines results, and accuracy is validated with ground truth data. Digital classification is efficient and scalable, suitable for large-scale landscapes and trend analysis.

FLOW CHART



Purification of Signature

Purification ensures the accuracy of spectral signatures in classification algorithms. Training data is collected to define initial spectral signatures. Validation processes, such as ground truthing, identify discrepancies and refine the signatures iteratively. Adjustments ensure the signatures accurately reflect the spectral patterns of land cover types, considering factors like seasonal variations. The purified signatures guide digital classification algorithms (e.g., Maximum Likelihood, Support Vector Machines) for precise pixel categorization. This enhances the accuracy and reliability of the LULC map.

Accuracy Assessment

Accuracy assessment compares the classified LULC map with reference data from ground truthing or high-resolution imagery. A representative sample of locations is verified, and statistical measures (overall accuracy, producer's accuracy, user's accuracy) evaluate the map's accuracy. Overall accuracy measures the general match, producer's accuracy assesses individual classes from the reference data perspective, and user's accuracy evaluates the likelihood that a classified pixel truly belongs to that class. The assessment identifies misclassifications and areas of uncertainty, allowing refinements to improve the map's accuracy.

Conclusion

Land use land cover map classification is a crucial tool for understanding and managing our environment. By accurately categorizing and analysing the various types of land cover, we can make informed decisions about resource allocation, urban planning, and environmental conservation. This process provides valuable insights into the changing landscape, facilitating sustainable development and effective natural resource management.

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STRATEGIES FOR MITIGATING DROUGHT IN PULSES

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Abstract

In light of the changing climate, our study offers valuable insights into the physiological mechanisms and research findings needed for developing drought- resistant legume species. This aims to enhance the adaptability and resilience of agricultural systems in regions affected by drought globally.

Introduction

Promoting legume cultivation in developing countries can benefit smallholder farmers, improve soil health, and enhance food security. Legumes contribute significantly to global crop production and protein needs, serving as vital cash crops for millions of smallholders. They also improve soil quality, increase yields, and mitigate soil erosion and pathogens, making them valuable in sustainable agriculture practices.Legumes demonstrate advantageous impacts on crop yield when grown in rotation or as cover crops alongside cereals. Additionally, they aid in boosting soil carbon (C) and nitrogen (N) levels, mitigating soil erosion, and reducing the prevalence of specific soil pathogens. Employing legumes as manure in conservation agriculture improves soil porosity and reduces bulk density. Promoting the cultivation of legumes in developing countries could serve as a powerful tactic for progressing towards the Millennium Development Goals, particularly in addressing poverty and hunger, improving health, and promoting environmental sustainability.

Pulses

Drought stress has a profound impact on crop yield, presenting a significant global challenge, particularly in arid regions that account for 40% of India's food output. It is imperative to comprehend how varying degrees of water stress affect the growth and development of grain legumes. This review encapsulates recent studies on the mechanisms of drought tolerance in plants and strategies for managing it, with a specific emphasis on grain legumes.

Root Parameters

A robust root system is vital for early plant growth, aiding in water extraction from shallow soil layers to prevent evaporation, especially in legumes. Postgate (1998) notes that Fabaceae plants develop root nodules to form a symbiotic relationship with nitrogen-fixing rhizobia. These bacteria utilize carbon from the plant to convert atmospheric nitrogen into nitrogen compounds, benefiting the plant. The importance of root systems in water uptake has long been recognized. Root system growth facilitates increased water absorption and maintains essential osmotic pressure through higher proline levels in Phoenix dactylifera. In Populus species, root dry weight declines under mild and severe water stress. The augmented root-to-shoot ratio during drought conditions is associated with the presence of ABA content in both roots and shoots.

Drought Impact In Physiological Approaches

Moisture stress in plants can rupture the water column, reducing water uptake and causing wilting. It triggers increased ethylene secretion, leading to leaf loss, impacting photosynthesis and growth. Drought impairs leaf development and reduces leaf expansion irreversibly, stunting overall plant growth. Reduced emerging leaf area is a key indicator of drought stress, highlighting the interconnectedness of plant processes.Under drought conditions, leaf senescence is triggered by abscisic acid production, leading to stomatal closure and limited CO2 intake, causing photosynthetic starvation, nutrient remobilization, and altered phloem transport.

Drought Impact In Different Phases

Early vegetative phase	Drought significantly impedes the germination and initial development of pea varieties, ultimately affecting the overall growth and productivity of legume crops. Plant growth is a complex process involving genetic, physiological, ecological, and morphological factors. The quality and quantity of plant growth depend on processes like cell division, enlargement, and differentiation, which are highly sensitive to drought stress. Severe water scarcity can hinder cell elongation by disrupting water supply to the elongating cells, resulting in decreased plant height, leaf area, and overall crop growth. The reduction in yield caused by drought has been extensively observed in various crop species, with the degree of impact varying based on the severity and duration of the stress.
Late vegetative phase	Drought occurring later during the vegetative growth stages is comparatively more manageable for plants, even though it may lead to issues such as postponed cell division, elongation, and differentiation. Plants sustain their growth processes under stress, as an early drought triggers immediate survival responses or adaptation, wherein plants modify their metabolic and structural abilities via changes in gene expression.
Reproductive phase	Drought during the reproductive stage significantly impacts crop yield, with similar reductions observed whether drought occurs throughout the growing season or specifically during the reproductive phase. Grain legumes suffer yield losses due to various mechanisms, including shortened reproductive development, reduced branching leading to fewer pods, and decreased seed weight and number per pod.

	Early reproductive stage drought, especially during flowering, is particularly devastating, causing barrenness by limiting assimilate flow to developing seeds. Additionally, drought during grain filling reduces assimilate partitioning and the activity of starch-synthesizing enzymes, further diminishing yield potential. Pigeonpea demonstrates a 40–55% yield reduction when drought coincides with the flowering stage.
Plant water relation	Drought-tolerant mung bean varieties like SML-668 and Pant Mung-3 exhibit superior water potentials, transpiration rates, and lower resistances compared to susceptible varieties. Conversely, sensitive pea genotypes suffer more from reduced relative water content under drought. Leaf temperature regulation plays a crucial role in managing water status during drought. Pea plants with drought tolerance maintain high water-use efficiency by minimizing water loss, but severe growth impediments lead to significant reductions in efficiency. Water stress prompts changes such as increased root-shoot ratio and cell wall thickness, along with decreased leaf area index in mung bean.
Plant Nutrient Relations	Drought reduces water availability, limiting nutrient uptake by roots, transport to shoots, and unloading mechanisms. It typically increases nitrogen (N) but decreases phosphorus (P) without clear effects on potassium (K). Drought also hampers energy availability for assimilating NO_3^- /NH_4^+ , PO_4^{3-} , and SO_4^{2-} . During flowering and pod filling, nodules compete with fruits for photosynthates, drastically reducing nitrogen fixation, especially in legumes like groundnut and faba bean, which exhibit higher yields during drought compared to species with limited nitrogen fixation like green gram, black gram, and cowpea. This competition, coupled with root growth cessation and impaired water uptake due to stress, heightens sensitivity to drought in symbiotic

	plant
Photosynthesis	Moisture stress induces a decrease in photosynthetic rate by reducing leaf area and leaf area index through inhibited cell division and elongation. Additionally, ethylene production under stress conditions enhances leaf abscission, further reducing leaf area. The closure of stomata by ABA signaling and reduced stomatal conductance decrease carbon dioxide diffusion into mesophyll chloroplasts, leading to the production of reactive oxygen species that damage thylakoid membranes, inhibiting photosynthetic activity. Furthermore, moisture stress downregulates non-cyclic photophosphorylation and obstructs ATP synthesis, inhibiting photosynthesis. Low tissue water potential triggers the formation of inhibitors binding to the carboxylation site of RUBISCO, lowering its activity, along with reducing the activity of NADP-ME, PPDK, and PEPCase enzymes.
Assimilate flux into the developing pods	Reduced activity of acid invertase can interrupt the maturation process of reproductive tissues by interfering with the efficient unloading of nutrients in the phloem. Inadequate provision of hexose sugars to developing ovules can hinder cell division in embryo and endosperm tissues, leading to diminished sink activity and possibly causing the abortion of pods.
Generate Reactive oxygen species	Under conditions of water stress, reactive oxygen species like superoxide anion radicals (O2-), hydroxyl radicals (OH-), hydrogen peroxide (H2O2), alkoxy radicals (RO), and singlet oxygen (O2^1) are generated. These reactive oxygen species engage with lipids, proteins, enzymes, and DNA, causing lipid peroxidation, breakdown of structural and functional proteins, nucleic acids, and enzyme deactivation. Consequently, membrane impairment occurs, disrupting normal cellular processes. In pea leaves subjected to moderate water stress, there can be an accumulation of proteins damaged by oxidation.

Drought Resistant Mechanisms:

Drought tolerance pertains to a plant's ability to thrive, blossom, and yield economically even when faced with restricted water availability. Plants exhibiting drought tolerance can adapt, survive, and flourish under drought conditions by instigating diverse morphological, biochemical, and physiological adjustments.

Morphological mechanisms:

Drought tolerance in plants involves adaptations occurring at the tissue, entire plant, physiological, and molecular levels. The existence of one or more of these inherent adaptations dictates a plant's ability to withstand reduced water availability.

Drought Escape:

Drought escape happens when a plant's growth and development are timed to coincide with periods of available soil moisture, particularly in regions with shorter growing seasons and predominant terminal drought stress. Developing short-duration varieties of grain legumes has proven effective in reducing yield loss due to terminal rought, as early maturity allows the crop to avoid stress periods.

Drought Avoidence:

Drought resistance in plants involves strategies such as regulating stomatal openings to minimize water loss through transpiration and ensuring sufficient water uptake through well-developed root systems. Mung bean varieties known for their drought tolerance, such as SML-668 and Pant Mung-3, exhibit characteristics such as high xylem water potentials, elevated transpiration rates, decreased leaf diffusive resistance, lower canopy temperatures, and reduced temperature differentials between the canopy and surrounding air, in contrast to more susceptible varieties. Leguminous plants like common bean, cowpea, and lupin cope with mild drought stress by tightly regulating stomatal conductance, which can lead to a reduction in internal $CO2$ levels, potentially impacting photosynthesis and growth. Some legumes maintain turgor pressure by minimizing epidermal conductance, while others lower their osmotic potential. Certain leguminous species employ a combination of these mechanisms, while others rely on a single strategy. Leaf surface characteristics, such as pubescence, aid in heat dissipation and reduce transpiration rates. Additionally, some plants possess leaves capable of adjusting their orientation to mitigate overheating; those that align away from direct sunlight are termed paraheliotropic, while those perpendicular to the sun's rays are known as diaheliotropic.

Drought Mechanisms:

Physiological mechanisms:	
1. Osmotic adjustment	Accumulation of compatible solutes helps plants protect against stress by contributing to osmotic adjustment, detoxifying reactive oxygen species, stabilizing membranes, and preserving enzyme and protein structures. Osmotic adjustment reduces cell osmotic potential, enhancing water influx and turgor maintenance, which is vital during drought. Improved tissue water status can result from osmotic adjustment and changes in cell wall elasticity. Accumulating organic solutes like sugars, amino acids, and ions lowers cell osmotic potential, attracting water and maintaining turgor. In roots, this enables continuous water extraction from low soil water potentials. Osmotic adjustment also improves carbohydrate translocation during grain filling, enhancing photosynthesis and growth. In legumes, osmotic adjustment mitigates drought's impact on productivity, with higher proline levels observed in certain pea and mung bean cultivars under drought stress. Chickpea cultivars show variation in osmotic adjustment, correlating seed yield with osmotic adjustment under drought. Determining leaf water status and content is useful for screening drought tolerance in chickpeas.
2. Antioxident defence mechanisms	The enzymatic and non-enzymatic antioxidant systems are highly efficient against oxidative stress. Enzymatic antioxidants like catalase, peroxidases, peroxiredoxins, ascorbate peroxidase, dehydroascorbate reductase, monodehydroascorbate reductase, and glutathione reductase actively scavenge superoxide radicals and H_2O_2. Superoxide dismutase converts superoxide into less toxic O_2 and H_2O_2. Carotenoids and abietane diterpene compounds scavenge singlet oxygen and lipid peroxy-radicals,

	inhibit lipid peroxidation, and reduce superoxide generation under dehydration. Non-enzymatic antioxidants such as β-carotenes, ascorbic acid, α- tocopherol, and reduced glutathione also effectively scavenge oxygen free radicals under stress.
3. Cell membrane stability	Cell membrane stability, a key indicator of drought tolerance, is evaluated by its increase under water deficit conditions, distinguishing different cultivars and correlating with reduced growth rates under stress. Drought decreases cellular volume, causing crowding and increased viscosity, which heightens the risk of protein denaturation and membrane fusion. Compounds like proline, glutamate, glycinebetaine, carnitine, mannitol, sorbitol, fructans, polyols, trehalose, sucrose, and oligosaccharides help prevent these adverse molecular interactions. Ion leakage may also result from thermal inhibition of membrane-bound enzymes that maintain chemical gradients.
4. Endogenous plant growth regulator	Under drought, auxin, gibberellin, and cytokinin levels decrease, while abscisic acid and ethylene levels increase, yet phytohormones are vital for drought tolerance. Auxins help form new roots, aided by calcium in signaling proline accumulation. Gibberellic acid biosynthesis mutants show increased rhizogenesis, suggesting its role in this process. Abscisic acid increases root-to-shoot ratio, deeper roots, and triggers stomatal closure to conserve water. Ethylene regulates leaf performance and mediates drought-induced senescence. Salicylic acid boosts reactive oxygen species in stressed Arabidopsis thaliana. Polyamines protect membranes from stress by binding with phospholipids.

Molecular mechanisms:	
1. Aquaporins	Aquaporins are intrinsic membrane proteins that facilitate and regulate passive water exchange across membranes, significantly increasing water permeability. Abundantly present in plasma and vacuolar membranes, they are crucial for root water uptake and cellular osmoregulation in root cells. Factors such as phosphorylation, calcium, and pH modulate their activity, enabling control of transcellular water transport.
2. Stress protiens	The synthesis of various transcription factors and stress proteins is crucial for drought tolerance. Dehydration-responsive element-binding genes (DREB1 and DREB2) are activated by cold and dehydration, respectively, playing key roles in abiotic stress signaling pathways. Engineering transgenic plants to manipulate these genes has enhanced drought tolerance, as demonstrated in groundnut. Drought stress alters the expression of late embryogenesis abundant (LEA)/dehydrin-type genes and molecular chaperones, which protect cellular proteins from denaturation. They accumulate not only during seed desiccation but also in vegetative tissues under water deficit, aiding in protein protection and preventing degradation.

Drought Management Stategies:

To achieve this, two key strategies are crucial: (a) developing and enhancing plant varieties through breeding or genetic modification, and (b) inducing drought tolerance in plants via priming or hormonal application.

Use of Selection and breeding strategies:

Conventional breeding traditionally prioritizes yield without understanding its physiological and molecular basis. Yet, comprehending these mechanisms can target traits limiting yield. Assessing germplasm for drought tolerance is challenging naturally but feasible in controlled stress environments. Genetic analysis of secondary traits like root system architecture has garnered attention. An ideal secondary trait should be genetically linked to yield under drought, highly heritable, easily measurable, and not linked to yield loss under ideal conditions. Drought-tolerant species minimize water loss without compromising biomass production.

Induction of drought resistence:

Using growth-regulating and other chemicals externally has been effective in enhancing drought resistance at different growth stages in several plant species.

Seed Priming	Use of Plant Growth Regulators	Use of Osmoprotectants	Use of Nutrients
Seed priming is a method wherein seeds are given partial hydration to kickstart germination processes without the emergence of the radicle. This method often leads to improved germination rates, uniformity, and overall percentages. Du and Tuong (2002) found that osmopriming with 4% KCl solution and saturated CaHPO4 solution enhanced seedling emergence, crop stand establishment, and yield in rice under moisture stress. Priming benefits include faster seedling emergence, early flowering, and increased grain yield, even in drought conditions. In sunflower, both KNO3 osmopriming and hydropriming have been shown to boost germination and stand establishment under stress.	Drought stress inhibited plant growth, but gibberrelic acid reversed this. Other substances like 1-aminocyclopropane-1-carboxylic acid delayed aging. Treatments with uniconazole, brassinolide, and abscisic acid increased soybean yields under drought. Jasmonic acid boosted pear drought tolerance by increasing betaine levels. Salicylic acid improved drought tolerance by enhancing catalase activity. Maize seeds treated with salicylic acid showed increased polyamine content, enhancing drought tolerance.	Using exogenous osmolytes like glycinebetaine can enhance drought tolerance in plants by improving leaf water status through enhanced osmotic adjustment and photosynthesis. Specifically, foliar-applied glycinebetaine boosts stomatal conductance and Rubisco carboxylation efficiency. Timing-wise, applying glycinebetaine during the vegetative stage proves most effective in mitigating drought effects. Additionally, glycinebetaine application increases antioxidant enzyme activity under water deficit conditions.	Applying development availability during drought condition. Similarly, exogenously applied silicon enhances root photosynthetic rate, and stomatal conductance, improving mechanisms facilitating

Molecular and functional genomics approaches:

Transgenic expression of stress-regulated genes has been shown to increase drought tolerance in crops, but often causes growth retardation, limiting practical applications. While transgenic approaches are mainstream for bioengineering drought tolerance, bioinformatics has also characterized many quantitative trait loci related to membrane stability and other functions.

1. Pyrroline-5-carboxylate synthase, a critical enzyme in the proline biosynthesis pathway, undergoes activation.
2. Introducing genes encoding Betaine aldehyde dehydrogenase, an enzyme crucial for glycine betaine accumulation, into plants that do not naturally accumulate glycine betaine has proven to be successful in enhancing tolerance to a range of environmental stresses.
3. Myo-Inositol 6-o methyl transferase serves as a pivotal enzyme governing the buildup of the cyclic sugar alcohol known as pinitol.
4. Glyceraldehyde-3-phosphate dehydrogenase might facilitate an enhanced carbon influx into organic compounds to support osmotic regulation.
5. Genes responsible for producing enzymes like S-adenosylmethionine synthase and peroxidase, crucial in lignin formation, are influenced by osmotic stress

Yield and Parameters Associated With Yield Attribution

In drought conditions, soybean plants suffer reduced seed yield compared to well-watered ones, influenced by critical growth stages like germination, vegetative growth, flowering, and seed filling. Legumes in dry regions like the Mediterranean face yield challenges due to terminal droughts. Even in countries like Brazil with ample precipitation, brief water deficiencies can cause significant losses in legume yields. Drought is the primary abiotic stressor for soybean production, causing a 60-70% yield reduction in dryland systems in the USA. Drought stress in soybeans lowers both total and branch seed yield.

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IMPACT OF WATER STRESS ON CEREALS

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Introduction

Unpredictable rainfall can result in drought, which limits the growth of crop plants and wild animals alike. Furthermore, the majority of soil has varying degrees of wettability, which causes a heterogeneous moisture profile after irrigation or precipitation. During their life cycles, plants frequently encounter environmental constraints that affect their ability to survive, reproduce, and yield. One such limitation is drought. Even when the soil is not dry, salt and occasionally high or low temperatures can also cause water stress in the mesophytes. Generally speaking, a plant has a water deficit when its absorption of water falls short of its intake.

EFFECT OF WATER STRESS

A plant's water deficiency frequently manifests itself. Water stress has certain morphological, physiological, and metabolic impacts on mesophytes.

Morphological alterations brought on by lack of water

Water stress in relation to Ontogeny:

The stage of plant growth at which water stress (WS) occurs determines the extent of damage that results. Typically, the yearly crop life cycle may be easily separated into three separate stages, which are as follows:

1.Growth of vegetables

2.Development of seedlings

3.Reproductive growth

i. Seed germination and seedling growth:

In field circumstances, the presence of WS in the soil inhibits seed germination and seedling growth, which leads to poor crop stands.

ii. Growth of vegetation:

The deficiency of soil water significantly hinders the growth of vegetation overall, and the expansion of leaves specifically. Wilting is a symptom of visible damage from WS. During a drought, leaves seem pale and dry. Because of the buildup of ABA during droughts, leaf abscission is frequently observed. Reductions in cell volume and water potential can contribute to decreased growth.

iii. Growth by reproduction:

The crop's reproductive period is extremely vulnerable to drought

EFFECT ON CEREALS

Cereals such as rice and wheat suffer damage from water deficiency during the onset of floral development and anthesis. Crop productivity suffers when flowering synchronization is lost. Stress during the ripening period causes the test weight of cereals to decrease.

1.Affect the leaf area and plant height

2.The weight of the leaves was greatly decreased.

3.A decrease in photosynthesis.

4.Significant reduction in stomatal conductance

5.Rolling drying and early leaf mortality of leaves

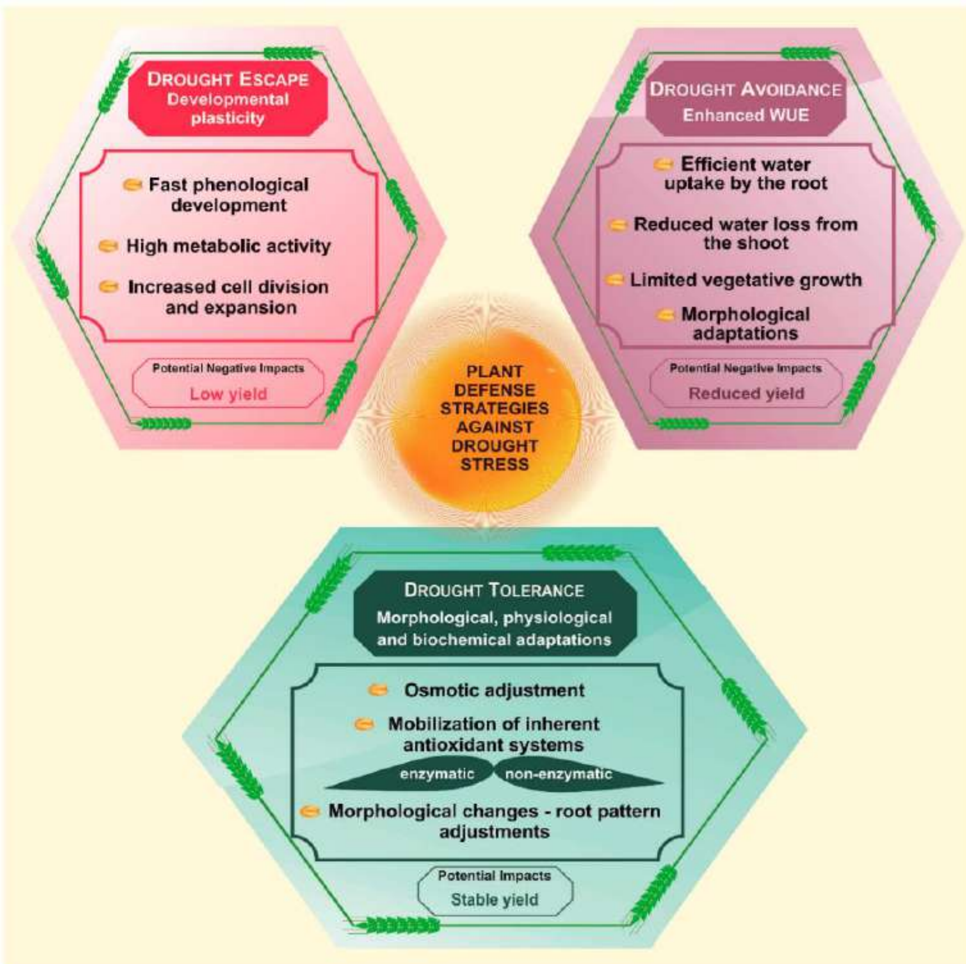
6.Total dry matter

GENE ACCOUNTABLE FOR DROUGHT TOLERANCE IN PLANTS

Host Plant	**Gene Accountable**	**Function**
Wheat	TaNAC69	Greater capacity to withstand drought
Maize	NF-YB2	It increases yield and photosynthetic rate during drought
Rice	AP37, OSNAC10	Grain yield and drought tolerance both rose

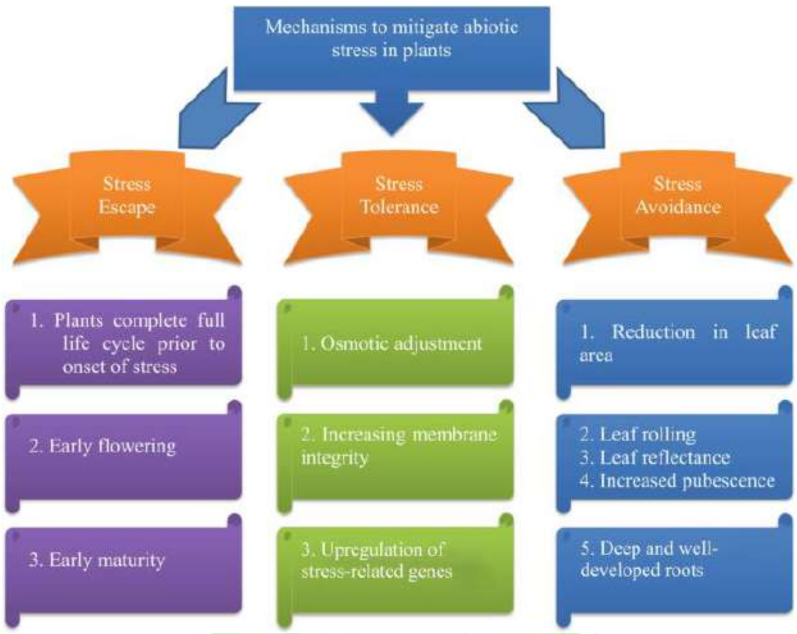
PLANT RESPONSE TO DROUGHT /WATER STRESS

Over time, different ways of adapting have been developed that enhance a plant's ability to withstand the adverse effects of drought stress. When faced with drought conditions, plants mainly use three strategies for survival: avoiding stress, fleeing, and adapting. Consequently, plants respond in various ways to water stress, from the molecular to the reproductive stage of the plant



ESCAPE REACTION

To counteract the detrimental effects of drought stress on plant productivity, several plants adopt mechanisms include self-reproduction, rapid development and shortening of the life cycle, and seasonal growth before the start of the driest part of the year. While this method may suggest a notable reduction of the plant growth season, early flowering is perhaps the best possible escape adaptation for plants.



Adavantages of water stress in crops:

Crops are not usually harmed by water stress. On occasion, it raises the caliber.

1.There is a noticeable increase in rubber content

2.Turkish tobacco's desired aromatic qualities have risen

3.Digitalis, belladonna, datura, and other plants have higher alkaloid contents.

4. There is an increase in the oil content of soybeans, olives, and mint.

5.A rise in wheat's protein content is frequently observed.

Conclusion

The main obstacle in the current state of climate change worldwide situation is sustainable crop production. One of the most important abiotic variables that adversely affects agricultural productivity is drought stress. Cereals are the main food crops that are essential to the global existence of human civilization. These crops are necessary for livestock cultivation as well as for human consumption. With all of the extreme changes in the global climate, there are many concerns about our food security and distribution. SMART breeding techniques and marker-assisted breeding are essential for increasing agricultural output. One such instrument to enhance SMART breeding is proteomics. To better its applicability in cereal crops, genomics, proteomics, transcriptomics, and metabolomics must be integrated in future green systems biology research.

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EFFECT OF WATER STRESS ON VEGETABLE CROPS

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Abstract

One of the main causes of the low yield of most vegetable crops worldwide, which lowers average yield for most vegetable crops, is climate change. Vegetable cultivation faces significant challenges due to hostile environmental circumstances such drought, waterlogging, excessive salinity, harsh temperatures, and other issues. Water stress among other things has a negative impact on stomata function, germination, growth decrease, premature senescence, and productivity. There are two types of water stress: water logging and drought. Reducing the loss of yield requires careful consideration of water stress mitigation. Mulching, using Plant Growth Regulators, anti- transpirants, hydrogel, grafting procedures, and using resistant cultivars are some ways to mitigate the effects of water stress.

Introduction

With an estimated 10.35 million hectares of output and 191.77 million tonnes of vegetables produced, India is the second-largest vegetable producer after China (Indian Horticultural Database, 2019–20). Due to their ability to fend against various illnesses and their high calorific value, vegetable are regarded as protective foods. They also happen to be a great source of vitamins, minerals, and fiber. Drought stress can affect vegetables, especially in the flowering to fruit development period. Drought hinders vegetable crops' ability to grow, absorb water and nutrients, and perform photosynthesis, which ultimately results in a large decrease in yield. Vegetables that are stressed by drought develop drought-tolerance mechanisms that involve specific morphological, physiological, and biochemical reactions.

Water stress

The lack of sufficient moisture in soil required for a plant to develop healthily and complete its life cycle is known as water stress.

Negative impacts of water stress

Vegetable crops under water stress suffer from reduced growth, yield, and quality. Important repercussions consist of:

1. Reduced Growth and Yield: Photosynthesis and nutrient uptake are hampered by a lack of water.
2. Produce of low quality: Vegetables that are smaller and less marketable.
3. Deficits in certain nutrients: Reduced ability of plants to transfer nutrients.
4. An increase in pests and disease Susceptibility: Plant defenses that are weakened.
5. Slower crop development and later harvests are examples of delayed maturity.
6. Physiological Disorders: Problems such as tomato blossom end rot

Water stress responsible factor

One of the biggest obstacles to plant development and productivity is water stress, which poses a serious risk to the production of sustainable crops in the face of climate change.

1. Rainfall is Unpredictable
2. Inadequate Soil Water Retention
3. Less soil capillary water
4. Type of soil
5. Irrigation channel
6. Irrigation with saline water
7. A subpar drainage mechanism
8. Transpiration and water-uptake rate in plant architecture

9.Global warming

Drought stress response

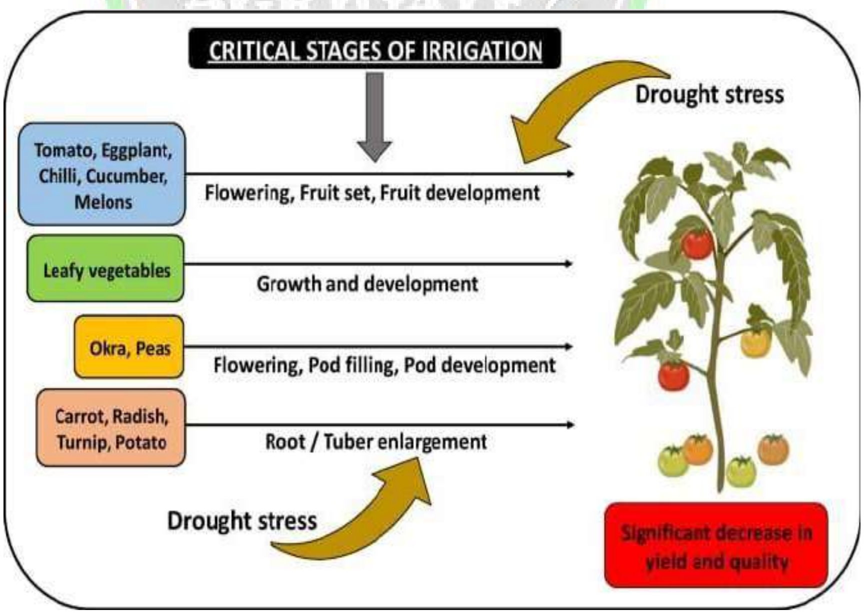
Morphological response

Water stressors alter plant morphology in a variety of ways, including changes to root development, morphology and movement of the leaves, and ultimately productivity. A greater number of stomata, thicker leaves with smaller leaf areas, thicker cuticles, developed veins and bundles, decreased transpiration, enhanced root system, and higher root shoot ratio are all contributing factors to increased water absorption and conveyance. Because of the decrease in turgor pressure, cell development is regarded as one of the processes that is most sensitive to dryness. Cell elongation under water shortage conditions can be prevented by stopping the flow of water from the xylem to the surrounding elongating cells. Reduced growth and yield were caused by defective mitosis brought on by cell elongation and expansion during a drought.

Physiological & biochemical response

The buildup of ABA leads to stomata closure. Increased ability to withstand cytoplasmic dehydration as a result of the quick build-up of stress proteins, osmolytes, and dehydrins heightened antioxidant enzyme system activity One of the main chloroplast devices for photosynthetic activity in plants is chlorophyll. According to reports, there is a drop in chlorophyll content during drought stress, which could be caused by oxidative stress and chlorophyll breakdown. Plants' cytoplasm actively accumulates osmolytes, which lowers osmotic potential while maintaining turgor potential. Osmolytes accumulated during drought stress, include mannitol, glycine betaine, proline, trehalose, etc.

Critical stages of irrigation



Source: Muhammed Fasil Khalid [1,4] (2002)

Impact of drought stress on vegetable crops

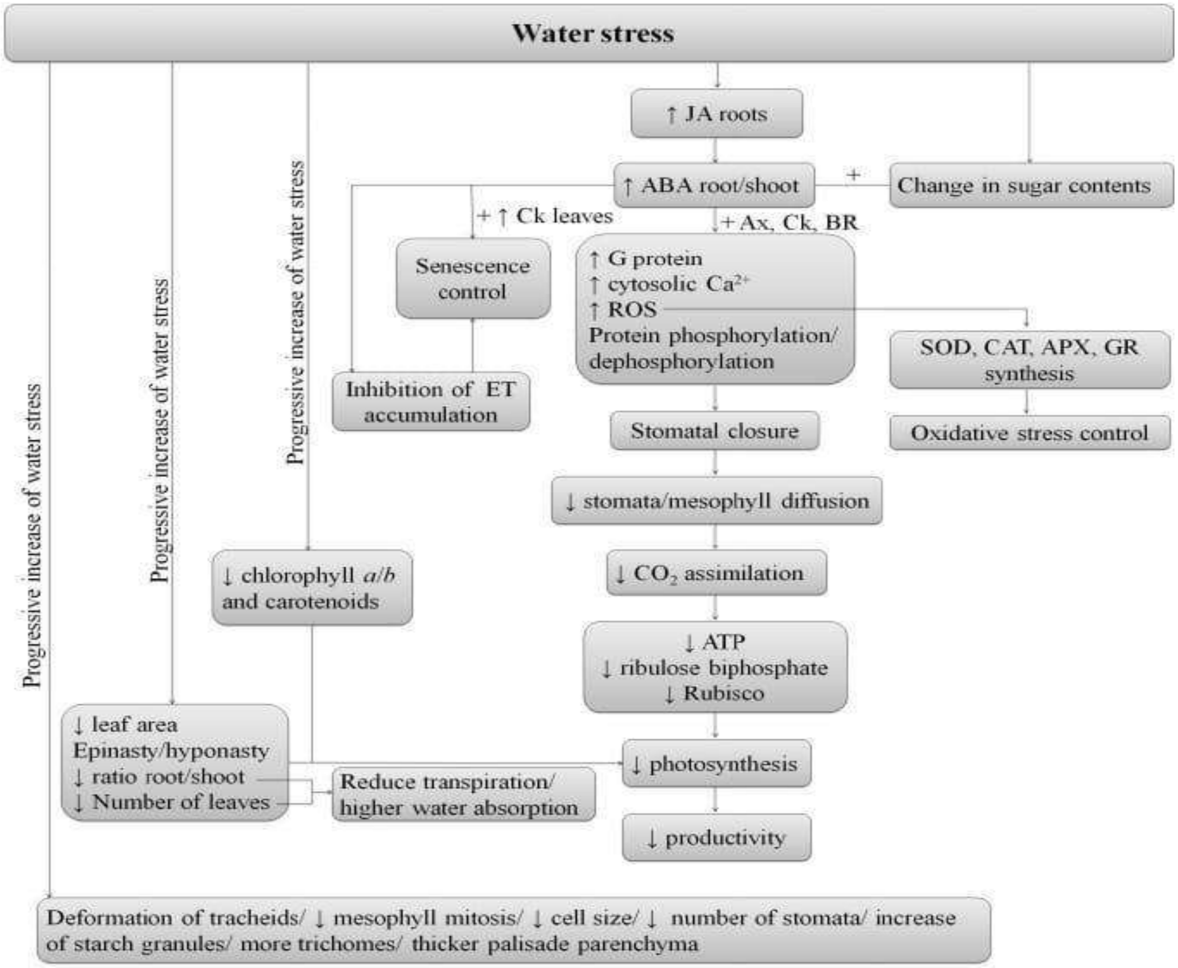
Vegetables	**Crucial phase**	**Impact of water deficit**
Tomato	Flowering and fruit enlargement	Shedding of flower, BER, reduced fruit size
Eggplant	Flowering and fruit development	Less yield, poor color development
Root crops	Root enlargement	Distorted, rough, and poor roots, Splitting, forking
Chilli & Capsicum	Flowering and fruit set	Shedding of flowers and fruits
Cabbage & Cauliflower	Head or curd formation, enlargement	Tip burning, splitting of the head, and buttoning in cauliflower
Bhendi	Flowering and development of pod	Yield loss, fiber development
Pea	Flowering and pod-filling	Root nodulation is less, poor grain filling

Source: Bahadur et al. (2011) ; Kumar et al. (2012)

Fig.1 Cabbage head-splitting

Fig.2 Tip burn in Cauliflower

Mechanism of water stress



Drought management in vegetable crops

Germplasm selection

It is necessary to choose short-duration types with an effective root system and the ability to recover when stress has subsided. Rainfed farming is appropriate for vegetable crops including drumstick, Brinjal, Okra, Cluster beans, French beans, Cowpea, lima beans, Chilli, and drumsticks.

Use of drought stress tolerant root crops

When suitable drought-tolerant rootstocks are used, the growing of these plants can be accomplished under stressful circumstances.

Seed priming

The process of semi- hydrating seeds to the point where germination-related metabolic processes start but radicle emergence doesn't happen is known as "seed priming." Primed seeds exhibit higher germination uniformity and a higher germination rate. $ZnSO_4$, $MnSO_4$, KCl , KH_2PO_4, succinic acid, ascorbic acid, Cycocel , $MgSO_4$, Sodium Chloride, etc.

Crop	Priming compound	Changes	Reference
Tomato	Silicon	At 75 and 100% FC, priming improves fruit quality and yield.	Chakma et al (2021a, 2021b)
Cucumber	Pyridoxine, Water and Ascorbic acid	Enzymes involved in plant antioxidant defense enzymes are increased by pyridoxine and ascorbic acid.	Mombeini et al.(2021)
Pea	Silicon, Potassium silicate, *Bacillus thuringiensis*, and Carrot extract	The highest resistance to drought stress was demonstrated by Bacillus thuringiensis and carrot extract priming by physiological, growth, and biochemical means.	Arafa et al. (2021)
Onion	Gibberellic acid with PEG 6000	Boost the qualities of biomass and germination.	Arvin and Kazem(2003)
Cabbage	Urea, Potassium nitrate and water	Priming boosted the production of osmolytes antioxidative enzymes and germination.	Yan (2015)

Use of anti-transpirants

Chemicals known as anti-transpirants are sprayed on plants to create a layer that hinders water from evaporating through their stomata and hence lowers water transpiration losses. Acropyl in grapes, polycot in bananas, and kaolinite (3–8%) in various fruit plants are only a few of the substances that have been effectively employed.

Use of plant growth regulators

Root growth is increased while shoot growth is decreased by ABA and Cycocel. Under drought stress, exogenous gibberellic acid administration increased the stomatal conductance, rate of transpiration , and net photosynthetic rate. Yields were enhanced by the exogenous application of uniconazole, brassinolide, and abscisic acid in both well-watered and water-deficient environments. Under water stress conditions, plant growth regulator treatments boosted chlorophyll content and considerably increased water potential.

Use of PGPR

Crop	PGPR	References
Cucumber	*Burkholderia cepacia* *Promicromonospora sp.*	Sang-Mo et al. (2014)
Tomato	*Bacillus subtilis*	Ullah et al. (2016)
Cabbage	*Bacillus megaterium* *Peanibacillus polymyxa*	Samancioglu et al. (2016)
Pepper	*Bacillus licheniformis*	Lim and Kim (2013)

Conclusion

The most significant effect of global climate change is frequent drought. Tomatoes are susceptible to conditions of water deficiency at every stage of their life cycle. Plants undergo physiological, biochemical, and molecular alterations while under stress. Low water availability lowers the rate of photosynthesis, yield, and generation of dry matter as well as the absorption of water and minerals. Reactive oxygen species produced during drought stress cause oxidative damage to cellular structure. A unique natural antioxidant system in plants helps to lessen the effects of water stress. A lack of water inhibits a plant's ability to grow and develop, it results in the formation of smaller organs as well as impeded grain filling and bloom production. The synthesis of reactive oxygen species in organelles including chloroplasts, mitochondria, and peroxisomes is one of the main causes of reduced plant growth and productivity during drought stress. The breakdown of enzyme proteins and nucleic acids, as well as the peroxidation of lipids in cellular membranes, are the targets of reactive oxygen species. Increasing stomatal resistance, growing big and deep root systems, osmolyte accumulation, and osmoprotectant synthesis all contribute to a reduction in water loss. It has been suggested that abscisic acid, cytokinin, and salicylic acid are key components of drought tolerance. Important mechanisms of drought tolerance include the expression of stress proteins, aquaporin, cell membrane integrity, and enzymatic and nonenzymatic systems that scavenge reactive oxygen species.

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CASHEW – GOLD MINE OF WASTE LAND

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Introduction

Cashew (*Anacardium occidentale L.*) belongs to the family Anacardiaceae. It is native of Brazil, from where it was introduced to Malabar coast of India in the sixteenth century. Cashew is grown mainly in Maharashtra, Goa, Karnataka and Kerala along the west coast and Tamil Nadu, Andhra Pradesh, Orissa and West Bengal along the east coast.

Botany

The cashew tree is a low spreading, evergreen tree with a number of primary and secondary branches and with a very prominent tap root and a well developed and extensive network of lateral and sinker roots. The fleshy peduncle, the 'cashew apple', is juicy and sweet when ripe. The apple varies in size, colour, juice content and taste. It is a rich source of vitamin C and sugar. However, it is not commercially exploited anywhere in the country except in Goa where it is used for the preparation of cashew feni. The cashew fruit is a kidney shaped drupaceous nut, greenish grey in colour. The nuts vary in size, shape, weight (3 to 20 g) and shelling percentage (15-30%).

Climate and soil

It can come up in places situated within 35° latitude on either side of the equator and also in the hill ranges up to 700 m MSL. It can grow well in places receiving rainfall from 50 cm to 250 cm and tolerate a temperature range of 25° to 49°C. It requires a bright weather and does not tolerate excessive shade. Cashew is cultivated on a wide variety of soils in India like laterite, red and coastal sandy soil. It do not prefer water logged or saline soils.

Varieties

Improved varieties of cashew have been released from various research stations. Some of them are listed below:

Name of the variety	Remarks
Cashew Research Station, Bapatla	
BPP-1	A hybrid. Yield : 17- 25 kg/ tree with nut weight of 5 g and 27.5 shelling percentage
BPP-2	A hybrid. Yield : 19- 25 kg/ tree with nut weight of 4 g and 26.0 shelling percentage
BPP- 3 to 6	Clonal selections. Yield: 15- 50 kg/ tree with nut weight of 5-6 g and 24 shelling percentage.
BPP- 8	A hybrid. 14. 5 kg/ tree yield and nut weight 8.2 g. shelling per cent is 29.
Cashew Research Station, Vengurla, Maharashtra	
Vengurla 1 and 2	Clonal selections from germ plasm. Yield : 23-24 kg/ tree. Nut weight is 6 g and shelling percent is 31.
Vengurla- 3 to 8	Hybrids. Yield : 15- 23 kg/ tree. With Vengurla 8 having highest nut weight of 11.5 g. shelling percent varies from 28- 30.
Regional Research Station, Virudhachalam, Tamil Nadu	
VRI- 1 to 3	Clonal selections from germplasm with yield ranging from 6- 10 kg/ tree. Nut weight: 5- 7g

	and shelling percent 20- 29%
VRI- 4	Selection from M44/3. Yields upto 7.2 kg/ tree
VRI- H1	A hybrid with yield of 13.2 kg/ tree and shelling percent of 30.05
Agricultural Research Station, Ullal, Karnataka	
Ullal 1 to 5	Yield 8 to 20 kg/ tree and ullal- 5 has the highest shelling percent 32.8 %
Directorate of Cashew Research, Puttur, Karnataka	
NRCC 1 and 2	Yield : 9- 10 kg/ tree with shelling percent of 28.8%
Cashew Research Station, Anakkayam, Kerala	
Anakkayam-1	A selection from open pollinated seedlings. Yield : 12 kg/ tree and 28% shelling per cent.
Sulabha	A selection from open pollinated seedlings. Yields 21.90 kg/ tree and 29. 40 shelling per cent.
Cashew Research Station, Madakkathara, Kerala	
Madakkathara 1 and 2	A selection from open pollinated seedlings. Yield ranges from 13- 17 kg/ tree.
Dhana, Kanaka, Priyanka, Dhanasree, Amrutha and Damodhar, Raghav, Akshaya, Anagha, Poornima	Hybrids.

Propagation

Seed propagation is not recommended now. Seeds are however used to raise rootstocks. Seeds are collected during March-May and soaked in water then mixed with 2 parts of fine sand and sown. It take around 15- 20 days to germinate.

Vegetative propagation

Air- layering- one year old shoots as well as current season shoots are used. But the root system is not well developed in this method. Hence not used for commercial purpose.

Epicotyl grafting and soft wood grafting are methods recommended for commercial scale adoption. In the case of epicotyl grafting, tender seedlings with height of 15 cm are selected as root stocks and a 'V' shaped cut is made after beheading it at a height of 4 to 6 cm from the cotyledons connective. The pre-cured scion is collected and a wedge is made at the base of it, so as to exactly fi t in the cut made at the base of the stock. The scion is exactly fitted in the stock and tied with polythene strips. The success of epicotyl grafting varies from 50 to 60 percent. When the above method is adopted in 30 to 40 days old seedling, it is known as soft wood grafting. The success varies from 40 to 50 percent.

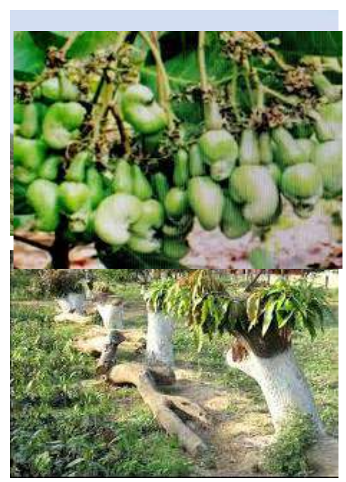
Planting

Pits of 45 × 45 × 45 cm are dug and filled with a mixture of top soil, 10 kg of farm yard manure and one kg of neem cake at a distance of 7m × 7m either way during June July and planted.High density planting is now recommended. Under Tamil Nadu conditions, a spacing of 5X 4 m accommodating 500 plants/ha is recommended under HDP while a spacing of 8x4 or 4x4 m is good under Kerala situation.Under irrigated situation, ultra high density planting (4 x2 or 3 x 2 m spacing) can be followed under intensive management situation to obtain maximum yield.

Pruning

As cashew bears its panicle terminally on the current season shoots, immediate after harvest pruning is recommended to encourage more shoots which will produce new flushes bearing panicles in December- January. This is highly essential under HDP and UHDP systems.

Top working in cashew



As most of the existing cashew plantations are of seedling progenies, the yield level is very low and highly erratic. Hence, top working with improved clones are suggested now. Trees of 20 to 25 years old are beheaded at a height of 0.5 m from the ground during December - February. A paste, made using 50 g. each of BHC 50 per cent wettable powder and copper oxychloride in a litre of water, should be applied all over the stump to check any infection by invading pathogens and borer insects. Profuse sprouting normally results in but only 10 to 15 healthy shoots and properly spaced on the stumps are alone retained. These shoots are grafted at softwood stage (cleft grafting) when they are about 40 to 50 days old. 7-8 successful grafts may be encouraged to grow and the sprouts should be periodically removed. Top worked trees grow vigorously due to the well-established root system and they start yielding about 4kg per tree from the second year of rejuvenation and the yield gradually increases to stabilise at 8 kg from the fourth year of top working.

Nutrition Management

Age of plantation	Manures per tree			
	FYM or Compost (Kg)	N	P	K
		(g)		
One year old	10	50	25	25
Two years old	20	100	50	50
Three years old	20	150	75	75
Four years old	30	150	75	75
Five years and above	50	500	125	125

Harvesting

The cashew tree commences fruiting in third or fourth year, attains full bearing by tenth year. Flowering in November extends upto February. The peak months of harvest are March- April. The nuts collected should be dried immediately under sun by spreading in a thin layer. If the surface is of cement concrete, drying for two full days is sufficient.

Cashew processing

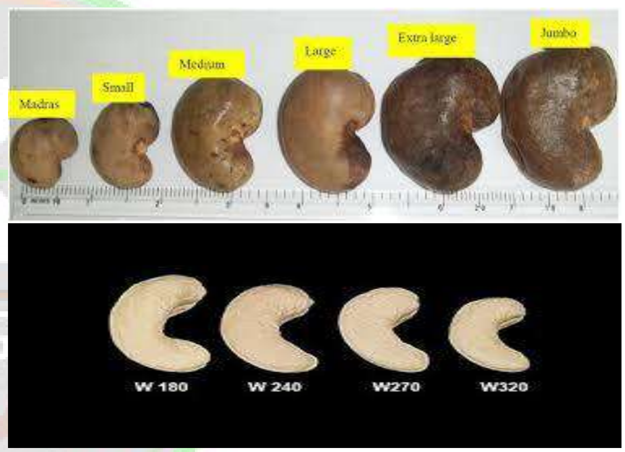
Processing consists of roasting, shelling, extracting the oil, and peeling, grading and packing.

1. **Roasting:** Roasting makes the shells brittle, besides making the extraction of kernels easier. In the open pan roasting method, one kilogram of nuts is kept in shallow iron pans or earthen pots and is heated over an open fire. The nuts are rapidly turned to prevent charring.The roasted nuts are then removed from the pan and thrown on the floor. They are quickly covered with earth which would absorb shell oil adhering to the roasting nuts and also cool them. The nuts are then subjected to subsequent operations.

a. **Continuous roasting process:** The principle adopted in this system is the same as in the case of open pan roasting method. This plant consists of a single walled or double walled rotating metallic drum.

b. **Oil bath process:** In this method, the nuts are held in wire trays and are passed through a bath of cashew shell oil maintained at a temperature of 200 to 202**°C** for a period of three minutes whereby the shell oil is recovered from the shells to the maximum possible extent. This process ensures uniform roasting of nuts and eliminates charring of kernels.

2. **Shelling:** After roasting, shelling is done by labour. Each nut is placed edgewise and cracked open with a light wooden mallet andthe kernel extracted with or without the help of a wire prong. Carehas to be taken that the inner kernel is intact and is not broken into bits.
3. **Peeling:** Removal of a thin outer brown skin is done by hand with the help of a safety pin or small hand knife. Peeling is made easier when the kernels are subjected to a heat treatment for about four hours in a drying chamber.
4. **Grading:** Grading is done based on "counts" or number of kernels per pound. The kernels which have no split are separated as 'wholes'. These are again separated into different grades as 180,210,240,280,320,400 and 430 whole nuts per pound. The graded kernels should be fully developed, ivory white in colour and free from insect damage and black or brown spots. The broken and split kernels are then separated and classified as standard and scorched pieces, splits, butts, small pieces and each grade is separately packed.



Packing: Packing is done in this. In this method, the air inside the tin is exhausted and they are recharged with CO2 before they are sealed air-tight.

Volume: 04 Issue No: 07

CROP-WEED ASSOCIATION, CROP-WEED COMPETITION AND ALLELOPATHY

Article ID: AG-VO4-I07-60

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Introduction

Weeds possess many growth characteristics and adaptations that enable them to successfully exploit the numerous ecological niches left unoccupied by crop cultures. Weeds compete with themselves and with crop plant. Among the more important adaptations relevant to competitive advantage are properly synchronized germination, rapid establishment and growth of seedlings, tolerance to shading effects by the crop or by other weeds at the time of establishment, quick response to available soil moisture and nutrients, adaptation to the most severe climatic situations of the habitat, adaptations to the edaphic regime, relative immunity to post seeding soil disturbance, practices and resistance to herbicides that are used. In the initial stages of invasion by weeds of exposed ecological niches, only a very limited competition for resources by the crop and weed may occur, but as establishment of the crop-weed association is completed, competition for the available resources is more obvious. Plant competition is a natural force whereby crop and weed plants tend to attain a maximum combined growth and yield, with the development of each species being to some extent at the expense of the other. It occurs when the demands of the plants for moisture, nutrients, light, and possibly carbon dioxide exceed the available supply. Competition may develop between crop and weed plants and also between individual plants of each. The ultimate outcome of competition usually results in the development of a characteristic crop-weed association. Crop plants and weeds may grow and mature in the state of mutual suppression that is often found in crops where no suitable herbicide is available to control the weeds. The weed suppresses the crop and result in reduction of yield. The crop also suppresses the weeds, a condition often found in row crop cultures. This is a logical sequence in a crop habitat where both cultural and herbicide methods provide effective control. A principle of plant competition is that the first plants to occupy an area have an advantage over latecomers. This principle is of foremost consideration in practical weed control, where cropping practices are always directed to the establishment of the crop ahead of the weeds. Competition and allelopathy are the main interactions, which are of importance between crop and weed. Allelopathy is distinguished from competition because it depends on a chemical compound being added to the environment while competition involves removal or reduction of an essential factor or factors from the environment, which would have been otherwise utilized.

Crop Weed Competition

Weeds appear much more adapted to agro-ecosystems than our crop plants. Without interference by man, weeds would easily wipe out the crop plants. This is because of their competition for nutrients, moisture, light and space which are the principle factors of production of crop. Generally, an increase in on kilogram of weed growth will decrease one kilogram of crop growth.

1. **Competition for Nutrients**

   Weeds usually absorb mineral nutrients faster than many crop plants and accumulate them in their tissues in relatively larger amounts.

- *Amaranthus sp.* accumulates over 3% N on dry weight basis and the termed as "nitrophills".
- *Achyranths aspera*, a 'P' accumulator with over 1.5% P_2O_5
- *Chenopodium sp.* & *Portulaca sp*. are 'K' lovers with over 1.3% K_2O in dry matter Mineral composition of certain common weeds on dry matter basis

S.N.	Weed species	N	P_2O_5	K_2O
1	Achyranthus aspera	2.21	1.63	1.32
2.	Amaranthus viridis	3.16	0.06	4.51
3.	Chenapodium album	2.59	0.37	4.34
4.	Cynodon dactylan	1.72	0.25	1.75
5.	Cyperus rotundus	2.17	0.26	2.73

Crop plants				
1.	Rice	1.13	0.34	1.10
2.	Sugarcane	0.33	0.19	0.67
3.	Wheat	1.33	0.59	1.44

- ✓ The associated weed is responsive to nitrogen and it utilizes more of the applied 'N' than the crop. Eg. The 'N' uptake by Echinochloa crusgalli is more than rice.
- ✓ Nutrient removal by weeds leads to huge loss of nutrients in each crop season, which is often twice that of crop plants. For instance at early stages of maize cultivation, the weeds found to remove 9 times more of N, 10 times more of P and 7 times more of K.

2. Competition for Moisture

- In general, for producing equal amounts of dry matter, weeds transpire more water than do most of our crop plants. It becomes increasingly critical with increasing soil moisture stress, as found in arid and semi-arid areas.
- As a rule, C4 plants utilize water more efficiently resulting in more biomass per unit of water. Cynodon dactylon had almost twice as high transpiration rate as pearl millet.
- In weedy fields soil moisture may be exhausted by the time the crop reaches the fruiting stage, i.e. the peak consumptive use period of the crop, causing significant loss in crop yields.

3. Competition for Light

- It may commence very early in the cop season if a dense weed growth smothers the crop seedlings.
- It becomes important element of crop-weed competition when moisture and nutrients are plentiful.
- In dry land agriculture in years of normal rainfall the crop-weed competition is limited to nitrogen and light.
- Unlike competition for nutrients and moisture once weeds shade a crop plant, increased light intensity cannot benefit it.

4. Competition for Space (CO2)

Crop-weed competition for space is the requirement for CO_2 and the competition may occur under extremely crowded plant community condition. A more efficient utilization of CO_2 by C_4 type weeds may contribute to their rapid growth over C_3 type of crops.

Effect of weed competition on crop growth and yield

1. Crop growth and yield is affected
2. Crop suffers from nutritional deficiency
3. Leaf area development is reduced
4. Yield attributes will be lowered
5. Reduce the water use by the crop
6. Affect the dry matter production
7. Lowers the input response
8. Causes yield reduction
9. Pest and disease incidence will be more

Losses Caused by Weeds

A. Reduction in crop yield

Weeds compete with crop plants for nutrients, soil moisture, space and sunlight. In general an increase in one kilogram weed growth corresponds to reduction in one kilogram of crop growth. Depending on type of weed, intensity of infestation, period of infestation, the ability of crop to compete and climatic conditions the loss varies. The table below depicts the percentage range of yield loss due to weeds in some important field crops.

Table1.1.Yield losses due to weeds in some important crops

Crop	Yield loss range (%)	Crop	Yield loss range (%)
Rice	9.1 – 51.4	Sugarcane	14.1 – 71.7
Wheat	6.3 – 34.8	Maize	29.5 – 74.0
Linseed	30.9 – 39.1	Cotton	20.7 – 61.0
Millets	6.2 – 81. 9	Carrot	70.2 – 78.0
Groundnut	29.7 – 32.9	Peas	25.3 – 35.5

Among the pests weeds account for 45 % reduction in yield while the insects 30%, diseases 20% and other pests 5%.

B. Loss in crop quality

If a crop contains weed seeds it is to be rejected, especially when the crop is grown for seed.

For example, the wild oat weed seeds are similar in size and shape of the crops like barley, wheat, and its admixture may lead to rejection for seed purpose. Contamination by poisonous weed seeds is unacceptable and increases costs of crop cleaning. The leafy vegetables much suffers due to weed problem as the leafy weed mixture spoil the economic value.

C. Weeds as reservoirs of pests and diseases

Weeds form a part of community of organisms in a given area. Consequently, they are food sources for some animals, and are themselves susceptible to many pests and diseases. However, because of their close association with crop they may serve as important reservoirs or alternate host of pests and diseases.

D. Interference in crop handling

Some weeds can make the operation of agricultural machinery more difficult, more costly and even impossible. Heavy infestation of *Cynadon dactylon* causes poor ploughing performance.

E. Reduction in land value

Heavy infestation by perennial weeds could make the land unsuitable are less suitable for cultivation resulting in loss in its monetary value. Thousands of hectare of cultivable area in rice growing regions of India have been abandoned or not being regularly cultivated due to severe infestation of nutgrass (*Cyperus rotundus*) and other perennial grasses.

F. Limitation of crop choice

When certain weeds are heavily infested, it will limit the growth of a particular crop. The high infestation of parasitic weeds such as *Striga lutea* may limit the growing of sorghum or sugarcane.

G. Loss of human efficiency

Weeds reduce human efficiency through physical discomfort caused by allergies and poisoning. Weeds such as congress weed (*Parthenium hysterophorus*) causes itching. Thorny weeds like *Solanum spp.* restrict moment of farm workers in carrying out farm practices such as fertilizer application, insect and disease control measures, irrigation, harvesting etc.

H. Problems due to aquatic weeds

The aquatic weeds that grow along the irrigation canals, channels and streams restrict the flow of water. Weed obstruction cause reduction in velocity of flow and increases stagnation of water and may lead to high siltation and reduced carrying capacity. Aquatic weeds form breeding grounds for obnoxious insects like mosquitoes. They reduce recreational value by interfering with fishing, swimming, boating, hunting and navigation on streams and canals.

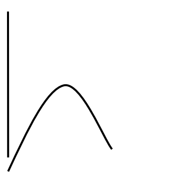
I. Other problems

Weeds are troublesome not only in crop plants but also in play grounds and road sides etc. *Alternanthera echinata* and *Tribulus terrestris* occurs in many of the playgrounds causing annoyance to players and spectators.

Factors affecting the competitive ability of crops against weeds

a. Density of weeds

Increase in density of weed decrease in yield is a normal phenomenon. However, it is not linear as few weeds do not affect the yields so much as other weed does and hence, it is a sigmoidal relationship.



b. Crop density

Increase in plant population decreases weed growth and reduce competition until they are self competitive. Crop density and rectangularity are very important in determining the quantum and quality of crop environment available for the growth of weeds. Wide row spacing with simultaneous high, intra-row crop plant population may induce dense weed growth. In this respect, square planting of crops in which there are equal row and plant spacing should be ideal in reducing intra-crop plant competition.

c. Type of weeds species

The type of weeds that occur in a particular crop influences the competition. Occurrence of a particular species of weed greatly influences the competition between the crop & weed. For eg. *E. crusgalli* in rice, *Setaria viridis* in corn and *Xanthium sp.* in soybean affects the crop yield. *Flavaria australasica* offers more competition than the grasses

d. Type of crop species and their varieties

Crops and their varieties differ in their competing ability with weeds e.g., the decreasing order of weed competing ability is as: barley, rye, wheat and oat. High tolerance of barley to competition from weeds is assigned to its ability to develop more roots that are extensive during initial three weeks growth period than the others.

Fast canopy forming and tall crops suffer less from weed competition than the slow growing and short stature & crops. Dwarf and semi-dwarf varieties of crops are usually more susceptible to competition from weeds than the tall varieties became they grow slowly and initial stage. In addition, their short stature covers the weeds less effectively. When we compare the crop-weed competition between two varieties of groundnut TMV 2 (Bunch) and TMV 3 (Spreading), TMV 2 incurred a loss of over 30% pod yield under uncontrolled weed - crop competition while TMV 3 lost only about 15% in its yield. The main reason is due to the spreading nature of TMV 3, which smothered weeds. Longer duration cultivars of rice have been found more competitive to weeds than the short duration ones.

e. Soil factors

Soil type, soil fertility, soil moisture and soil reaction influences the crop weed competition. Elevated soil fertility usually stimulates weeds more than the crop, reducing thus crop yields. Fertilizer application of weedy crop could increase crop yields to a much lower level than the yield increase obtained when a weed free crop is applied with fertilizer.

Weeds are adapted to grow well and compete with crops, in both moisture stress and ample moisture conditions. Removal of an intense moisture stress may thus benefit crops more than the weeds leading to increased yields. If the weeds were already present at the time of irrigation, they would grow so luxuriantly as to completely over power the crops. If the crop in irrigated after it has grown 15 cm or more in a weed free environment irrigation could hasten closing in of crop rows, thus suppressing weeds.

Abnormal soil reactions often aggravate weed competition. It is therefore specific weed species suited to different soil reactions exist with us, our crops grow best only in a specified range of soil pH. Weeds would offer more intense competition to crops on normal pH soils than on normal pH soils.

f.Climate

Adverse weather condition, Eg. drought, excessive rains, extremes of temperature, will favour weeds since most of our crop plants are susceptible to climatic stresses. It is further intensified when crop cultivation is stratified over marginal lands. All such stresses weaken crops inherent capacity to fight weeds.

g. Time of germination

In general, when the time of germination of crop coincides with the emergence of first flush of weeds, it leads to intense Crop-Weed interference. Sugarcane takes about one month to complete its germination phase while weeds require very less time to complete its germination. Weed seeds germinate most readily from 1.25 cm of soil and few weeds can germinate even from 15cm depth. Therefore, planting method that dries the top 3 to 5 cm of soil rapidly enough to deny weed seeds opportunity to absorb moisture for their germination usually postpones weed emergence until the first irrigation. By this time the crop plants are well established to compete with late germinating weeds.

h. Cropping practices

Cropping practices, such as method of planting crops, crop density and geometry and crop species and varieties have pronounced effects on Crop-Weed interference.

i. Crop maturity

Maturity of the crop is yet another factor which affects competition between weeds & crop. As the age of the crop increases, the competition for weeds decreases due to its good establishment. Timely weeding in the early growth stages of the crop enhances the yield significantly.

Critical period of weed competition

Critical period of weed competition is defined as the shortest time span during the crop growth when weeding results in highest Economic returns. The critical period of crop-weed competition is the period from the time of sowing up to, which the crop is to be maintained in a weed free environment to get the highest economical yield. The weed competition in crop field is invariably severe in early stages of crop than at later stages. Generally in a crop of 100 days duration, the first 35 days after sowing should be maintained in a weed free condition. There is no need to attempt for a weed free condition throughout the life period of the crop, as it will entail unnecessary additional expenditure without proportionate increase in yield. Critical period of weed competition for important crops are as follows

S.No.	Crops	Days from sowing	S.No.	Crops	Days from sowing
1.	Rice (Lowland)	35	7.	Cotton	35
2.	Rice (upland)	60	8.	Sugarcane	90

3.	Sorghum	30	9.	Groundnut	45
4.	Finger millet	15	10.	Soybean	45
5.	Pearl millet	35	11.	Onion	60
6.	Maize	30	12.	Tomato	30

It becomes clear that weed free condition for 2-8 weeks in general are required for different crops and emphasizes the need for timely weed control without which the crop yield gets drastically reduced.

ALLELOPATHY

Allelopathy is the detrimental effects of chemicals or exudates produced by one (living) plant species on the germination, growth or development of another plant species (or even microorganisms) sharing the same habitat.

Allelopathy does not form any aspect of crop-weed competition, rather, it causes Crop-Weed interference, it includes competition as well as possible allelopathy.

Allelo chemicals are produced by plants as end products, by-products and metabolites liberalised from the plants; they belong to phenolic acids, flavanoides, and other aromatic compounds viz., terpenoids, steroids, alkaloids and organic cyanides.

Allelopathic Effect of Weeds on Crops

(1) Maize

- Leaves & inflorescence of *Parthenium sp*. affect the germination and seedling growth
- Tubers of *Cyperus esculentus* affect the dry matter production

(2) Sorghum

- Stem of *Solanum* affects germination and seedling growth
- Leaves and inflorescence of *Parthenium* affect germination and seedling growth

(3) Wheat

- Seeds of wild oat affect germination and early seedling growth
- Leaves of *Parthenium* affects general growth
- Tubers of *C. rotundus* affect dry matter production
- Green and dried leaves of *Argemone mexicana* affect germination & seedling growth

(4) Sunflower

- Seeds of Datura affect germination & growth Allelopathic Effect of crop plants on weeds

(i) Root exudation of maize inhibits the growth of *Chenopodium album* (ii) The cold water extracts of wheat straw when applied to weeds reduce germination and growth of *Abutilon sp.*

Allelopathic effect of weeds on weeds

• Extract of leaf leachate of decaying leaves of Polygonum contains flavonoides which are toxic to germination, root and hypocotyls growth of weeds like *Amaranthus spinosus*

• Inhibitor secreted by decaying rhizomes of *Sorghum halepense* affect the growth of *Digitaria sanguinalis* and *Amaranthus sp.*

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NATURE'S SHIELD: PLANTS' STRATEGIES AGAINST PATHOGENIC INVADERS

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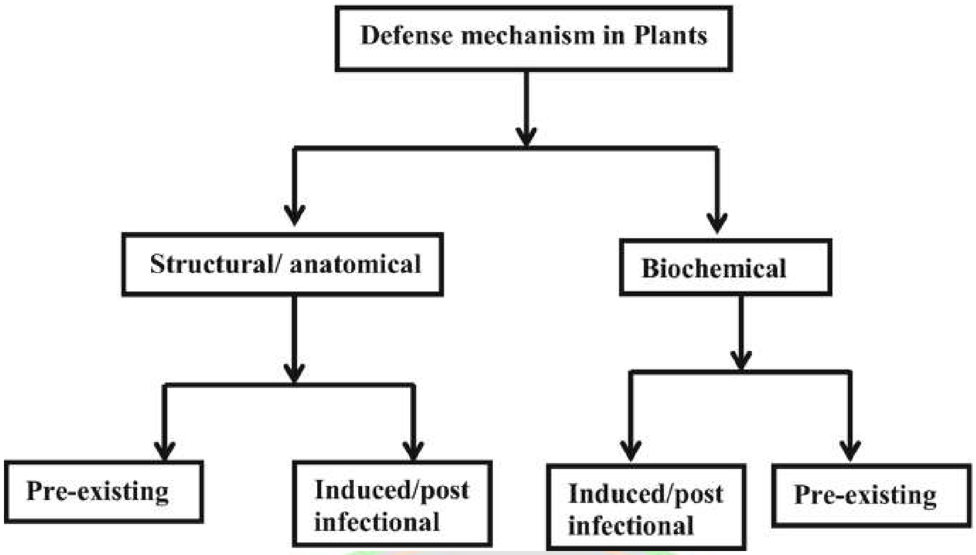
Abstract

The capacity of higher plants to endure stress is indispensable for their survival. Consequently, plants have undergone evolutionary adaptations to cope with stress by altering their typical defense mechanisms. When faced with pathogen attacks, plants employ a broad array of defense mechanisms, starting with structural defenses and later engaging cellular mechanisms in response to host-pathogen interactions. These defenses encompass the production of waxes, thin and thick cuticles, natural openings, cork layers, abscission layers, tylose formation, gum deposition, hyphal sheathing, hypersensitive responses (HR), as well as the presence and release of antimicrobial substances by the plant. Additionally, secondary metabolites like phytoalexins and PR proteins play crucial roles. This article elucidates the significance of both structural and biochemical defense mechanisms in plants against pathogens such as fungi, bacteria, viruses, nematodes, and others.

Introduction

In general, plants defend themselves against pathogens by two ways: structural or morphological characteristics that act as physical barriers and biochemical reactions that take place in cells and tissues that are either toxic to the pathogen or create conditions that inhibit the growth of the pathogen in the plant.

TYPE OF DEFENSE MECHANISMS IN PLANTS:



❖ **STRUCTURAL DEFENSE MECHANISMS:**

The surface of the host is first line of defense against the pathogen. The pathogen must adhere to the surface and penetrate, if it is to cause infection. Structural defense mechanism are mainly two type:

1. Pre-existing structural defense mechanism
2. Post-infectional or induced structural defense mechanism

1. PRE-EXISTING STRUCTURAL DEFENSE:

Wax, Thick cuticle, Thickness and toughness of the outer wall of epidermal cells, Stomata, Sclerenchyma cells, Lenticel.

Wax: It is the mixture of long chain of apolar lipid. It forms a protective coating on plant leaves and fruit. It is synthesized by epidermis and extremely hydrophobic.

Cuticle and Epidermal cell: Tick cuticle provides resistance to pathogen attack. Ex: Disease resistance in Barberry species infected with *Puccinia graminis tritici* has been attributed to the tough outer epidermal cells with a thick cuticle. In linseed, cuticle acts as a barrier against *Melampsora lini*. Silicification and lignifications of epidermal cells offers protection against *Pyricularia oryzae* and *Streptomyces scabies* in paddy and potato, respectively.

Structure of natural opening

Stomata: Most of pathogen enters plants through natural openings. *Puccinia graminis* f.sp. *tritici* wheat enters the host only when the stomata are open. Uredospores germinate early in the morning and stomata of wheat crop are also remain open in the morning at 6 am that enables entry of germtube of uredospore. Hope cultivar of wheat is resistant to *Puccinia graminis* f.sp. *tritici* because the stomata in Hope cultivar are opens at 9 am in the morning, during that time the germ tube of germinated in the morning will dries up. Structure of stomata provides resistance to penetration by certain pathogenic bacteria. Ex: Citrus variety, Szinkum, is resistant to citrus canker because the smaller size of stomatal opening.

Lenticels: Lenticels are openings on fruit, stem and tubers that are filled with loosely connected cells that allow the passage of air. Shape and internal structure of lenticels can increase or decreases the incidence of fruit diseases. Ex. Small and suberised lenticels will offer resistance to potato scab pathogen, *Streptomyces scabies*.

Hydathodes: Black rot of cabbage is internally seed borne disease, it enters through the hydathodes.

2. POST-INFECTIONAL/INDUCED STRUCTURAL DEFENSE MECHANISM

Most of the pathogens manage to penetrate their hosts through wounds and natural opening and to produce various degree of infection. Pathogen penetration through the host surface induced the structural defense mechanism in the host cells. These may be regarded as: Histological defense barriers (cork layer, abscission layers and tyloses formation) and cellular defense structures (hyphal sheathing).

Histological defense structures:

Cork layer: Infection by fungi, bacteria, some viruses and nematodes induce plants to form several layers of cork cells beyond the point of infection. These cork cells inhibits the further invasion by the pathogen beyond the initial lesion and also blocks the spread of toxin substances secreted by the pathogen. It also stop the flow of nutrients and water from the healthy to the infected area and deprive the pathogen nourishment.

Abscission layer: An abscission layer consists of a gap formed between infected and healthy cells of leaf surrounding the locus of infection. Due to the disintegration of middle lamella of parenchymatous tissue. Gradually, infected area shrivels, dies, and sloughs off, carrying with it the pathogen. Abscission layers are formed on young active leaves of stone fruits infected by fungi, bacteria or viruses. Ex: *Xanthomonas pruni*, and *Closterosporium carpophylum* on peach leaves.

Tyloses: Tyloses are the overgrowths of the protoplast of adjacent living parenchymatous cells, which protrude into xylem vessels through pits. Tyloses have cellulosic walls. It formed quickly ahead of the pathogen and may clog the xylem vessels¬ completely blocking the further advance of the pathogen in resistant varieties. Ex: Tyloses form in xylem vessels of most plants under invasion by the vascular wilt pathogens.

Gum deposition: Various types of gums are produced by many plants around lesions after infection by pathogen or injury. Gums secretion is most common in stone fruit trees but occurs in most plants. Generally the gum is exudated by plant under stressed condition

Cellular defense structure:

Hyphal sheathing: Hyphal sheathing is observed in flax infected with *Fusarium oxysporum* f.sp. *lini*.

❖ **BIOCHEMICAL DEFENSE MECHANISM**

1. PRE-EXISTING CHEMICAL DEFENSE:

Inhibitors: Released by plant in its environment and present in plant cells before infection Phenolics (Phytoanticipns).

Inhibitors:

Plants exude a variety of substances through the surface of their aboveground parts as well as through the surface of their roots. Inhibitory substances directly affect micro-organisms or encourage certain groups to dominate the environment which may act as antagonists to pathogens.

Ex 1: Root exudates of marigold contain α-terthinyl which is inhibitory to nematodes.

Ex 2: In *Cicer arietinum* (chickpea), the ascochyta blight resistant varieties have more glandular hairs which have maleic acid which inhibit spore germination.

Ex 3:Red scales of red onion contain the phenolic compounds, protocatechuic acid and catechol called as phytoanticipins.

Saponins: It have antifungal membranolytic activity. Ex: Tomatine in tomato and Avenacin in oats.

Lactins: They are proteins bind specifically to certain sugars and occur in large concentrations in many types of seeds, cause "lysis" and growth inhibition of many fungi.

Hydrolytic enzymes: Glucanases and chitinases enzymes. It may cause breakdown of pathogen cellwall.

INDUCED CHEMICAL DEFENSE

Hypersensitivity response (HR)

Production of Antimicrobial substances-Phytoalexins, PR proteins and Plantibodies

Hypersensitive response (HR): The term hypersensitivity was first used by Stakman (1915) in wheat infected by rust fungus, *Puccinia graminis*. The HR is a localized induced cell death in the host plant at the site of infection by a pathogen, thus limiting the growth of pathogen. HR occurs only in incompatible host pathogen combinations. HR is initiated by the recognition of specific pathogen produced signal molecules known as elicitors.

Phytoalexins:

Muller and Borger (1940) first used the term phytoalexins for fungistatic compounds produced by plants in response to injury (mechanical or chemical) or infection. Phytoalexins are toxic antimicrobial substances. It produced in appreciable amounts in plants only after stimulation by phytopathogenic microorganisms or by chemical or mechanical injury. Phytoalexins are not produced during compatable reaction.

❖ **CHARACTERISTICS OF PHYTOALEXINS**

- Fungitoxic and bacteriostatic at low concentrations.
- Produced in host plants in response to stimulus (elicitors) and metabolic products.
- Absent in healthy plants.
- Remain close to the site of infection.
- Produced in quantities proportionate to the size of inoculum.
- Produced in response to the weak or non-pathogens than pathogens.
- Produced within 12-14 hours reaching peak around 24 hours after inoculation.
- Host specific rather than pathogen specific.

❖ **MODE OF ACTION**

- These are the fungistatic rather than fungicidal
- Inhibit the spore germination, mycelial growth and germ tube elongation
- Reduce the symptom development
- Some of the pathogen detoxify the toxins
- Ex. Pisatin is produced in pea against the *Rhizoctonia solani*, Aschochyta detoxify the pisatin by producing pisatin demythlase enzyme.

Phytoalexin	Host	Pathogen
Pisatin	Pea	*Monilinia fructicola*
Phaseolin	French bean	*Sclerotenia fructigena*
Rishitin	Potato	*Phytopthora infestans*
Gossipol	Cotton	*Verticillum alboratum*
Cicerin	Bengal gram	*Ascochyta blight*
Ipomeamarone	Sweet potato	*Ceratocystis fimbriata*
Capsidol	Pepper	*Colletotrichum capsici*
Isocoumarin	Carrot	*Cerotystis, Fusarium*
Orchinol, Hircinol	Orchid	*Rhizoctonia*
Medicarpin	Alfa alfa	*Helminthosporium*

Plantibodies: Transgenic plants have been produced which are genetically engineered to incorporate into their genome, and to express foreign genes. It shown in transgenic plant.¬ Ex:Artichoke mottled crinkle virus

PR proteins (Pathogenesis Related Proteins): PR proteins are a structurally diverse group of plant proteins that are toxic to invading fungal pathogens. These are widely distributed in plants in trace amounts but are produced in much greater concentration in pathogen attack or in stress. Exist in plant cell both intercellularly and also intracellularly.

Conclusion

In conclusion, the combined arsenal of structural and biochemical defense mechanisms in plants constitutes a sophisticated and dynamic frontline against pathogenic threats. From physical barriers like waxy cuticles and cell walls plants have evolved a multifaceted defense strategy to combat pathogens. This intricate interplay underscores the resilience of plant biology and holds significant implications for agriculture, ecosystem health, and the development of novel approaches for disease management in crops.

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REVIEW ON BOVINE RUMEN ACIDOSIS

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Introduction

Rumen Acidosis is a digestive and metabolic disorder commonly seen in bovines causing severe metabolic alterations, progressive deterioration of condition of animal and eventually death. It is clinically charectized by fall in Rumen pH (below 5), rumen atony and followed by distension, sour odour from rumen contents, dehydration, recumbency, collapse of animal (in acute cases) and in subacute cases poor rumen health, poor body condition, decrease in milk production and unexplained diarrhoea. Rumen Acidosis is an emergency condition and should be treated in time.

Predisposing factors

- Poor feeding management
- Repeated access to highly fermentable feed stuffs , Poor and low fibre diet
- Garbage/free roaming behaviour (get access to many human food grade products)
- Inanition
- Festivals and family occasions
- Sudden dietary changes

Aetiology

Rumen Acidosis is caused by eating moderate to excess quantity of highly fermentable carbohydrates (Rice, Gruel, Sweets or any human food grade carbohydrates) leads to rapid fermentation of these feed beyond the buffer limit (accompanied by low fibre diet) cause sudden fall in Rumen pH

Pathophysiology

Once the cattle got access to these feed stuffs, they are rapidly gets degraded in rumen and form acids like D and L lactic acids causing fall in rumen pH. Declined pH retards the growth of rumen protozoa (especially small protozoa) and decrease in their count. These conditions flares-up of population of gram positive bacteria like *Streptococcus bovis* etc, they make more fall in pH. Rumen atony and Rumenitis sets in and necrotic changes occurs in mucosa of rumen. As osmolality of ruminal contents increases lead to continued fluid filling (and distension) of Rumen from the systemic circulation causing severe haem concentration and decrease tissue perfusion, dehydration.

Escape of lactic acid in to systemic circulation causes organ damage and metabolic acidosis. Amines like histamine and tryptamine, ethanol will be released from rumen, histamine causes severe Laminitis and lameness. VFA released in high quantity leads to damage in Rumen epithelium and leakage of Rumen Flora in systemic circulation causes liver abscess. Altered rumen environment also favours the growth of Rumen fungi like Mucor etc. causes mycotic rumenitis (in later stages).

Lactic acid is known to be increased in the rumen from 1 to 1500 mg/100 mL (*Uhart and Carrol, 1967; Walker, 1968*) and in the blood from 4.5 to 90 mg/100 mL (*Heuter et al. 1956; Dunlop and Hammond, 1965*)

Classification

Based of amount of fermentable feed stuffs animal has been taken, duration, frequency of incidence, they are classified in to

- Acute Rumen acidosis
- Sub acute Rumen acidosis (SARA)
- Chronic latent Rumen Acidosis (CLRA)

In acute cases signs are rapid and causes death in less time. SARA is common in field conditions, often signs are misleading and mistreated (in chronic cases also) and the incidence of SARA is more

Sequelae

- Metabolic acidosis
- Liver Abscess (*Fusobacterium necrophorum*)
- Laminitis (due to release of toxic amines)

- ❖ Mycotic Rumenitis
- ❖ Kidney failure (due to poor perfusion)
- ❖ Sepsis
- ❖ Polyencephalomalacia (accompanied by Thiamine deficiency – Cerbro cortical necrosis)

Clinical signs

Acute cases

- Rapid rumen distension, suspended rumination, decreased rumen motility and atony, drunken stance and gait, incoordination and wry neck, depression.
- Increase in heart rate and respiratory rate. poor vision, recumbency, decrease in capillary refilling time, severe dehydration and sunken eye balls, subnormal temperature, bruxism, mucopurulent nasal discharge.
- Eventually animal shows Laminitis, anorexia, dark watery diarrhoea and bubbles in it indicates fermentation while passing of faeces through the gastrointestinal tract.
- Oliguria followed by anuria due to poor kidney perfusion.
- Nervous signs due to Polyencephalomalacia and Death.

Subacute Rumen acidosis (SARA)

- Decrease in feed intake and in performance, severe loss of body weight and milk production with drastic reduction milk fat
- Poor body condition, lameness, bruxism, decrease the Roman motility and fermenting capacity
- Repeated digestive disorders like diarrhoea which may not respond to the empirical treatment
- Improper digestion of feed and in the ding with fibre traces and altered VFA production

Chronic cases

- Signs mostly as in SARA, Chronic cases lead to Rumen parakeratosis, cerebral cortical necrosis, liver Abscess (may show hepatodynia), poor performance and Laminitis

Diagnosis

Based on history and clinical findings like recumbency, drunken gait, distended abdomen, sunken eye balls, dehydration (especially at the festival times) indicate rumen acidosis (tentatively)

Fluid splashing sound on tapping Rumen

Rumenocentisis (done at left Para lumbar fossa) to perform tests on rumen liquor

1. Physical examination of Rumen contents – pH (below 5), Colour (milky grey), Smell (sour and fermenting)
2. Protozoal Count and motility
3. MBRT (below 5 minutes)
4. Sedimentation and cellulose digestion test
5. Increase in gram positive bacteria count

Blood

- Estimation of histamine level (increased)
- Decrease thiamine level and increase in inorganic phosphorus levels in blood
- Haematology: increase in haematocrit values, haem concentration evidence of metabolic acidosis in blood gas analysis and increase in lactic levels
- Increase in serum creatinine levels
- Aciduria (below 5)
- Treatment
- No water should be given orally to the cattle.

Counter dehydration and acidosis

Intravenous Sodium Bicarbonate and Fluid Therapy: The systemic acidosis and the dehydration are treated with intravenous solutions of 5% sodium bicarbonate at the rate of 5 L for a 450-kg animal given initially over a period of about 30 minutes. This will usually correct the systemic acidosis. This is followed by isotonic sodium bicarbonate (1.3%) at 150 mL/ kg BW intravenously over the next 6 to 12 hours (*Dr.Mohammad Al-Taliby*)

Ringers lactate can be given rather than dextrose to counter dehydration and acidosis (lactate in RL alkalizes the blood). Emergency Rumenotomy (on standing position) and remove all the fermenting rumen contents followed by thorough lavage of rumen, once lavage has been done, should be refilled with rumen liquor from healthy animals (probably from slaughterhouse) along with the straw tea made from boiled dry paddy straw.

Introducing pro bang via mouth carefully in acute cases and drench antacids or commercial preparations (for countering acidosis) available in the market to the animal. Conventional antacids like magnesium oxide, magnesium carbonate and magnesium hydroxide, sodium bicarbonate powder (100 to 150 gm/animal) but it will be helpful in initial stages only. if above mentioned antacids are not available baking soda can be used

Antihistamines like Phenaramine or chlorphenaramine should be given intramuscular or intraruminal. Thiamine (10mg/kg) intravenous therapy or vitamin B complex supplementation to prevent Polyencephalomalacia. thiamine fastens the metabolism of lactate. Penicillin antibiotic therapy to prevent bacterial replication and formation of Abscess in liver. Calcium borogluconate intravenous therapy to counter serum decreased calcium levels. Rumenotorics should be given to restore rumen function to normal along with Rumen buffers.

Rumen liquor (Strained/Sieved) – transfaunation once animal is completely recovered. In acute and emergency cases, oral drenching of liquids should not be done as it may cause aspiration into lungs.No grains are given for next 2-3 days followed by slowly bringing back the normal feeding schedule

Prevention and control

- Prevent the animal to get access to fermentable carbohydrate feedstuffs
- Provide good quality green folder (good in fibre) in adequate quantity as fibrous feeds stimulate salivation and prevents SARA and increase rumination of the feed. in addition, too much long fibres are not advised as it cattle may go off feed.
- Add buffers / Ionophore antibiotics like monensin and prebiotics (that decreases the lactate production) bacteria like lactobacilli, they utilize lactate decrease the chances of SARA.
- Changes in feed should be done gradually.
- Education to the farmers regarding the ruminal acidosis and advise them not to offer such type of feeds to animals which are meant for human consumption especially at the time of festivals.

Control

1. 1:1 combination of sodium and potassium carbonates at the rate of 2% in concentrate.
2. 2% sodium bicarbonate and 0.25% thiopeptin in the ration.
3. Exercise of animals.
4. Strict monitoring of feeding schedule.
5. Inoculation of ruminal fluid from adopted cattle to unadopted or affected cattle (Amalendu Chakrabarti,2007)

Conclusion

Ruminants and rumen can only utilise herbivorous diet, they're not meant to utilize the feed stuff like rice, gruel, sweets etc, they are human grade food. so if the animal is fed with such kind of feeds they suffer with rumen acidosis. with or without awareness feeding of animals such a way is highly dangerous can even cause death of animals. the prognosis of the acidosis depends on how much animal has eaten, how fast treatment was given and how much efficient it is. So prevention is better than cure educating the farmers regarding lactacidosis is highly important to decrease the incidence

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ROLE OF GOVERNMENT POLICIES IN FACILITATING MODERNISATION IN TRADITIONAL FISH FARMING IN INDIA AND THE WORLD

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Abstract

Many people around the world, including those in india, have practiced aquaculture, or fish farming, as a source of income and food. Nevertheless, several factors, such as the use of archaic techniques, environmental changes, and monetary constraints, make it important to adopt new strategies to become sustainable and productive. This article aims to highlight the role and relevance of government policies in promoting the advancement of conventional aquaculture in India and around the world. it concentrates on the various policies, their implementation, and their impact on the sector, while also providing specific examples and cross-country comparisons. Government policies can imposesignificant changes by employing modern techniques, upgrading infrastructures, and encouraging research and development. Therefore, this study calls for a sound and coherent policy framework, effective cooperation, and ongoing commitment towards the modernization of conventional fish farming.

Introduction

Fish farming, also known as aquaculture, is a key player in the global food supply because it is a major source of protein for a large population of people. For many decades, India's rural population has relied on fish farming for nutritional support. However, with more demands, challenges from the environment, and the call for a sustainable system, the traditional techniques have to be modernized. Government policies, which aim to maintain the business viability and productivity of fish farming without harming the environment, largely enable this transformation.

Traditional fish farming practices: Extensive and intensive fish farming practices adopted by different countries employ their historical and cultural practices, as well as a diversified nature associated with the geographical environment and local economy. Research has revealed that these practices, passed down through generations, have endured in certain communities for hundreds of years. Despite their similarities, they face numerous challenges in the modern world.

They include: Traditional fish farming practices share the following features.

Dependence on a Natural Water Source: Conventional fish farming partially depends on natural water sources such as fish ponds, the sea, lakes, and rivers, among others. Fish farmers employ these waters to rear fish, and these bodies of water hardly undergo any modification or improvement. This dependence on natural conditions limits traditional fish farming practices, making them bound to the specific environment and seasonal changes.

Minimal technological intervention: Traditional approaches are known to incorporate minimal, if any, methods of using technology in the learning process. Concepts and practices are still raw, but they embrace the use of human energy and easily accessible materials. Breeding, feeding, and harvesting fish are practices that are still unsophisticated; therefore, the level of technology in fish farming is relatively low.

Extensive farming techniques: In animal rearing, intensive farming practices involve little or no crowding and use little feed or fertilizer. These methods avoid adding feed to the bodies of water, instead allowing the fish to feed on naturally occurring food sources like algae and plankton, which are readily available in the water.

Some of the difficulties encountered in traditional fish farming include the following:

Low Productivity: Traditional practices mean harvesting fewer fish than are available through cultural practices in today’s world. This low productivity is attributed to large, expansive farming practices, minimal supplementation with processed feeds, and low space occupancy. These are attributable to the fact that while global consumption of fish is on the rise, traditional fishing practices cannot adequately address this demand, posing food security risks.

Environmental Impact: Intensive fish farming has a variety of negative impacts on the environment, just as conventional fish farming techniques do. Sustained fishing with fishing gear, particularly in open waters, exhausts the fish stock and interferes with water systems. They also contribute to environmental degradation by destroying habitats, such as mangroves that are cut down to establish fish ponds. Organic waste and chemical fertilizers also have a negative impact on the quality of water bodies and aquatic life.

Economic Viability: Small-scale traditional fish farmers may be at a disadvantage in competing with large-scale commercial fish producers. These are usually large-scale operations, which, through economies of scale, improved technologies, and better access to markets, are capable of producing fish at lower costs. In this environment, the old-style farmers with fewer inputs and less output cannot make much economic sense.

Regional differences in traditional aquaculture practices: Traditional fish farming practices vary from one region to the next, depending on the area's environmental conditions, culture, and resources.

Asia: Integrated Rice-Fish Farming: In many parts of Asia, integrated rice-fish farming is prevalent. Fish farmers keep fish in the flooded rice paddies, and both crops benefit each other reciprocally. In return, fish feed on pests and weeds that may affect the rice plants, while the rice plants act as shades and homes for the fish. This mutualism thus promotes efficiency and durability.

Africa: Seasonal Floodplain Aquaculture: Seasonal floodplain aquaculture is practiced in areas such as the Niger Delta in Nigeria and the Nile floodplain in Egypt. During the rainy season, the floodplains submerge, serving as temporary habitats for fish and other animals. Depending on the availability of water and nutrients in different seasons, these fish breed and confine themselves in natural or concrete tanks.

Indigenous aquaculture systems in South America: These indigenous people living in the Amazon Basin have developed relatively advanced aquaculture methods that incorporate water migration and indigenous fish species. For example, the Arawak and other indigenous people build fish ponds and canals to regulate water and fish stock appropriately.

Case Study:

- Traditional fish farming means using local resources and natural conditions to produce fish, along with some enhancements, and fish farming has recently grown rapidly in the agricultural production sector in Bangladesh.
- Bangladesh has traditionally had a huge number of recorded water bodies, including rivers, ponds, and flood plains, and is well known for practicing traditional forms of fish

cultivation. The country's traditional aquaculture practices include:The country's traditional aquaculture practices include:

Pond Culture

- Pond culture is predominant in Bangladesh's rural areas, and most of the ponds used for fish production are small. Some farm owners construct concrete or dredge ponds along their farms' shorelines or excavate depressions into fish ponds, producing carp and tilapia. Such ponds combine several uses, such as rearing fish for home consumption, irrigation for agriculture, and water for livestock.

Floodplain Fisheries

- During the rainy season, floodplains flood, providing a wide stretch of water that supports fish breeding and growth. People catch fish in these bodies of water, especially during flood and post-flood seasons. The fish found in such water are normally those that breed and grow in water that is temporary in nature.

However, the country's corporate practices of sustainable fishing face several challenges, such as overfished fish sources, water pollution, and competition from commercial fisheries. Only state initiatives and support programs can resolve these challenges and realities, encouraging the transfer to a new level of efficiency.

Government Policies for Modernisation: Aquaculture modernisation should address policy changes in fish farming and technology, as well as improvements in infrastructure on fish farms.

1. **Research and Development (R&D):** Modernisation of fish farming depends on investing in the R&D process. To break new ground, governments must provide research funding for institutions and universities. This includes:
   - **Developing New Technologies:** This includes the development of RAS and IMTA, as well as researching new aquaculture systems. Since wastes are cyclical and converted into resources for other species, they are efficient ways of conserving water and the environment.
   - **Enhancing Breeding Practices:** Genetic studies have the potential to make fish immune to diseases and grow much faster, thereby improving production ability and minimizing losses.

- The concept of sustainable feed development explains the search for alternative feed sources, such as insect protein feeds and plant-based feeds, to replace the common fish meal and fish oil feeds.

The government should use the extension services as well as partner with industries in the dissemination of the results found in the research so that such improvements benefit farmers.

2. **Financial Support:** The technological and quantitative improvement of conventional fish farming necessitates a lot of capital, which is a challenge for most bulk producers.
   - **Subsidies and Grants:** These are schemes designed to reduce the costs associated with the implementation of new technologies and the establishment of necessary infrastructure. For instance, the government provides subsidies to establish RAS infrastructure or purchase premium feed.
   - **Low-interest Loans:** Providing farmers who are interested in making improvements to their farming methods with loans with flexible repayment options. You can use these loans to buy machinery, improve farming structures, or boost production capabilities.
   - Insurance schemes introduce initiatives in the form of insurance to cover farmers' losses due to factors such as diseases, adverse weather, weather risks, and fluctuating market prices.On the same note, this reduces the financial risks incurred and helps farmers embrace advanced farming methods.
3. **Infrastructure Development:** The state's decisive influence is evident in infrastructure investment. This includes:
   - **Hatcheries:** To provide farmers with high-quality fingerlings all year, I could establish government-affiliated hatcheries.
   - **Cold Storage Facilities:** Implementing proper handling requirements, such as cold chains for storage, to improve the quality of fish products and reduce losses. This is beneficial for both the domestic and export markets.It is equally critical for the home market and the export market.
   - **Transportation Networks:** Improving transport infrastructures so that the fish products produced from the farms can easily find their market. Features such as paved roads, cold vehicles, and warehouses are economical and reduce product waste.

4. **Training and education:** Fish farmers' education is one of the key initiatives in the modernization process.
    - **Extension Services: Developing services that farmers can utilize is critical.** These services can include advice, solutions, and information regarding new technologies.
    - **Training Programmes:** Providing training activities such as workshops, seminars, and even courses to educate farmers on new methods in aquaculture, disease control, and conservation.
    - **Collaborative Networks:** Providing ongoing technical assistance to farmer organisations and other types of learning and knowledge-sharing networks.This particular form of learning among peers can go a long way in spreading modern 'best practices'.
5. **Regulatory Framework:** There must be strict supervision to ensure that modernisation measures lead to environmentally friendly fish farming. Governments should:
    - **Establish clear guidelines:** enact and enforce measures regarding confining animals in small cages, sanitation standards, and the use of antibiotics and chemicals.
    - **Monitor Compliance:** They must set up a schedule for having the companies supervised and checked for compliance with the set environmental policies and best practices.
    - **Protect Aquatic Environments:** Create marine reserves and legal systems that will regulate the use of valuable ecosystems, adequate and orderly fishing, and species differences. The creation of MPAs and the use of ecosystem approaches in resource management are two examples.
6. **Environmental Conservation Projects**: Policies that support modernization initiatives while promoting sustainable aquaculture practices, such as integrated multi-trophic aquaculture (IMTA), mangrove conservation, and water recycling, help to preserve ecosystems and biodiversity.
    - **Sustainable approaches**: promoting practices such as integrated multi-trophic aquaculture (IMTA), mangrove conservation, and ecosystem-based management to minimize environmental impacts.
    - **Habitat Restoration**: Investing in projects that restore and protect natural habitats essential for fish breeding, feeding, and spawning.
    - **Climate Resilience**: promoting adaptation measures like water management plans and sturdy infrastructure to lessen the effects of climate change on aquaculture.

7. **Support for Cooperatives and Farmer Associations**: Promoting the establishment of cooperatives and farmer groups enables small-scale fish producers to pool resources, including joint marketing channels, access to government programs, and bulk purchases of supplies.
   - **Collective Bargaining Power**: encouraging the formation of cooperatives and associations to enable small-scale farmers to negotiate better prices for inputs and access shared resources.
   - **Capacity Building**: boosting collaborative management, governance, and entrepreneurial skills through training and funding.
   - **Policy Advocacy**: representing the interests of fish farmers in policy discussions and advocating for policies that support their modernization and sustainable development goals.

Case Studies: India

1. The Blue Revolution aims to enhance aquaculture practices to increase fish production and productivity. The Blue Revolution scheme came into existence in 2015. In terms of credit facilities, the scheme provides fish farmers with access to credit facilities, physical facilities, and capacity-building programs.
2. The Pradhan Mantri Matsya Sampada Yojana (PMMSY) was announced in 2020 to promote the efficient and legal growth of the fishery industry.It has strategies for expanding fish production, a three-fold increase in fishers' absolute income, and post-harvest structures.
3. The National Fisheries Development Board (NFDB) supports fish farmers by providing funding, capacity development, and access to the right technologies.It has been instrumental in framing policy on recommended practices and sustainable fish farming.

Case Studies: Global Perspectives

1. **China:** As the largest producer of aquaculture products, China has made strides in terms of its approach, which targets technology, research, and capital investment. This realisation has seen subsidies come in handy in transforming conventional farming to what may be termed high-input farming systems.
2. **Norway:** As expected from a country whose aquaculture production is among the most advanced in the world, the Norwegian government has been supportive of sustainable

practices, research, and development projects, as well as a follower of some of the most stringent legislation.

3. Vietnam has sought to develop a long-term vision for aquaculture; they subsidise and invest abroad to enhance their fish farming.

Challenges and Solutions: Nevertheless, the advancement of new techniques in traditional fish farming presents several obstacles, as follows: Adopting a model approach is the best way to address the numerous perturbation challenges. The following section provides further details on the challenges and possible solutions mentioned earlier.

1. **Resistance to Change**

Challenge: From the above discussion, it is evident that the majority of traditional fish farmers may not adopt new technologies and practices due to a lack of awareness, fear, and sheer tradition.

Solutions:

- **Awareness Campaigns:** The governments and relevant organisations should carry out awareness campaigns to educate the farmers on the advantages of practicing modern aquaculture. Such campaigns can use a variety of media, including radio, television, social media, and community meetings.
- **Demonstration Projects:** Perhaps the establishment of examples of successful farming through the use of newer methods can be the best way of convincing such farmers. It is equally important to see positive outcomes in different settings, which goes a long way in overcoming resistance.
- **Hands-on Training:** Farmers may be more at ease when using the technologies in the field after going through practical and activity-based training sessions. We need to develop field visits, training sessions, and workshops to motivate and benefit the farmers.

2. **Funding Constraints**

Challenge: Lack of capital is one of the main obstacles that users face when trying to employ advanced aquaculture methods. This is because most small-scale farmers cannot afford to embark on investments in new technologies, equipment, and structures.

Solutions:

Increased budget allocations: Governments can increase spending in the fisheries and aquaculture sectors. Govt. can modernize fish farming with national budgets or specific grants.

- **Low-Interest Loans:** Extending concessional credit or credit facilities to fish farmers can improve their ability to fund production modernization. These should be financial products that meet the needs of the aquaculture industry.
- **Public-Private Partnerships:** The combination of international government and private sectors may bring more resources into the system. The private sector can bring in capital investment, technology, and skills, while the government can support policies and help open up markets.

3. **Environmental Concerns**

Challenge: The current practices in the aquaculture system should embrace sustainability to avoid environmental impacts like water pollution, habitat loss, and biodiversity loss.

Solutions:

- **Stringent Regulations:** Governments must oversee the issue by setting high standards of protection to prevent any negative impact of aquaculture on the environment. This includes pollution control, waste management and discharge, chemical use, and the effects on neighboring habitats.
- **Promoting Eco-Friendly Technologies:** Explaining the benefits of sustainable technologies such as biofilters, RAS, and IMTA may help to reduce negative effects on the environment and natural resources.Governments can encourage the use of such technologies in production processes.
- **Research and Development:** It's crucial to research to improve sustainable aquaculture, support efforts, and identify new technologies for application. Government bodies generally fund research work, allowing research institutions to collaborate with universities and various companies to develop efficient aquaculture methods.

4. **Skill Gaps**

Challenge: Farmers often struggle to implement necessary changes in their farming practices due to a lack of expertise. A lack of skilled personnel can hamper the adoption and subsequent performance of new technologies.

Solutions:

- **Continuous Education and Training Programmes:** Farmers must receive well-planned and implemented education and training techniques to equip them with a comprehensive understanding of modern aquaculture. I am advocating for the availability and affordability of such programs, ensuring they meet clients' needs.

- **Extension Services:** Governments can bolster extension services as a way of enhancing support for fish farmers through practical strategies. Some of the responsibilities of extension officers include providing farmers with technical support and problem solving, as well as ensuring that they follow best practices.
- **Certification Programmes:** It may also be possible to introduce certification programmes for the farming of fish to enhance conformity to particular standards across the farmers as well as be certain of their competency levels. Certified farmers may also benefit from better market access and higher prices for their products.

Additional Challenges and Solutions

5. **Market Access**

Challenge: Restrictions on the domestic market or even exports can result in high production costs. These key challenges include inadequate infrastructure, a lack of information about the market, and competition from imported fish.

Solutions:

- **Improving Infrastructure:** They can also put their resources into enhancing the physical asset base, which includes roads and avenues, cold storage, and transportation systems. This will help the farmers avoid post-harvest losses and have better access to markets.
- **Market Information Systems:** There is potential to build an MIS bureau that will facilitate the supply of practically real-time price, demand, and supply data to farmers. Governments can facilitate such practices through the technology platforms that foster the appointment of efficient systems for checking the operations of their members.
- **Trade Policies:** To compete with imported fish, local fish producers must develop trade policies that strengthen trade barriers and promote sustainability. This may involve import and export taxes, direct financial assistance, and promotional assistance.

6. **Climate Change**

Challenge: Climate change has become one of the biggest threats to aquaculture businesses. Factors such as rising temperatures, fluctuations in rainfall, and acts of God may affect water quantity, quality, and fitness.

Solutions:

- **Climate-Resilient Practices:** Implementing climate change mitigation adaptation measures as well as encouraging sustainable, climate-resilient aquaculture, including ISF, water conservation, and appropriate species, can reduce climate change effects.

- **Disaster Preparedness:** By providing farmers with strategies to adhere to and mobilize themselves in the event of adverse climatic conditions, we can plan and manage disasters. This may include signs of imminent danger, a disaster action plan fund, and an increase in structural standards.
- **Research on Climate Impact:** There is still a need to support studies specifically on the effects of climate change on aquaculture production, as well as the formulation of mitigation mechanisms. International and research organizations can help to strengthen these initiatives.

7. **Health and biosecurity**

Challenge: This comes in the form of diseases that are prevalent in fish farming, posing biosecurity threats. In this case, the failure to follow some beneficial practices and the lack of biosecurity concerns have significant economic and environmental repercussions.

Solutions:

- **Biosecurity Protocols:** Adapting an 'all clear' policy line in order to avoid diseases' introduction and dissemination is crucial. This includes actions such as implementing quarantine measures, assessing stock health, and feeding disease-resistant species to prevent disease effects.
- **Veterinary Support:** To manage diseases in their early stages, it is critical to provide fish farmers with technical support and veterinary services.Governments can help provide veterinarians and diagnostic services, as they may be difficult to access in some locations.
- **Health Management Training:** Flood management, enhanced farm biosecurity, disease prevention, and control measures are measures that, if undertaken, will provide farmers with adequate knowledge and skills to deal with diseases affecting the fish stocks.

Conclusion

This is still as true today as before: it is still possible for the government to play an active role in the process of modernising traditional fish farming practices while at the same time ensuring that the methodology used is sustainable, productive, and economically viable. Governments must seize the opportunity to change the aquaculture sector's image by funding the research process, providing finances, developing aquaculture businesses' infrastructure, and embracing sustainable development. Evaluating the lessons of the successes and failures of countries like India, China, Norway, Vietnam, and so on requires interrelated and coherent policies, positive relations with key players, and consistent investment in such change. The future of fish farming would depend on the development of current technologies and techniques, as well as the traditional methods upheld by the government's policies.

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NATURAL FARMING: PROMOTION AND PERSPECTIVE THROUGH KRISHI VIGYAN KENDRA, DAHOD

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Introduction

Krishi Vigyan Kendra, Anand Agricultural University, Dahod was previously established at Devagadh Baria and it was shifted to the District Head Quarter and Agricultural Research Station, Anand Agricultural University, Muvaliya Farm, Dahod in July, 2005. The erstwhile Panchmahals district has now been divided into two districts *viz*. Panchmahal district with its head quarter at Godhra and Dahod district with its head quarter at Dahod.

The Dahod district is well-known as “Adivasi region” in Gujarat. The district lies between 22044’ to 22058’ North Latitude and 7407’ to 74027’ East Longitude. This district’s height is above 217 meter from sea level. The Dahod district consists of 9 talukas with 723 villages. Thus, total population is 16, 36,433, population of scheduled castes 32,884 (2.01 %), scheduled tribes 11, 82,508 (72.31 %) so Dahod consist Tribal District. The district falls under region of Middle Gujarat belonging to Agro-Climatic Zone - III of Gujarat state. The average normal rainfall for the district is 1000 mm to 1150 mm. Erratic and long dry spells are common even in rainy seasons. Therefore, the district faces drought situation frequently. Most of the Tribal farmers are small and marginal. Maize and Soybean are the two major kharif crops of the district while wheat and gram are the principal crops grown in rabi season. Bullocks are the main source of farm power. Although the district has an impressive cattle wealth, their productivity is very low as the cattle are poorly maintained.

Natural Farming

Natural Farming is a chemical-free farming system rooted in Indian tradition enriched with modern understanding of ecology, resource recycling and on-farm resource optimization. Its emphasis on organic practices and minimal disturbance to the ecosystem, offers substantial benefits to the environment. By abstaining synthetic pesticides and fertilizers, natural farming preserves soil health and fertility, fostering a robust ecosystem of beneficial microorganisms and insects. This approach not only enhances biodiversity but also promotes natural pest control mechanisms, reducing the need for chemical interventions that can harm both wildlife and water sources. Moreover, natural farming methods typically require less water, contributing to water conservation efforts and help to sustain local ecosystems. By prioritizing the health of the soil and surrounding environment, natural farming plays a pivotal role in building climate resilience, sequestering carbon, and mitigating the impacts of climate change.

The state, Gujarat also known for its progressive agricultural policies, encourages innovation and sustainable practices amongst farmers. More than 50% of the total available land in Gujarat is used for agricultural purposes. Gujarat is endowed with abundant natural resources, in terms of different kinds of soil, climatic conditions and diversified cropping patterns. In the district Dahod, approximately 28,190 acres are under natural farming, with 28,190 farmers engaged across all 9 blocks. The Prime Minister has been emphasizing about need for a paradigm shift in agriculture through crop diversification, use of recent improved technologies and adoption of natural farming as a way towards "***Atmanirbhar Bharat***".

Promote natural farming through Krishi Vigyan Kendra

With a view to promote natural farming, Krishi Vigyan Kendra, AAU, Dahod established a demonstration unit in the year 2020-21 to promote sustainability at its level. The unit showcases practices such as ***Jeevamrut, Bijamrut, Ghan-jeevamrut,*** **Vaspa, Mulching, and Mixed cropping**. Farmers across Dahod district and neighboring states like Madhya Pradesh and Rajasthan often visit the Integrated Farming System unit to learn such techniques. Practical demonstrations and hands-on training are conducted for preparation method of ***Jeevamrut, Bijamrut, Ghan-jeevamrut, Neemastra, Agniastra,*** and ***Brahmastra***. This initiative aims to encourage holistic approaches towards agriculture that align with sustainable practices and contribute positively to environmental stewardship. The demonstration unit serves as a learning hub for farmers interested in adopting natural farming methods, enhancing productivity while minimizing environmental impact. Through method demonstrations and practical sessions, Krishi Vigyan Kendra empowers farmers with knowledge and skills to implement these sustainable practices effectively in their respective fields.

Farmers Awareness

Alongwith, farmers have been made aware of important practices for adopting natural farming such as no use of external inputs, use of local varieties, on farm produced microbial formation for seed treatment (*Bijamrut*), microbial inoculants (*Jivamrut*) for soil enrichment, mulching for nutrient recycling, management of pest through botanical concoctions (*Neemastra, Brahmastra and Agniastra*) and integrating livestock especially of native breeds etc. through various training programmes held at on and off campus by KVK Scientists. Also, farmers have been aspired about benefits of natural farming like rejuvenation of soil health, improve in yield, increase in farmers income, resilient against climate change, reduces risks in farming, ensure better health by eliminating the application of chemical inputs, livestock sustainability, and environment conservation.

Hands on practice of preparation method of Brahmastra

Demonstration on Jeevamrut

Hon. Minister, Agriculture and farmers Welfare, GoG, Gujarat, Hon'Vice Chancellor, Director of Research pays a visit to farmers natural farming stall at KVK, Dahod

Demonstration on Jeevamrut

Scientists at KVK conduct various training programs and field demonstrations to encourage farmers to adopt natural farming practices. They also offer vocational training and engage in extension activities such as field visits, agricultural fairs, and farmers' scientist interaction etc. to raise awareness about natural farming. Additionally, KVK scientists deliver numerous lectures on natural farming across various departmental programs. Moreover, under the guidance of the Natural Farming Board, KVK scientists serve as Taluka Nodal Officers to promote sustainable agricultural practices in their respective districts.

Table 1. Particulars about various training programmes, activities conducted by KVK to promote natural farming at grass root level

S. No.	Particulars	No. of activities conducted	No. of Participants		
			Male	Female	Total
Year 2022					
A.	Trainings (On and off Campus)	22	491	105	596
B.	Extension Activity				
i.	Demonstrations	10	313	31	344
ii.	Seminar/Kisan Goshtis organized and co-organized	29	4538	653	5161
iii.	Others (Lecture delivered/ Radio talks)	17	1639	379	2018
Year 2023-24					
A.	Awareness Programme	21	672	277	949
B.	Training Programme				
i.	On Campus Training	24	767	214	981
ii.	Off Campus Training	6	211	47	258
C.	Extension Activity				
i.	Demonstrations	28	728	353	1081
ii.	Lecture Delivered	85			31522

Several politicians, high-profile individuals, and policymakers visited the Natural Farming Demonstration units on site last two year and were pleased to observe the efforts. Shri. Bacchubhai Khabad, (State Minister) Ministry of Agriculture and Farmers Welfare, GoG, Gujarat visited natural farming demonstration at KVK and was impressed by the efforts KVK is making for small scale farmers.

Shri. Prafulbhai Sanjeliya and Dr. Dixit Patel visited IFS unit

Hands on Practical for preparation of Brahmastra

Shri. Bachhubhai Khabad, Hon' Minister of Agriculture and Farmers Welfare, GoG, Gujarat, Dr. K. B. Kathiria, Hon. Vice Chancellor, Dr. M. K. Jhala, Directorate of Research, Dr. G. R. Patel, Registrar, AAU, Anand and other dignitaries visited unit of natural farming at the premise

Farmer's visit at KVK as part of exposure visit for natural farming

District collector Dr. Harshit Gosawi, DDO Smt. Neha Kumar and DDO Mr. Utsav Gautam also visit the demo units and encouraged us to work even far better. Dr. K. B. Kathiria, Honorable Vice Chancellor of AAU, Anand monitored and appreciated KVK for its demo models as well as activities carried out by KVK for betterment and upliftment of Tribal farmers. Directorate of Research and Dean PG Studies, Directorate of Extension Education, Deans of various faculty of AAU, other Heads of KVK under Anand judiciary visited the IFS model at the premise and was thrilled to see KVK's efforts towards aspiring farmers on natural farming. Two visits to the premises' demonstration units on natural farming were made by Shri. Prafulbhai Sanjeliya, the Gujarat state coordinator, and Shri. Dixitbhai Patel, the Gujarat state sub-coordinator for natural farming.

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NAVIGATING THE CLIMATE-DRIVEN SHIFTS IN PLANT MINERAL UPTAKE: IMPLICATIONS FOR LIVESTOCK SUSTAINABILITY

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Introduction

Climate change refers to long-term shifts in global or regional climate patterns. These changes can be caused by both natural and human-induced factors. Natural factors that can influence climate include changes in the sun's output, volcanic eruptions, and variations in the Earth's orbit. Human-induced climate change is primarily driven by the increased release of greenhouse gases, such as carbon dioxide and methane, into the atmosphere through activities like burning fossil fuels, deforestation, and agriculture. Climate change poses a significant challenge to animal agriculture because of its potential impact on heat stress, food and water security, extreme weather events, vulnerable shelter, and population movement. Temperature and humidity are common environmental stressors that negatively impact oocyte growth, puberty, quality, and developmental competence, as well as milk supply.

Impact of climate change

The effects of climate change can include rising global temperatures, sea level rise, changes in precipitation patterns, and more frequent and severe weather events. Climate change poses significant risks to ecosystems, human health, food and water supplies, and economic activities around the world. These impacts can have cascading effects on various sectors, including the livestock industry.

Mineral Uptake in Plants

Plants require various essential minerals, such as nitrogen, phosphorus, and potassium, for growth and development. Climate change can alter the availability and uptake of these minerals by plants, which can affect their nutritional quality and yield. Factors like changes in temperature, precipitation, and atmospheric CO2 levels can influence the solubility, mobility, and absorption of minerals in the soil, as well as the plant's ability to take up and utilize these minerals. This can lead to changes in the nutritional profile of plants, potentially affecting the quality and quantity of livestock feed. Additionally, climate-induced shifts in plant species composition and distribution can further impact the availability and accessibility of suitable forage for livestock.

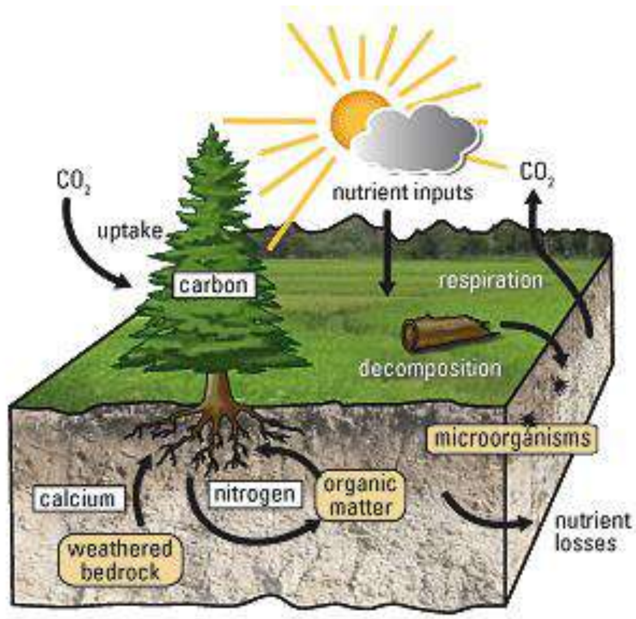
Effects of nutrient stress on plant growth:

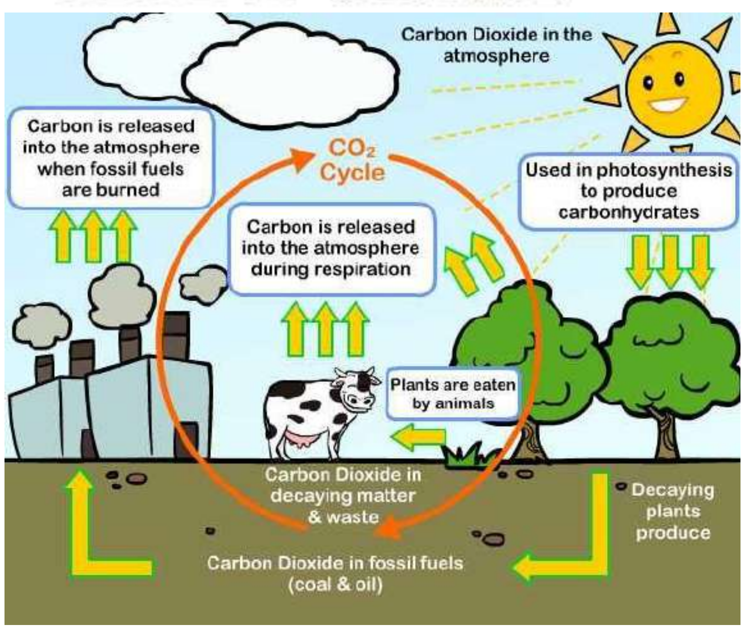
Overall, nutrient deficiencies can significantly impact plant growth, development, and productivity, highlighting the importance of balanced nutrient availability for optimal plant performance livestock sector. The livestock sector is highly dependent on the availability and quality of forage and feed crops, which can be directly affected by the impacts of climate change on plant mineral uptake. Reduced mineral content in livestock feed can lead to nutritional deficiencies in animals, impacting their health, productivity, and reproductive performance. This, in turn, can have significant economic consequences for livestock producers and the broader agricultural industry. Addressing these challenges requires a comprehensive understanding of the complex interactions between climate change, plant nutrition, and the livestock sector.

Changes in mineral uptake in Plants and Livestock

The changes in mineral uptake and plant nutritional quality can have significant consequences for the livestock industry. Livestock rely on plants as their primary source of nutrition, and any alterations in the mineral content or palatability of forage can affect the health, productivity, and reproductive performance of livestock. This, in turn, can impact the overall supply, quality, and economic and economic viability of the livestock sector. Reduced mineral availability in plants can lead to nutritional deficiencies in livestock, impacting their health, growth, and reproductive performance. Additionally, changes in the distribution and prevalence of livestock diseases and parasites due to climate change can further challenge the resilience and productivity of the livestock industry.

Addressing these challenges will require a multifaceted approach, including the development of climate-resilient crop and livestock management strategies, as well as investments in research and infrastructure to support the adaptation of the livestock sector to the impacts of climate change. Addressing these challenges will require a multifaceted approach, including the development of climate-resilient crop and livestock management strategies, as well as investments in research and infrastructure to support the adaptation of the livestock sector to the impacts of climate change. This may involve the adoption of precision farming techniques, the development of drought-tolerant and nutrient-efficient forage varieties, and the implementation of early warning systems to monitor and respond to changes in plant and animal health. Collaboration between policymakers, researchers, and industry stakeholders will be crucial in developing and implementing effective solutions to mitigate the impacts of climate change on the livestock sector.





Plant and Livestock adaptation strategies against climate change

1. **Plant strategies**

- Crop diversification: Planting a variety of crops that are resilient to different climate conditions, such as drought-tolerant or heat-resistant varieties.
- Agroforestry: Integrating trees and shrubs into agricultural systems to provide shade, reduce soil erosion, and improve soil fertility.
- Improved irrigation and water management: Implementing efficient irrigation systems, water harvesting techniques, and drought-resistant irrigation methods.
- Soil conservation practices: Adopting practices like no-till farming, cover cropping, and organic matter management to improve soil health and water-holding capacity.
- Pasture management: Implementing rotational grazing, improving forage quality, and managing stocking rates to ensure sustainable use of grazing lands.
- Integrated pest and disease management: Adopting integrated pest management strategies, including the use of biological controls and resistant crop varieties, to reduce the impact of pests and diseases.

2. **Livestock strategies**

- Livestock breed selection: Choosing livestock breeds that are better adapted to the local climate, such as heat-tolerant or disease-resistant breeds.
- Early warning systems and climate-informed decision-making: Utilizing weather forecasts, climate data, and early warning systems to make informed decisions about planting, harvesting, and livestock.
- Improved feed and water management: Implementing strategies to ensure adequate and nutritious feed and water availability for livestock, such as cultivating drought-resistant forage crops, improving water storage and distribution systems, and optimizing grazing patterns.
- Herd health monitoring and disease prevention: Enhancing disease surveillance, vaccination programs, and biosecurity measures to protect livestock from climate-related health challenges.
- Diversification of livestock species and production systems: Exploring the integration of multiple livestock species and mixed farming systems to increase resilience

Conclusion

The successful implementation of these plant and livestock adaptation strategies will require collaboration among policymakers, researchers, and industry stakeholders. Investments in research, extension services, and infrastructure development will be crucial to support the adoption of climate-resilient practices. Additionally, policies and incentives that promote sustainable land use, water management, and livestock production can further enhance the resilience of the agricultural sector to the impacts of climate change. Ultimately, a comprehensive and coordinated approach is necessary to ensure the long-term viability and sustainability of the livestock industry in the face of a changing climate. By investing in adaptive strategies and fostering collaboration, the livestock sector can build resilience, maintain productivity, and contribute to global food security in the face of the challenges posed by climate.

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RECENT TRENDS IN HI-TECH VEGETABLE NURSERY PRODUCTION

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Introduction

'A vegetable nursery' is a place or an establishment for raising or handling of young vegetable seedlings until they are ready for more permanent planting. The seeds of some vegetable are first sown in the nursery beds and the seedlings from these beds are later transplanted in the main field. Such vegetables are generally small seeded crops which belong to solanaceous, cruciferous and cucurbitaceous family besides onion, lettuce, asparagus etc.

Advantages of nursery raising: Nursery raising is an essential practice owing to the following reasons (Nandpuri and Surjan Singh, 1986):

- It is convenient to look after the 'baby seedlings' with better care in nursery bed.
- The size of seeds being small, it is almost impossible to do direct sowing properly.
- The hybrid seeds being expensive can receive better care and thus ensuring uniform crop stand.
- The land can be economically used as it can be put under some other crop when the nursery is being raised.
- Less expense is involved in controlling insect-pests and diseases in nursery beds.
- Undesirable seedlings can be discarded at the time of transplanting.
- Availability of sufficient time for field preparation, manure and fertilizer application after harvesting the previous crop.

Disadvantages of nursery raising:

Besides benefits of nursery raising it has some limitations as well, which are as follows:

- Transplant shock, which delays crop growth but it is less severe on cell raised seedlings as compared to bare rooted seedlings.
- Cost of seedlings, which adds to production cost.
- Extra labour to transplant/establish the crop.

Selection of site: The following points should be taken into consideration while selecting an area for nursery production:

- The land should be well drained, fertile and rich in organic matter.
- The area should be free from the water logging.
- It should always be away from shade to get desired sunlight.
- The nursery area should be near to a water source.
- The area should be fenced from the pet and wild animals.

A. **Conventional method:** For raising healthy nursery through conventional method following protocol is mainly adopted (Anonymous, 2009):

i) Raised nursery beds of well pulverized soil with 3m × 1m × 0.15m size are prepared.

ii) The beds are fertilized with 20 to 25 kg well rotten FYM, 200 g SSP and 15-20 g Dithane M-45.

iii) To prevent damping off disease, nursery beds are treated with formaldehyde (25 ml/litre of water) and are covered with air tight polythene for one week and after removing the polythene the soil is turned up and down for three weeks to remove the remains of the formalin fumes.

iv) Pre treatment of seed with Captan and Bavistin (2 -3 g/kg of seed) is also practiced to check the attack of damping off.

v) The treated seeds are sown in the lines 5 cm apart at 0.5-1.0 cm depth and are covered with thin layer of well rotten FYM and soil mixture.

vi) In order to conserve soil moisture, beds are mulched with dry grass and are irrigated in morning and evening hours regularly till the seedlings emerge out.

vii) Mulched grass is removed as soon as the seedling emergence is observed and nursery beds are drenched with a mixture of Dithane M-45 (0.25%) and Bavistin (0.1%) to avoid damping off disease.

viii) In case seedlings are weak/deficient in nitrogen, urea is sprayed @ 0.3% when seedlings are 8-10 cm tall.

ix) The seedlings become ready for transplanting in 4-6 weeks or when they attain a height of 10-15 cm.

x) Irrigation is withheld 3-4 days prior to transplanting so that plants become hardened. But, on the day of transplanting, sufficient water is applied in the nursery bed and then seedlings are taken out for transplanting.

xi) The transplanting is mainly carried out during evening hours for better crop establishment.

Preparation of nursery bed

Seed treatment

Line sowing

Grass thatching

Seedlings after germination

Seedlings ready to transplant

B. Hi-tech nursery raising techniques

i) Covering with polythene sheets

In order to ensure early germination, thatching can be swapped with transparent/white polythene sheet (150 micron thickness). After seed sowing, irrigation water is applied in the nursery beds up to field capacity. Then the beds are covered with transparent/white polythene sheet and are made air tight by covering the sheet edges with soil. The polythene sheath is removed after the competition of germination process. Rest of the cultural practices are similar to conventional method of nursery raising.

Covering nursery bed with polythene sheet

Seedlings after germination

Poly tunnels for normal weather

The nursery beds are covered with pre fabricated tunnels of size 3m long, 1.5m wide and central height of 1.0m. The semi circular structure is clad with UV-polythene sheath (200 micron) with 75 per cent transmittance. Once the seed sowing, covering and irrigation to field capacity is over, the bed can be covered with the tunnels. Both the openings can be closed if nursery is grown in winters.

Emerging seedlings inside poly tunnel

Seedlings ready to transplant

ii) Sunken nursery for weather extremes

i) Prepare a trench of any length, 1.2m wide and 50cm deep.

ii) Prepare a raised bed of 5-10 cm height at the bottom of the trench. The soil should not be imported from outside the trench. Albeit, FYM (25kg) and inorganic fertilizer mixture (100g) may be added as recommended earlier. Precautions must be observed in applying FYM. It may be treated with fungicide/Trichoderma (1kg/100kg dung) at least 15 days prior to bed preparation.

iii) Seed treated with Captan/bavistin may be sown in lines at 5cm width and cover the seed with the same soil.

iv) Drench the beds with water to the field capacity of the soil.

iii) Cover the trench with white, transparent polythene sheath, providing taper to both sides.

iv) Make the sheath air tight from all sides.

v) Start observing the emergence of the seed through the poly sheath from tenth day onwards.

vi) Once the emergence is over, irrigation may be regulated, as required till the 4 leaf stage is achieved.

Viii) Polythene cover may be removed in sunny days or converted into a roof in rainy days.


Trenches of 3 m × 1 m × 0.5 m (length, width, depth) size


Preparation of nursery bed inside a trench


Nursery raising inside a trench using portrays


Air tight covering of a trench


Emerging seedlings inside a trench


Seedlings ready to transplant

iv) Naturally ventilated polyhouse

For commercial nursery production, naturally ventilated polyhouses can be used. In a polyhouse of 100 m^2 area, 40,000 seedlings can be raised in one batch and we can have a total of five such batches per year.


Nursery raising on beds inside a polyhouse


Nursery raising using portrays inside a polyhouse

v) Poly bags for cucurbits

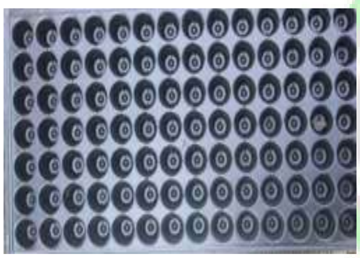
Most of the cucurbits are seed propagated and in situ sowing is practiced. In some cases where early crop is desired, seeds can be sown in alkathene bags and germinated under protected cover from low temperature. The seedlings are transplanted from the bags at 2-true-leaf stage. This practice is prevalent in Punjab, especially in the case of muskmelon and it can be done in the hills to get early crop in July. Normally, the cucurbits do not stand transplantation beyond this stage due to injury to tap root. There is considerable saving in seed quantity, nearly 50 to 60 per cent as compared to in situ sowing (Bose and Som, 1986).

Raising of healthy nursery of cucurbits using polybags

vi) Plug tray technique

- The seedling tray (pro-tray) is filled with the growing medium (coco peat, perlite and vermiculite).
- A small depression (0.5 cm) is made with fingertip in the center of the cell of the pro tray for sowing.
- One seed per cell is sown and covered with medium.
- Coco peat with 300 to 400 per cent moisture is used and hence no immediate irrigation is required until germination.
- After sowing 10 trays are kept one over other for 3 to 6 days, depending on the crops.
- The entire stack will be covered using polyethylene sheet to ensure conservation of moisture until germination. The stacked trays are spread once the germination commences to avoid etiolation.
- The trays are shifted to net house on germination of seedlings and spread over the beds.
- The trays are irrigated lightly every day depending upon the prevailing weather conditions by using a fine sprinkling rose can or with hose pipe fitted with rose.

- Drenching the trays with fungicides as a precautionary measure against seedling mortality is also being done.
- Spraying of 0.3 per cent (3g/litre) water soluble fertilizer using poly feed (19 all with trace elements) twice (12 and 20 days after sowing) is practiced to enhance the growth of the seedlings.
- The trays are provided with protective cover from rain by covering with polyethylene sheets in the form of low tunnel whenever it rains.
- The seedlings at right stage of planting are hardened by withholding irrigation and reducing the shade before transplanting or selling to the growers.
- Systemic insecticides are sprayed 7-10 days after germination and before transplanting for managing the insect vectors.
- The seedlings would be ready in about 21-42 days for transplanting to the main field depending upon the crop.



Pro-tray for sowing

Growing media

Trays filled with media

Seed sowing

Matured seedlings

Seedlings ready to transplant

Seedling production using protrays

Conclusion

The advent of different nursery growing technique has opened the new vistas for growing vegetable crops in any month of the year irrespective of any vegetable crop. Such innovative techniques are facilitating the growers in producing off season vegetables for fetching remunerative prices.

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SPIRULINA FARMING: A SUPERFOOD SOLUTION FOR NUTRITION AND EMPLOYMENT CHALLENGES

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Abstract

The increasing prevalence of malnutrition and health risks associated with modern lifestyles necessitates the exploration of alternative dietary supplements. Spirulina, a nutrient-dense blue-green algae, offers a promising solution due to its ease of production and rich nutritional profile, including essential vitamins, minerals, antioxidants, and proteins. This article outlines the cultivation process of Spirulina, highlighting its potential to address nutritional deficiencies and create employment opportunities, particularly through initiatives like India's ACABC scheme. Key cultivation steps include species selection, media preparation, mixing and aeration, temperature and pH control, and harvesting. The findings demonstrate that Spirulina farming is economically viable, with significant profit potential and minimal training requirements. The article concludes that Spirulina's high nutritional value and low production costs make it an ideal candidate for combating malnutrition and fostering agribusiness growth, especially in tropical and subtropical regions.

Key words: Spirulina, Superfood, Nutrition, Health, Agribusiness.

Introduction

Modern lifestyles and ecosystem changes have increased malnutrition and health risks, highlighting the need for cost-effective dietary supplements. Spirulina, a blue-green algae, is easy to produce, process, and distribute, and boasts a rich nutritional profile including B-vitamins, β-carotene, vitamin E, antioxidants, minerals, chlorophyll, and phycocyanobilin.

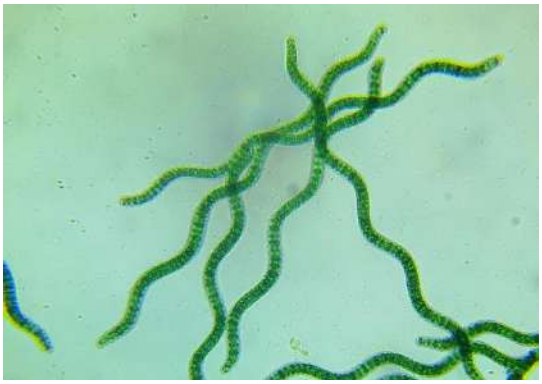
Recognized as a "super-food" since its discovery in 1519, Spirulina is endorsed by the United Nations as a vital future food. It offers numerous health benefits, such as allergy relief, immune support, antiviral properties, cholesterol reduction, diabetes management, anticancer effects, and antioxidant protection. Its rising demand has led to widespread production globally. In India, the government's Agri-Clinics and Agri-Business Centre (ACABC) scheme, launched in 2002, has boosted commercial Spirulina production, creating self-employment opportunities and addressing malnutrition. This article details Spirulina cultivation steps to inspire agribusiness ventures in the agriculture sector.

Cultivation of Spirulina

Spirulina is one of the various algal species found in natural freshwater environments. It thrives in habitats like soil marshes, seawater, and brackish waters with alkaline conditions. Spirulina can endure low temperatures of 15°C at night and up to 40°C for a few hours during the day. In the wild, its growth cycles are limited by the availability of nutrients. Large-scale cultivation of microalgae began in Japan with chlorella in the early 1960s, and spirulina cultivation followed in the early 1970s. Today, over 22 countries cultivate spirulina commercially on a large scale, leveraging its resilience and nutritional benefits.

Species Selection

Species selection is a crucial stage in spirulina cultivation. The two species most commonly used are *Spirulina platensis* and *Spirulina maxima* due to their valuable components, positive health effects, and non-toxicity for human consumption. These species are preferred for their rich nutritional profiles and beneficial impact on overall well-being.

Spirulina platensis *Spirulina maxima*

Open Raceway Pond

A raceway pond is a shallow artificial pond used for cultivating algae. Spirulina can be cultivated in open systems like ponds, lakes, or lagoons, as well as in closed systems. Open ponds are commonly used commercially to produce high-value spirulina products. These can include shallow, large ponds, circular ponds, tanks, and raceway ponds. Cultivation is typically done in two ways: concrete ponds or pits lined with PVC or other plastic sheets. Concrete ponds are often constructed, with ideal dimensions being 50 meters long, 2-3 meters wide, and 20-30 cm deep, although the length can vary depending on land availability. Infrastructures like these have been reported to yield spirulina biomass of 35 tonnes per hectare per year in commercial open mass cultivation ponds, such as those at Siam Algae in Bangkok.

Growth Conditions

Spirulina's growth conditions are similar to those of terrestrial plants, but it utilizes resources more efficiently, increasing biomass productivity with relatively less water use. For commercial and large-scale production, spirulina cultivation should be conducted in regions with suitable climatic conditions, particularly tropical and subtropical areas. These regions provide the necessary year-round sunshine. The growth rate and production of spirulina are influenced by several factors, including wind, rain, temperature fluctuations, and solar radiation.

Mother Culture

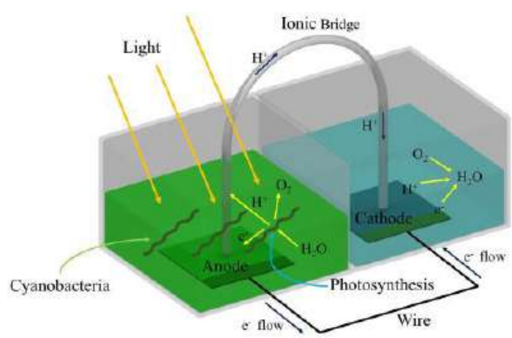
The mother culture is a fully developed, concentrated Spirulina culture essential for inoculum preparation and culture maintenance. The preferred Spirulina strain should have a high proportion of coiled filaments (less than 25% straight filaments, or none) and at least 1% gamma-linolenic acid (GLA) based on dry weight. The culture should be explicitly green in color. Under optimal temperature and climatic conditions, the growth rate is approximately 30% per day. The growth is proportional to the culture's exposure to light, so maximizing this exposure is crucial for optimal growth.

Media

Spirulina thrives in alkaline brackish water. The culture medium should provide all essential nutrients, including sodium carbonate and sources of nitrogen, phosphorus, iron, and trace metals (Raoof et al., 2006). Urea is also a key component; Spirulina can grow with either nitrate or urea alone, but using both simultaneously is more beneficial. Clean or filtered water is necessary to prevent the growth of other algae. Media preparations should align with local growing conditions for Spirulina, with Zarrouk's medium being the most commonly used. Nutrients account for 15-25% of the total production cost. The media should be prepared to meet local conditions while adhering to standard procedures.

Mixing and Aeration

Mixing the mother culture in the media is essential to homogenize and ensure even distribution of light among all Spirulina filaments during growth. This step is crucial for enhancing productivity. Aeration also plays a critical role in achieving high-quality and better yields of Spirulina. This is typically achieved using rotators, which gently agitate the growing cells, keeping them in suspension. There is a need of motorized rotators in the pond to ensure constant mixing and stirring. This setup helps to uniformly circulate carbon dioxide and eliminate



inhibitory substances like oxygen. Inadequate aeration can lead to inefficient energy utilization and reduced biomass production.

Temperature and pH

Spirulina thrives in temperatures ranging from 20°C to 37°C, with the ideal range for high growth and protein content being 29°C to 35°C. Temperature fluctuations significantly impact biomass production rates in Spirulina cultivation, with temperatures above 35°C potentially causing bleaching of cultures, while temperatures below 20°C are not conducive for growth. Installation of exhaust fans to regulate temperatures within the production unit are necessary. Maintaining a pH above 9.0 is crucial in Spirulina cultures to prevent contamination by other algae. pH adjustment is achieved by increasing carbon dioxide levels through the addition of carbonate salts to the culture medium. A pH range between 9 and 11 indicates a healthy culture, influencing algal growth, pigment production, and protein content, thereby impacting the antioxidant system. There a need of regular monitoring and controls pH levels during growth and taking necessary measures.

Light Intensity

In open-air cultivation systems, natural light or solar radiation serves as the primary source of energy for photoautotrophic organisms like Spirulina. Light intensity directly influences Spirulina production by affecting its protein content, growth rate, and pigment synthesis. The optical density of the culture is directly proportional to the light intensity; higher optical density requires more light, whereas lower optical density requires less light. To regulate light intensity during cultivation, the production unit should be covered with net shades. This helps in managing and optimizing the light exposure necessary for Spirulina growth.

Growth Rate & Productivity

In commercial Spirulina farming, creating a suitable culture medium is crucial as water serves as the primary medium for Spirulina growth. This medium must contain all essential nutrients necessary for healthy Spirulina growth. Maintaining the water level in tanks is critical for facilitating the photosynthesis process in Spirulina. Ideally, the water level should be shallow, around 20 cm. Deeper water levels can reduce sunlight penetration, which directly impacts algae growth and productivity. Therefore, controlling the water level optimizes conditions for Spirulina cultivation and enhances overall productivity.

Harvesting System

The concentration of algae in the production unit (pond) determines when Spirulina is ready for harvest. Typically, Spirulina is harvested approximately five days after the seeding process. Early morning is considered the most suitable time for harvesting due to the highest protein content in Spirulina at that time. The cool temperature facilitates easier handling, and ample sunshine hours during the day aid in drying the product.

After harvesting, Spirulina is allowed to dry. The harvesting process typically involves two steps:

Centrifugation

Centrifugation is a method used to separate Spirulina algae from the growth media. It involves using a centrifuge, which is equipment driven by a motor to rotate objects around a fixed axis, applying a perpendicular force to the axis. This process is generally efficient, though sensitive algal cells may incur damage when pelleted against the rotor wall. Careful handling is necessary to maintain the integrity of the harvested Spirulina biomass during centrifugation.

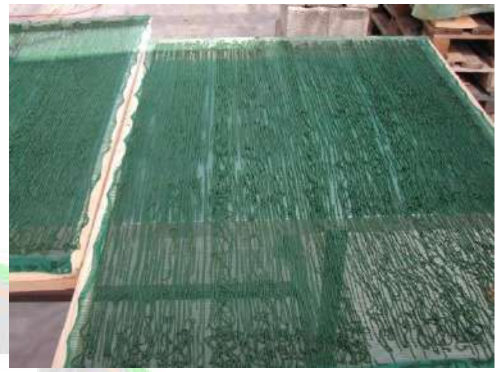
Filtration

In commercial Spirulina production processes, filtration devices play a crucial role in harvesting. There are two main types of filtration devices used: inclined screens and vibrating screens. Inclined screens typically range from 380 to 500 mesh with a filtration area of 2-4 m2 per unit, capable of harvesting approximately 10-18 m3 of Spirulina culture per hour. This method is widely regarded as the most suitable for harvesting Spirulina.

On the other hand, vibrating screens filter the same volume per unit time as inclined screens but require only one-third of the area. After filtration, the next step involves washing excess salts from the harvested biomass. The washed cake is then homogenized before being dried for further processing.

Drying

After harvesting, Spirulina needs to undergo a drying process to make it suitable for consumption. While Spirulina can be consumed fresh, slight drying is recommended before use. Fresh Spirulina is known for its quick digestibility and should ideally be consumed within 6 hours of harvest. However, for long-term storage, Spirulina can be dried using various methods such as sun-drying, freeze-drying, spray-drying, drum-drying, or cooking.



Given its thin and fragile cell wall, Spirulina can be effectively dried using sun-drying, which is popular due to its simplicity and cost-effectiveness. Sun-drying helps sterilize the algae and preserve its nutritional content. However, precautions are necessary during sun-drying to ensure the process is quick enough to prevent chlorophyll degradation, which can otherwise cause the dry product to appear blue. Sun-drying and drying machines to be employed for drying the harvested Spirulina, ensuring its preservation and suitability for consumption over extended periods.

Grinding/Powdering

After drying, Spirulina is typically processed into various consumable forms such as tablets, flakes, and powder to achieve this, the dried chips or rods of Spirulina undergo a grinding process aimed at increasing their apparent density and reducing them to a fine powder. Grinding typically continues for 6-10 hours until the average powder size reaches between 200-800 nm. The two primary forms of commercially available Spirulina are powder and tablets, which are widely used as whole foods or dietary supplements. Spirulina powder is also commonly included as a component in protein and energy-boosting powder mixes, enhancing its versatility and nutritional benefits for consumers.

Pellets/Capsules

Spirulina powder is compacted into pellets or encapsulated for enhanced ease of consumption and efficacy. These forms are designed to offer a well-balanced diet that supports optimal growth and health, fortified with proteinated trace minerals for improved stability, biological availability, and overall human well-being.

The advantages of Spirulina pellets include:

- Excellent water stability
- Ease of consumption
- Contains extra levels of preservatives and antioxidants
- Longer shelf life

Spirulina Cultivation Training

Spirulina cultivation doesn't require extensive training; it's a brief learning process that typically lasts just a few days. Hands-on experience alongside training is crucial to avoid simple mistakes that could jeopardize the entire farming venture. Proper training ensures high-quality yield, maximizing returns and minimizing initial investment risks. Some notable training centers include GMs Spirulina in Maharashtra, Nallayan Research Centre for Sustainable Development in Tamil Nadu, Spirulina Production, Research and Training Centre in Madurai, and the Division of Microbiology at ICAR-IARI in New Delhi.

Costs and Profit in Spirulina Farming

The economics of Spirulina farming, as per DST 2024 guidelines, offers a general perspective on investment and potential revenues. Each pond, sized at 10'×20', and with approximately 20 such ponds, can yield an average of 2 kg of wet culture per day. Considering the conversion rate of 1 kg of wet culture to approximately 100 grams of dry powder, a Spirulina farm with 20 tanks can produce between 4 to 5 kg of dry Spirulina powder daily. Monthly production typically ranges from 100 to 130 kg of Spirulina powder. In the market, dry Spirulina powder commands a price of about Rs. 600 per kg. This implies potential monthly earnings of Rs. 40,000 to Rs. 45,000 for a farmer. To enhance profitability, farmers can explore options such as using cost-effective, durable materials for additional tanks beyond concrete ponds, effectively utilizing available land to minimize labor and investment while maximizing profit returns.

Conclusion

Spirulina stands out as a promising "wonder food supplement," recognized by leading organizations for its beneficial effects on human health. In countries like India, it holds great potential as a dietary supplement to combat social malnutrition challenges. Unlike typical commercial setups in other countries, spirulina cultivation in India can thrive as an agribusiness, catering to a large population's nutritional needs. Initiatives like the ACABC scheme have already demonstrated success in this regard, offering substantial turnover with minimal capital investment and generating employment opportunities. There should be successful implementation of suitable cultivation designs and methods for spirulina production, emphasizing the importance of efficient growth techniques and organic fertilizers to maximize commercial yield.

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REVOLUTIONIZING FOOD PROCESSING INDUSTRIES THROUGH ARTIFICIAL INTELLIGENCE: ENHANCING EFFICIENCY, QUALITY, AND SUSTAINABILITY

Article ID: AG-V04-I07-68

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Abstract

The global food processing industry is undergoing a transformative shift propelled by the integration of Artificial Intelligence (AI). Facing challenges such as resource utilization, quality control, and sustainability, traditional food production methods are being redefined by AI-driven technologies. This review explores the diverse applications of AI across various facets of food processing, showcasing its potential to enhance efficiency, streamline operations, and address industry-specific challenges. From automating quality control processes with machine learning and computer vision to optimizing supply chain operations through demand forecasting and route optimization, AI is revolutionizing every aspect of food processing. Furthermore, AI-driven solutions enable personalized nutrition recommendations and innovative product development, catering to the evolving preferences and dietary needs of consumers. Despite the promising prospects, challenges such as data quality, regulatory compliance, and ethical considerations must be addressed to fully harness the transformative power of AI in food processing. Looking ahead, AI-driven sustainability initiatives, autonomous food processing systems, blockchain integration, and personalized food design offer exciting opportunities to reshape the future of food production and distribution on a global scale.

Introduction

Artificial Intelligence (AI) is defined in computer science as a field that mimics human thought processes, learning, and knowledge storage (Krittanawong et al., 2017). The global food processing sector plays a crucial role in meeting the increasing nutritional needs of a growing population. However, traditional methods often struggle with issues like inefficient resource usage, quality control deficiencies, and sustainability concerns. The emergence of Artificial Intelligence (AI) in recent years has brought about a significant shift in how food processing operates, presenting a range of innovative solutions to address these persistent challenges. AI technologies, including machine learning, computer vision, and predictive analytics, have become pivotal in transforming food processing practices worldwide. By harnessing AI, food processing firms not only boost operational effectiveness but also ensure rigorous quality control standards and pioneer sustainability initiatives throughout their supply chains.

This article embarks on an exhaustive exploration of the diverse applications of AI within the food processing realm. From automating quality assurance procedures to optimizing supply chain logistics and facilitating personalized dietary recommendations, AI is revolutionizing every aspect of food production and distribution. Furthermore, integrating AI holds the promise of fostering a more sustainable and resilient food ecosystem, aligning with global endeavours to combat environmental issues and conserve resources. Through a comprehensive examination of AI-driven progress, accompanying challenges, and future trajectories, this review aims to underscore the transformative potential of AI in reshaping food processing industries. By shedding light on this path ahead, we aim to inspire continued innovation, collaboration, and the widespread adoption of AI technologies, propelling the food processing sector toward a future characterized by enhanced efficiency, superior product quality, and sustainable practices.

Applications of AI in Food Processing

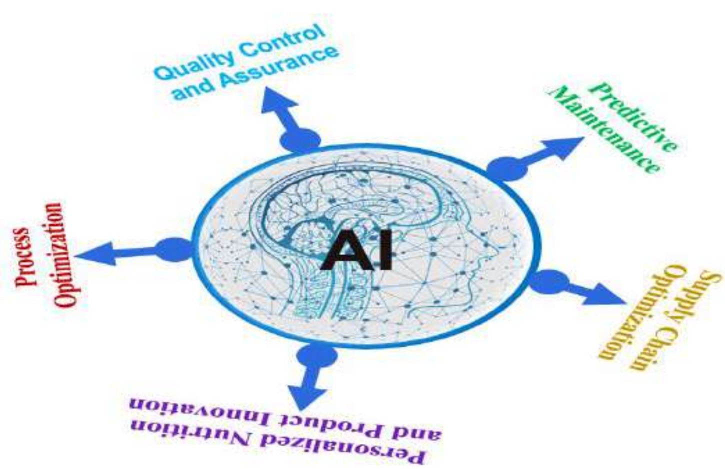

Fig 1. AI Application in Food Processing

Quality Control and Assurance

Ensuring product quality and safety is paramount in the food processing industry. AI-driven technologies such as machine learning and computer vision are employed to automate quality control processes, detect defects, and mitigate risks associated with contaminated or adulterated products. These systems analyze vast amounts of data from sensors and imaging devices to identify anomalies in raw materials, monitor production lines, and uphold regulatory compliance standards. Researchers study the relationships between proteins, lipids, and carbohydrates, as well as the impacts of heat, pH, and other variables. This data helps ensure safety, improve quality, and develop new products. Food microbiology studies the microorganisms in food and their influence on safety and preservation (Ahmadi, 2023).

Predictive Maintenance

AI-powered predictive maintenance systems have emerged as indispensable tools for minimizing equipment downtime, optimizing resource utilization, and extending the lifespan of critical assets in food processing facilities. By leveraging advanced analytics and machine learning algorithms, these systems forecast equipment failures, schedule maintenance tasks proactively, and optimize maintenance schedules based on real-time performance data, thereby reducing operational costs and enhancing overall efficiency.

Supply Chain Optimization

Efficient supply chain management is essential for ensuring timely delivery of raw materials, minimizing inventory costs, and meeting consumer demand. AI technologies enable food processing companies to optimize supply chain operations through demand forecasting, inventory management, and route optimization. By analyzing historical data, market trends, and external factors such as weather patterns, AI-driven supply chain solutions facilitate agile decision-making, reduce waste, and enhance overall resilience in the face of supply chain disruptions.

Process Optimization

AI algorithms play a crucial role in optimizing food processing parameters such as temperature, pressure, and mixing ratios to maximize product yield, flavor, and minimize energy consumption. Through real-time monitoring and adaptive control systems, AI-driven process optimization solutions enable fine-tuning of production processes, resulting in improved efficiency, consistency, and resource utilization across diverse food processing operations.

Personalized Nutrition and Product Innovation

Consumer preferences and dietary requirements are becoming increasingly diverse, driving the need for personalized nutrition solutions and innovative food products. AI-powered platforms leverage data analytics, genetic profiling, and consumer insights to develop tailored food products, dietary plans, and nutritional supplements that cater to individual needs and preferences. By harnessing AI technologies, food processing companies can unlock new opportunities for product innovation, enhance customer engagement, and differentiate themselves in a competitive market landscape.

Challenges and Limitations

Despite the remarkable advancements in AI-driven solutions for food processing industries, several challenges and limitations must be addressed to realize their full potential:

Data Quality and Availability

Effective implementation of AI technologies relies on access to large volumes of high-quality data for training and validation purposes. However, obtaining relevant data from heterogeneous sources, ensuring data consistency, and addressing data privacy concerns pose significant challenges for food processing companies, particularly in highly regulated environments.

Regulatory Compliance and Safety

To stringent food safety regulations and industry standards is paramount for ensuring consumer trust and mitigating liability risks. Integrating AI systems into food processing workflows requires rigorous validation, verification, and compliance with regulatory guidelines to ensure the reliability and accuracy of AI-driven solutions.

Integration Complexity and Scalability

Deploying AI technologies within existing food processing infrastructures entails complexities related to interoperability, scalability, and integration with legacy systems. Moreover, training personnel to effectively utilize AI-driven tools and ensuring seamless integration across diverse production environments pose significant logistical and organizational challenges for food processing companies.

Ethical Considerations and Societal Implications

The ethical implications of AI in food processing encompass a wide range of issues, including algorithmic bias, transparency, and accountability. Addressing these concerns requires adopting ethical frameworks, promoting algorithmic fairness, and fostering greater transparency and accountability in AI-driven decision-making processes.

Limitation

Furthermore, the high expenses associated with developing and maintaining intelligent machines and clever computers may be viewed as technological barriers to AI advancements. This is particularly true given that AI is constantly evolving, necessitating regular updates to hardware and software in order to stay up-to-date. Equipment requires costly upkeep and repairs. Because they are extremely complicated machines, their creation comes at a significant expense. The high cost of these applications, which could raise the price of the items, is another problem. Furthermore, in addition to the advantages that smart and computerized technologies provide, there are potential risks and concerns that could affect sustainability. These include enormous energy consumption, the e-waste issue, market concentration, employment displacement, and even the ethical framework (Ben and Hanana, 2021).

Future Trends and Opportunities

AI-Driven Sustainability Initiatives

As global concerns about environmental sustainability and resource conservation continue to escalate, AI technologies offer novel solutions for enhancing sustainability across the food processing value chain. From precision agriculture and waste reduction to energy optimization and eco-friendly packaging solutions, AI-driven sustainability initiatives hold the potential to minimize environmental footprint and promote responsible stewardship of natural resources.

Autonomous Food Processing Systems

Advancements in robotics, automation, and AI are paving the way for the development of autonomous food processing systems capable of performing complex tasks with minimal human intervention. By leveraging robotic platforms equipped with AI-driven algorithms, food processing companies can enhance operational efficiency, ensure product consistency, and mitigate labor-related challenges in demanding production environments. AI's prospective uses in the food industry seem bright for the future. Advances in computer vision, machine learning, and natural language processing will keep improving the accuracy and usefulness of AI systems. Increased IoT device and sensor integration will enable real-time monitoring of several food-related processes and enhance data collection (Rejeb et al., 2020).

Blockchain Integration for Enhanced Traceability

The integration of AI with blockchain technology offers unprecedented opportunities to enhance traceability, transparency, and trust in food supply chains. By leveraging blockchain-enabled platforms, food processing companies can track and trace the movement of products throughout the supply chain, verify authenticity, and address concerns related to food fraud, counterfeit products, and supply chain disruptions.

AI-Powered Food Design and Customization

Consumer preferences for personalized nutrition and customized food products are driving demand for AI-powered food design and customization solutions. By leveraging predictive analytics, machine learning, and sensory data analysis, food processing companies can develop tailored food products with customized Flavors, textures, and nutritional profiles, thereby catering to individual preferences and dietary requirements.

AI has the potential to be very helpful in addressing global problems pertaining to food security and sustainability. By improving agricultural yields, cutting waste, and optimizing resource management, AI can contribute to the development of more efficient and sustainable food systems. Collaboration between industry, academia, and policymakers is essential to overcoming these challenges and determining the future of AI in the food industry (Vasholm et al., 2020).

Conclusion

In conclusion, Artificial Intelligence (AI) technologies hold immense promise for revolutionizing food processing industries by enhancing efficiency, quality, and sustainability across the entire value chain. From quality control and predictive maintenance to supply chain optimization and personalized nutrition, AI-driven solutions offer multifaceted benefits for food processing companies seeking to remain competitive in a rapidly evolving market landscape. However, addressing key challenges related to data quality, regulatory compliance, and ethical considerations is essential to unlock the full potential of AI in food processing and ensure responsible and equitable deployment of these transformative technologies.

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SHIFTING TO HIGH DENSITY APPLE (*MALUS DOMESTICA*) FARMING CAN PROVE MORE PROFITABLE THAN CONVENTIONAL CROPS IN TEMPERATE HILLS OF J&K: A STUDY FROM MID BELT OF KASHMIR VALLEY

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Abstract

Farmer's income has been a major concern for agencies involved in the sector. Location specific crop diversification based on scientific knowledge and traditional wisdom can help in achieving higher returns. In hills, horticulture has proved their worth. Agriculture Farm Centre (Krishi Vigyan Kendra) -Kulgam conducted a study on crop diversification to high density apple in the mid belts of district. The aim was to see the impact on farm production and income and subsequently demonstrate the results to the famers during farm exposure and training programmes under the national agenda of doubling farmers' income. Net returns from apple were ₹8.8 lakh/ha in comparison to rice (₹1.5 lakh/ha) and maize (₹1.8 lakh/ha). On an average the net returns from apple farming (HDP) were 5.8 and 4.8 times higher than conventional rice and maize crops grown in the area. With High Density Apple farming, fruit productions is going to reach new heights and handling such productions will need policy and research attention discussed in the article.

Key words: Crop diversification, high density planting, temperate ecology

Introduction

Agriculture sector in the country has seen a spectacular transformation since independence. The focus of early research and policy interventions was to enhance food grain production but at present sustainability in terms of production, quality and income are the major targets. Agriculture keeps on evolving as per the demand and existing situations and priorities and practices are set based on situation. If we say change is a natural phenomenon, it would not be wrong to say that if world is changing in terms of technology why we should lag behind. So keeping pace with changing scenario is crucial to meet our goals. Science has a lot to offer for the benefit of human beings and so is true in the field of agriculture and allied. Despite all the developments in the field of agriculture we see a huge number of youth are distancing themselves from agriculture and seeking other professions for sustaining livelihood and income. This is also creating a problem of rural migration (Akeju 2013) and a sort of imbalance in the population distribution. Drudgery and less returns from traditional farming practices has been major factors of this disinterest across the country (Mubarak 2019a).

Image 1: High Density Apple Orchard at KVK

This demands a minimum possible modernization in agriculture practices which would lure the unemployed youth in this sector. Due to fragmented land and entirely different terrain, farmers in Kashmir valley need location specific technologies suitable for our small land holdings. Growing high value crops like fruits and vegetables offer a good choice. To keep pace with the developments taking place in horticulture sector Krishi Vigyan Kendra Kulgam established high density apple orchard in the year 2017 with the objective to evaluate and demonstrate technologies worth achieving the requirements under the National Agenda of Doubling farmers' Income.

Materials and methods

Farm Science center (Krishi Vigyan Kendra)- Kulgam-SKUAST Kashmir is situated in District Kulgam in the Kashmir Division of J&K. It is located at Longitude of 75.331, Latitude of 33.644 and an altitude of 1853 m above mean sea level. of study is characterized by temperate climatic conditions with mild summers and harsh winters. The site possesses facility of automatic weather station (AWS) for recording the weather parameters. The maximum temperature (25-35^{o}C) was recorded in May to August. The precipitation in the range of 75-100 mm per month was almost evenly distributed from May to September and then decreases drastically from October to November (25 to 30 mm per month). The soil of experimental site is silt loam in texture and has moderate fertility status with slightly acidic pH. The experiment site was under Maize cultivation before shifting to High Density Planting (HDP) of apple in year 2017. Three plots of size 0.2 ha each for conventional rice and maize crops and new HDP orchard, were established for comparative study in terms of impact on returns per unit area. The rates for different inputs and produce varied year after year depending on the prevailing rates in the area. The seed obtained from the field crops however was sold as truthfully labeled seed at NSP, SKUAST- Kashmir approved rates. The economics of rice and maize includes the value of straw and stover obtained from the respective crops, as these have demand in the area.

Results and discussions

The data after analysis indicates that the crop yield ranged between 40.3 to 49.6 q/ha with an average yield of 47.0 q/ha in case of rice and 32.5 to 47.3 q/ha with an average yield of 39.9 q/ha in case of maize. The yields were low in 2017 for field crops due to unfavorable weather conditions The increase in yield over the years was consistent and much higher in case of apple, which varied from 125 q/ha in 2018 to 381 q/ha in 2021. The returns per unit area also showed a similar trend as evident from the data in table 1 and Fig 1.Despite the fact that the field crops were grown for seed purpose (₹.35/kg) and paddy straw and maize Stover were also sold at good rates because of demand in the area, returns were much higher in HDP. There were no significant change in returns from field crops from 2018-2020. Returns however increased consistently from low to higher in case of high density apple planted in 2017 Fig 1. On an average the net returns from apple farming (HDP) were 5.8 and 4.8 times higher than

Image 2 : Experts visit to HDP at Kendra

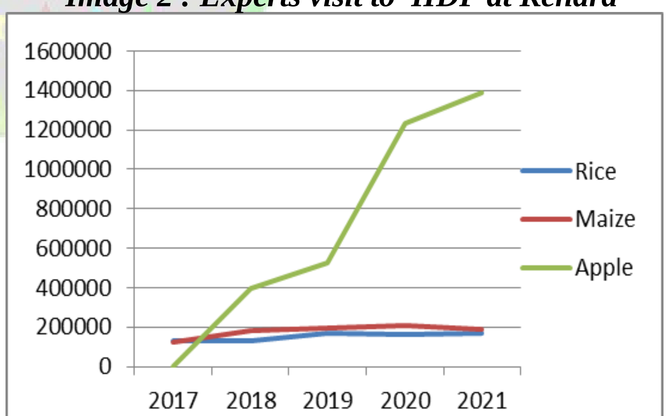

Fig 1: Net returns **(**₹./ha**)**

conventional rice and maize crops grown in the area. From these observation one can clearly understand the impact of apple farming in terms of crop yield and income and its potential to enhance farmers' income. Earlier studies and surveys also confirm that shifting to horticulture crops has substantially increased the farmers income (Ramesh *et al.*, 2008; Mubarak, 2019b; Gummagolmath *et al.* 2020).

Table1: Crop yield and net returns from different crops from 2017-2021

Crop / Year	Rice					Maize					Apple				
	Yield q/ha	**Cost of cultivation (₹./ha)**	**Gross returns (₹./ha)**	**Net returns (₹./ha)**	**B:C**	**Yield q/ha**	**Cost of cultivation (₹./ha)**	**Gross returns (₹./ha)**	**Net returns (₹./ha)**	**B:C**	**Yield q/ha**	**Cost of cultivation (₹./ha)**	**Gross returns (₹./ha)**	**Net returns (₹./ha)**	**B:C**
2017	40.3	55435	182935	127500	2.3	32.5	63000	189000	126000	2.0	-			-	
2018	49.6	55387	182777	127390	2.3	39.7	89750	269250	179500	2.0	125	164729	560079	395350	2.4
2019	48.0	70467	239587	169120	2.4	39.9	92429	286529	194100	2.1	177	285973	815023	529050	1.9
2020	46.3	70978	234228	163250	2.3	40.2	99006	306919	207913	2.1	256	318847	1549597	1230750	3.9
2021	40.9	69575	236555	166980	2.4	47.3	87273	279273	192000	2.2	381	386740	1775140	1388400	3.6
Average	47.0	65586	216434	150848	2.3	39.9	85668	265570	179902	2.1	234.7	305478	1191366	885887.5	2.9

Out come and Horizontal spread

The establishment of high density apple proved a successful intervention in attracting the farmers , especially youth towards Kendra. Data in Fig 2 shows the number of farmers visiting Kendra for advisories related to Horticulture crops, especially apple before and after the establishment of High Density apple orchard in 2017. Data indicates the increase in the number of farmers visits from 2017 onwards, except the year 2020 in which the number decreased due to covid restrictions .With the increasing demand of new apple varieties tested in the study at Kendra, a situation based comprehensive programme was started by the KVK. In the traditional apple orchards, the technique of top grafting with colour strains (Scarlet super 2, superchief, granny smith, Galla redlum, Red velox and Royal galla) was carried out by Kendra over 12 locations under Bio-Tech Kisan hub project on Apple rejuvenation. Besides demonstration on HDP apple, Kendra is providing training and awareness programmes on different technology components of HDP apple farming at Kendra, as well as at Farmers field including IDM, IPM, Plant architecture, pruning methods, vermicomposting , INM, intercropping, Grading and packing and so on. A model apple nursery has been established by Kendra for demonstration and training of youth under ARYA project. The planting material is partially fulfilling the demand of farmers in the area. Kendra is also providing graft and bud wood to farmers for further propagation of these varieties. Exposure to the HDP in collaboration with department of horticulture is a regular activity now. Given to the success of High Density Apple in the University demonstrations and the demonstrations at farmers' field , govt. of Jammu and Kashmir is giving reasonably good

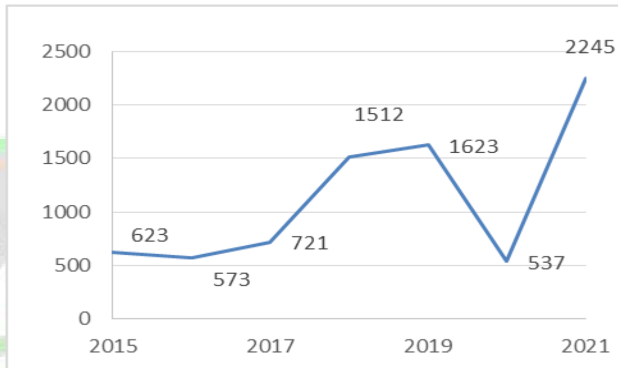

Fig 2: Increase in farmers visits to KVK related to

Image 3: Redlum Gala variety harvested from HDP

incentives for the area expansion under HDP. With the guidance of Kendra and support from department of horticulture around 50 acre of area has been covered for demonstration under the high density apple orchards in the district. Area is going to expand further in a couple of years, given to the demand of material by the farmers visiting Kendra. It is pertinent to mention that in 2010 area under apple was only 13614 hectare in the district, which is now close to 25000 hectare at present (Anonymous 2021). This is because of better returns from the apple crop, which are expected to be higher with high Density apple farming.

Major challenges and future prospects

The introduction of high density apple farming no doubt is gaining momentum and many success stories are emerging from this modernization in apple farming throughout the valley. We need to understand what the challenges are and what should we focus on. Less than 0.1% area under horticulture is currently occupied by the High-Density apple. We are in the transition phase and there is an enormous gap between present production and the potential. Area expansion under High Density Apple Orchards is going to boost productivity many fold and thus will surely help in bridging this gap to a great extent. At present good quality HDP apple is less in quantity and A grade apple production is also low overall in the valley due to traditional farming practices. Besides we have a competition not only from within the country particularly from Himachal Pradesh but also from the countries from where apple is imported. All these factors together are resulting in lower demand for our apple at present.

In future we are expecting enormous production through area expansion under HDP and handling huge quantity of apple will be a challenge to tackle and that needs policy support in terms of infrastructure. Sufficient storage facility, fruit processing units, advanced grading and packing facilities, relevant transportation facility and in fact market linkage will play a significant role. There are some other serious issues especially maintenance of quality standards to compete at global level, import and export policy, the commission agents and so on. What we have been observing over the years not only in apple but in other commodities throughout the country that farmers get a very less share of the price which consumers finally pay for their produce .

This is the reason that even higher production at times has not sufficiently benefited in quelling the farm distress. So processing and value addition along with regulating markets is also equally important. The thrust of government on formation of Farmer Producer

Companies/organizations is a good initiative which may prove quite helping in the dissemination of technology and reduction of risks at various levels of farming, including marketing. Apple farming is a major consumer of agrochemical in Kashmir valley (Bhat *et al.* 2020). Costs incurred on the procurement of these chemicals especially pesticides are very high compared to other components of cost of cultivation. This is not only impacting economics but also a threat to soil health, environment and human and animal health. Thus research and extension work is to be taken in hand for technology modules which can meet the objective of enhancing productivity without harming ecology and environment. There is urgent need to sensitize our farming community at village level to integrated organic and biological sources of nutrient with chemical fertilizer, as combined application of these nutrient sources are reported to have multiple advantages in the hills (Biswajit *et al.*, 2016; Mubarak and Singh 2011,Verma and Chouhan 2013, Wani *et al.* 2010). Soil health card scheme can also play a vital role in this regard. One thing that we must make our farmers understand is that following all components of crop management are essential, as it is seen in the field that they are more inclined to agrochemicals for crop nutrition and pest control and most of the times ignore other components of farming.

Orchard sanitation, proper drainage, use of well decomposed organic sources of nutrients, canopy management and so on are equally important. Some locations may be fit for other crops but not for apple farming so we have to be very careful in selecting site to make it profitable. This especially needs attention of the agencies when people are shifting apple farming to nontraditional areas. Here we need to generate scientific data with regard to choice of crop, variety and crop management practices because of a lot of variation in edaphic and microclimatic conditions. Situation and location specific apple based Integrated farming system (IFS) need to be standardize and popularize. Adding few suitable and compatible components in the existing farming systems, in addition to other benefits will help in reducing risks, recycling farm resources and generating more employment in hills (Mubarak and Sheikh 2014).

We must also focus on other fruit crops to strike a balance and for that making them competitive is essential. So classifying areas based on suitability for different crops (niche area) is need of the hour. These are some areas which we need to work on to sustain the production, quality and above all famers' income. It finally is the income which matters and that must increase to make farming profitable and to help in retaining future generations in farming.

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A NUTRIENT-RICH CROPS: THE SCIENCE AND STRATEGY OF BIO-FORTIFICATION

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Abstract

Food crop productivity has increased dramatically since the green revolution. However, agricultural nutrition could not keep up with the population's expanding needs. This has increased malnutrition, particularly in underdeveloped nations, due to a lack of balanced nutrition. Agronomic biofortification, or the practice of boosting micronutrient content in food crops using agronomic techniques, is regarded as a significant step toward improving the global malnutrition situation. It is regarded as a quick, healthy, and cost-effective way to include iron, zinc, and other micronutrients in our daily diet. Unlike molecular/genetic techniques, agronomic biofortification is performed on existing crops and types, therefore the product is widely accepted by consumers. Techniques such as integrated nutrition management (INM) based on soil test results, microbial application, and foliar nutrient spraying can significantly enhance the levels of micronutrients, vitamins, folic acid, and other nutrients in our food. Agronomic biofortification, with adequate research interventions and awareness initiatives, has the potential to enhance the world's nutritional status.

Keywords: biofortification, Genetical association, Micronutrition, Sustainability

Introduction

Dietary stability includes consuming adequate amounts of critical nutrients. In poor countries, staple crops make up the majority of people's daily food (Maertens *et al.*, 2017). This highlights the urgent need to cultivate highly nutritious foods for nutritional security. Bio-fortification is an effective solution, introducing essential nutrients into edible crop parts for human and animal consumption. By developing crop varieties with naturally higher nutrient levels, this method improves the genetic makeup of high-yielding crops. Unlike traditional nutrient supplementation, bio-fortification directly enhances the nutritional profiles of these crops (Zulfiqar *et al.*, 2020). Genetic engineering tools, including transgenic crops, enhance plant nutrition by modifying metabolic pathways to improve carbohydrates, fats, proteins, minerals, vitamins, and other beneficial compounds. These techniques optimize biochemical pathways, redistribute micronutrients, enhance bioavailability, and reduce anti-nutrient absorption. CRISPR-based gene editing has furthered crop bio-fortification, enabling targeted enhancements in crops like corn to boost beta-carotene and essential amino acids (Malik *et al.*, 2020).

The advancement of "Omics" technologies and CRISPR-based tools like CRISPR-Cas9/13 and TALENs, combined with accessible genome sequences for numerous species, has greatly enhanced the potential for crop biofortification. These innovations enable precise genetic modifications, leading to improved nutritional content in crops (Raza *et al.*, 2021 and Vaid *et al.*, 2022). Bio-fortification research involves crop, nutrition, food, and social scientists working on ex-ante analyses to identify target populations, crops, and nutrients, and employing plant breeding to develop bio-fortified varieties. Studies assess nutrient retention, bioavailability, absorption, efficacy, and health outcomes of these crops (Moura *et al*., 2015). This research follows an impact pathway from discovery to development, delivery, and scale-up to ensure the cost-effectiveness, inclusivity, and impact of bio-fortification programs. Advances in bio-fortification are mentioned in Figure 1.

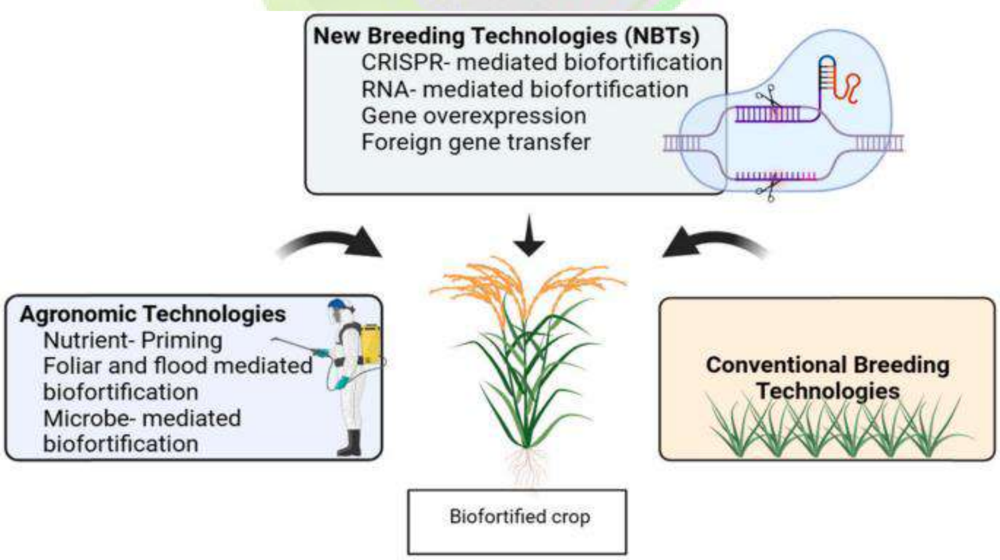

Fig. 1. Advanced technologies used in bio fortification of crops.

Methods of Biofortification

Three basic methods of biofortification are transgenic, conventional, and agronomic. These involve the use of biotechnology, crop breeding, and fertilisation techniques, respectively, to biofortify essential micronutrients into crop plants. These three methods are listed below.

Agronomic Method

- Agronomic biofortification involves the physical application of nutrients to crops. This is to temporarily boost their nutritional and physical health. Consuming these foods also improves human nutritional status.
- Agronomic biofortification is easy and cheap. However, it requires specific consideration for the nutrient source, application technique, and environmental impact. These need to be used frequently throughout each crop season. They are occasionally less cost-effective as a result.
- Agronomic biofortification has been used quite well to raise the quality of wheat, rice, and maize.

Transgenic Method

- When there is little to no genetic variation in the number of nutrients present in different plant kinds, the transgenic technique can be viable.
- Transgenic methods can be used to simultaneously incorporate genes that increase the:
  - concentration of micronutrients,
  - their bioavailability, and the
  - content of antinutrients that restrict the bioavailability of nutrients in plants.
- **Some of the successful examples of transgenic methods include the following:**
  - High lysine maize,
  - high unsaturated fatty acid soybeans,
  - high provitamin A and iron-rich cassava, and
  - high provitamin A Golden rice

Conventional Breeding Method

- The most widely known method of biofortification is conventional breeding. It provides a viable, affordable substitute for agronomic- and transgenic-based techniques.

- For conventional breeding to be successful, the trait of interest must have enough genotypic diversity. This variant can be used in breeding programmes to increase the number of vitamins and minerals in crops.
- In traditional plant breeding, recipient lines with desirable agronomic qualities are crossed with parent lines with high nutrient levels. This is done over several generations to generate plants with both the desired agronomic and nutrient characteristics.

Here are some examples of biofortified crops:

- **Vitamin A-enriched crops:** Golden rice, orange sweet potato, bioCassava Plus, and biofortified maize.
- **Iron-enriched crops:** Beans, lentils, pearl millet, rice, sorghum, and wheat.
- **Zinc-enriched crops:** Beans, maize, rice, sweet potato, and wheat.
- **Provitamin A carotenoid biofortified crops:** Cassava, maize, and sweet potato.
- **Selenium, iodine, and zinc-enriched crops:** Soybeans.

Benefits of Biofortification in Agronomy

1. **Enhanced Crop Nutrition** providing essential vitamins and minerals. Example: Orange-fleshed sweet potatoes (OFSP) enriched with Vitamin A.
2. **Improved Soil Health**: Example: Zinc-enriched wheat varieties improve soil zinc levels and benefit subsequent crops.
3. **Increased Crop Yields**: Example: Iron-rich beans show better resistance to pests and diseases, resulting in better yield.
4. **Pest and Disease Resistance**: Some biofortified crops are bred to resist specific pests and diseases, reducing the need for chemical interventions. Example: Vitamin A-enriched maize with improved resistance to maize streak virus.
5. **Reduced Need for Chemical Fertilizers**: Biofortified crops with improved nutrient use efficiency reduce the dependency on chemical fertilizers. Example: Pearl millet with enhanced iron content that requires less nitrogen fertilizer.
6. **Sustainability and Climate Resilience**: Biofortified crops are often more resilient to climate variations, promoting sustainable agriculture. Example: Drought-resistant cassava varieties enriched with beta-carotene.

7. **Economic Benefits for Farmers**: Higher yields and reduced input costs from biofortified crops increase farmers' income. Example: Farmers growing zinc-biofortified rice report better market prices and profitability.
8. **Support for Marginalized Communities**: Biofortified crops can thrive in poor soils, supporting agricultural productivity in marginalized areas. Example: Iron-fortified sorghum cultivated in arid and semi-arid regions.

Biofortification in India

The Government of India has made significant strides in connecting agriculture and nutrition through biofortification.

- The government endorses staple crop biofortification as a sustainable and cost-effective solution to alleviate malnutrition.
- On World Food Day 2020, the Prime Minister highlighted that common crop varieties often lack essential micronutrients for good health, leading to the development of biofortified varieties to address these deficiencies.
- He also dedicated 17 newly-developed biofortified seed varieties of eight local and traditional crops, including wheat and paddy rice, to Indian farmers.

The ICAR has launched the Nutri-Sensitive Agricultural Resources and Innovations programme, promoting family farming that links agriculture to nutrition. Nutri-smart villages are being established to enhance nutritional security, and location-specific nutrition garden models are developed and promoted by KVKs to ensure access to locally available, healthy, and diversified diets with adequate macro and micronutrients.

Under the NFSM, farmers receive assistance through State/Union Territory interventions, such as cluster demonstrations on improved practices, cropping system demonstrations, seed production, distribution of HYV, and cropping system-based training. Since 2014, 142 biofortified varieties including 124 field crops (Rice; Wheat; Maize, Pearl millet, small millets, Linseed, Lentil, Chickpea, Mungbean, Fieldpea, Urdbean, Mustard, Soybean, Sesame, Groundnut) and 18 horticultural Crops (Sweet potato, Amaranthus, Greater Yam, Potato and one each of Cauliflower, Okra, Grapes, Banana, Guava and Pomegranate) have been developed under aegis of the ICAR.

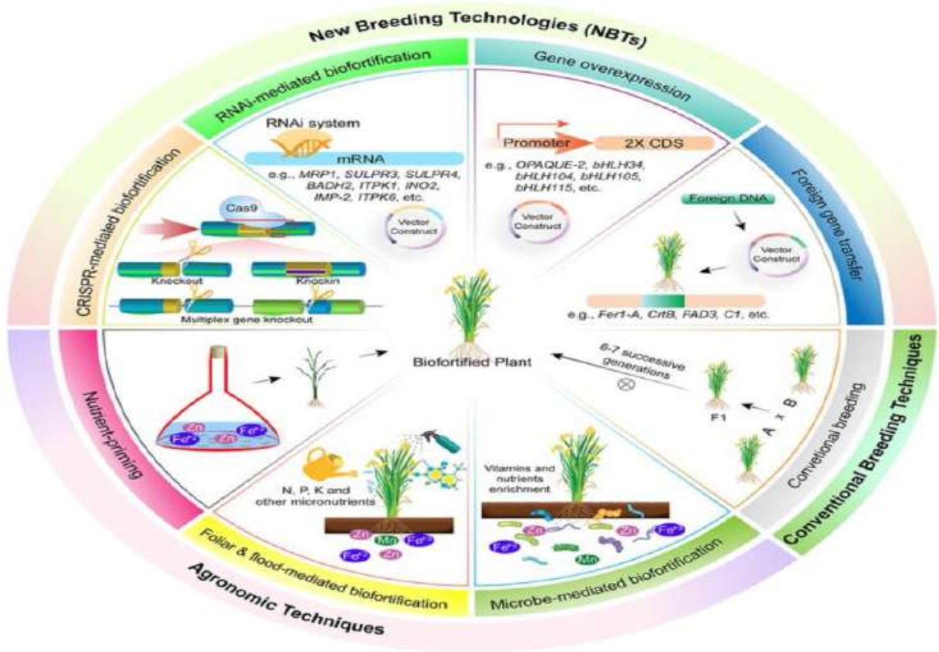

Figure 2: Different methods for biofortification of crops

Recent Approaches in Biofortification of Cereal and Pulse Crops

1. **Marker-Assisted Selection (MAS):** High-Yielding Biofortified Varieties: Using molecular markers to select for traits like higher nutrient content in crops like maize, wheat, and pearl millet. Quality Protein Maize (QPM): Identifying and breeding maize varieties with enhanced protein quality.
2. **Agronomic Biofortification:** Soil and Foliar Application: Application of micronutrient fertilizers to soil or directly to plant leaves to enhance nutrient uptake in crops like rice, wheat, and legumes. Biofortified Fertilizers: Developing fertilizers that specifically target nutrient enrichment of crops.
3. **Biotechnology:** CRISPR/Cas9 Gene Editing: Precise editing of crop genomes to enhance nutrient content, such as increased lysine in maize and iron in rice. Transgenic Approaches: Incorporating genes from other species to boost nutrient levels, like Vitamin E in maize.
4. **Microbiome Engineering:** Rhizosphere Modification: Using beneficial soil microbes to enhance the nutrient uptake efficiency of plants, particularly for iron and zinc in cereals. Endophyte Inoculation: Introducing nutrient-solubilizing microbes into plant tissues to improve nutrient content.

5. **Biofortified Crop Varieties:** Biofortified Millets: Development of finger millet and pearl millet varieties with higher levels of iron and zinc. Lentils and Chickpeas: Breeding programs focusing on increasing the bioavailability of iron and zinc in pulse crops.
6. **Nutrient Mapping and Phenotyping:** High-throughput Phenotyping: Utilizing advanced imaging and sensor technologies to identify nutrient-dense crop varieties. Geospatial Analysis: Mapping nutrient deficiencies in soils and targeting biofortification efforts accordingly.

Conclusion

Agronomic biofortification offers a promising avenue to enhance the nutrient content of crops through targeted soil and foliar applications. By optimizing nutrient uptake and utilization, this approach can improve dietary micronutrient intake, particularly in regions prone to deficiencies. Its integration with sustainable agricultural practices holds the potential for long-term nutritional benefits and food security.

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IMPACT OF COLD STRESS: RESPONSES AND MECHANISMS

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Introduction

Cold stress poses a significant threat to plant growth and productivity, influencing agricultural yields and ecosystem dynamics worldwide. Plants, as sessile organisms, are particularly sensitive to temperature fluctuations, which can disrupt fundamental physiological processes essential for their survival and development. Understanding the mechanisms of cold stress and how plants respond to these environmental challenges is critical for devising effective strategies to mitigate its impact and enhance resilience in agricultural and natural settings.

Cold stress in plants can manifest in various forms, including chilling injury, freezing injury, and frost damage, each causing distinct physiological and biochemical disruptions. Chilling injury occurs when temperatures hover just above freezing but below optimal growth conditions, leading to cellular damage and impaired metabolic function (Manasa et al., 2022). Freezing injury, on the other hand, results from exposure to sub-zero temperatures, causing ice formation within plant tissues and subsequent tissue death (Sanghera et al., 2011). Frost damage exacerbates these effects, particularly affecting tender plant tissues and disrupting growth and reproductive processes (Strum and Rhee, 2012).

Plant responses to cold stress are multifaceted and include physiological acclimation mechanisms such as changes in membrane lipid composition, accumulation of compatible solutes, and activation of cold-responsive genes (Knight and Knight, 2012; Miura and Furumoto, 2013). These adaptations aim to maintain cellular integrity, mitigate oxidative stress, and sustain metabolic activity under cold conditions.

This introduction aims to explore the intricate relationship between plants and cold stress, highlighting the diverse physiological responses and adaptive strategies employed by plants to cope with temperature extremes. By examining these dynamics, researchers and practitioners can develop innovative approaches to enhance cold tolerance in crops, improve agricultural resilience, and sustain global food security in the face of climate variability.

COLD STRESS

Chilling stress and freezing injury are distinct forms of cold stress that affect plants in different temperature ranges, each presenting unique challenges and physiological responses.

Chilling Stress:

Chilling stress occurs when plants are exposed to temperatures that are above freezing (0°C) but still significantly lower than their optimal growth temperatures. Typically, chilling stress ranges from 0°C to 15°C, although specific thresholds vary depending on the plant species and their cold tolerance adaptations.

Effects of Chilling Stress:

- **Physiological Disruptions:** Chilling stress primarily affects cellular membranes, leading to alterations in membrane fluidity and permeability. This disruption can cause leakage of cellular contents and impair cellular functions.
- **Symptoms:** Visible symptoms of chilling stress include chlorosis (yellowing of leaves), necrosis (tissue death), and overall stunted growth. In severe cases, chilling stress can lead to wilting and ultimately plant death if prolonged exposure occurs.

Mechanisms of Chilling Stress Response:

- **Membrane Adaptations:** Plants adjust their lipid composition to maintain membrane fluidity under cold conditions. This adaptation helps to stabilize membranes and reduce the risk of cellular damage.

- **Accumulation of Solutes:** Plants accumulate osmoprotectants such as sugars and proline, which help to maintain cellular osmotic balance and protect against chilling-induced dehydration.

Freezing Injury:

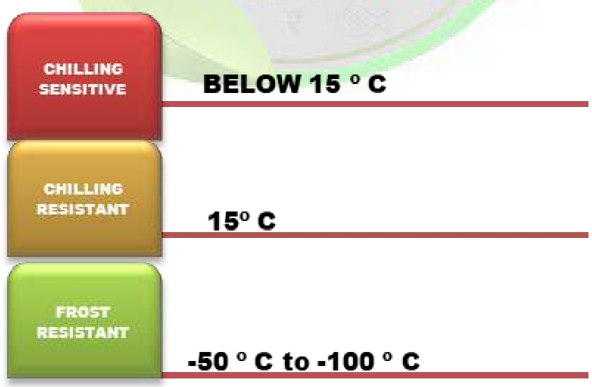
Freezing injury occurs when plant tissues are exposed to temperatures below freezing (0°C), resulting in the formation of ice crystals within cells and tissues. This mechanical damage disrupts cellular structures and can lead to irreversible damage if severe.

Effects of Freezing Injury:

- **Ice Formation:** Ice crystals form within plant cells, causing physical damage to cell walls, membranes, and organelles. This damage can lead to cell death and tissue necrosis.
- **Water Stress:** Freeze-thaw cycles can exacerbate freezing injury by causing cellular dehydration and rupture, further compromising tissue integrity.

Mechanisms of Freezing Injury Response:

- **Antifreeze Proteins:** Some plants produce antifreeze proteins that lower the freezing point of cellular fluids, helping to prevent ice crystal formation within cells.
- **Cold Acclimation:** Cold-hardy plants undergo physiological changes during cold acclimation, such as increased synthesis of protective proteins and adjustments in metabolic pathways, to enhance tolerance to freezing temperatures.



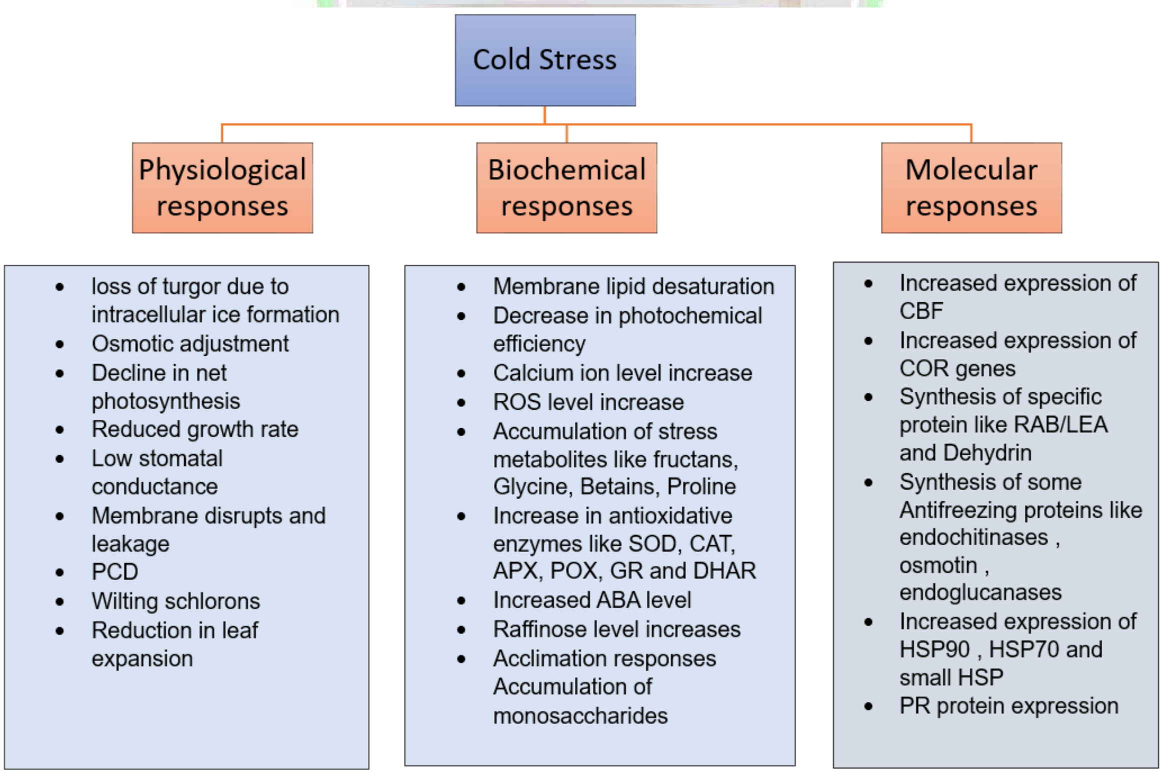
MEMBRANE PROPERTIES CHANGE IN RESPONSE TO CHILLING INJURY

1. In chilling sensitive plants, the lipids bilayers have a high percentage of saturated fatty acid chains and membranes with the composition solidify into a semicrystalline state well above 0 ° C

2. The result is inhibition of solute transport, energy transduction, enzyme dependant metabolism.
3. When exposed to high photon flux are photoinhibited causing acute damage to photosynthetic machinery.
4. Membrane lipids from chilling resistant plants often have a greater proportion of: -
    i. Unsaturated fatty acids (tolerance mechanism)
    ii. Shortening of fatty acid tail
    iii. Increasing the size or change of head group
    iv. Decreasing the concentration of membrane sterol

ANATOMICAL RESPONSES TO CHILLING STRESS

1. Thylakoids swell and distort
2. Starch granules disappear
3. Organellar development and ontogeny may be disturbed
4. Thylakoid dilation due to photooxidative condition produced during chilling at light
5. Mitochondria resistant to chilling



ECHANISMS FOR COLD TOLERANCE

Cold tolerance in plants is a critical trait that enables their survival and productivity in environments characterized by low temperatures. From crop fields to natural ecosystems, plants encounter various forms of cold stress, including chilling and freezing temperatures, which can severely impact growth, development, and ultimately, crop yields. Understanding the mechanisms that underpin cold tolerance is essential not only for agricultural resilience but also for ecosystem stability in the face of climate variability. Plants have evolved sophisticated strategies to withstand and adapt to cold stress, ranging from structural adaptations at the cellular level to complex biochemical and physiological responses. These mechanisms involve intricate regulatory networks that govern gene expression, metabolic adjustments, and the accumulation of protective compounds. By unraveling these mechanisms, researchers aim to unlock potential avenues for enhancing cold tolerance in crops, thereby helping in food security and sustainability in regions susceptible to temperature extremes.

By delving into these mechanisms, we can gain insights into how plants perceive, respond to, and ultimately survive under challenging cold conditions, paving the way for future advancements in agricultural and ecological resilience.

- LEA PROTEIN: - The dehydrins are a group of heat stable glycine rich LEA proteins thought to be important for membrane stabilization and protection of proteins from denaturation, when the cytoplasm become dehydrated.

  Ex: - COR 15 am :- prevents aggregation of proteins

  ERD 10: - early response to dehydration

  ERD 14: - function as chaperones
- ACCUMULATION OF SUGARS AND OSMOLYTE:-Synthesis of cryoprotectant molecules like soluble sugars (saccharose, raffinose)

  Sugar alcohol (sorbitol, mannitol)

  Low molecular weight nitrogen components (proline, glycine, betaine)

  Fructans
- INCREASED ACTIVITY OF ANTIOXIDATIVE ENZYMES: - SOD, Glutathione peroxidase, Ascorbate peroxidase and non-enzymatic antioxidants such as ascorbic acid.
- COLD ACCLIMATION: - It is treatment of low but non – freezing temperature that cause plant to tolerate freezing.

Conclusion

Cold stress poses significant challenges to plants, affecting their growth, development, and productivity. Chilling stress and freezing injury represent distinct but related forms of cold stress, each impacting plants in specific temperature ranges. Chilling stress disrupts cellular membranes and metabolic processes, leading to visible symptoms like chlorosis and stunted growth, while freezing injury causes mechanical damage due to ice crystal formation within tissues, resulting in tissue necrosis and cell death.

Plants have evolved various adaptive mechanisms to cope with cold stress, including adjustments in membrane lipid composition, accumulation of osmoprotectants, and production of antifreeze proteins during cold acclimation. These adaptations help plants maintain cellular integrity and mitigate the harmful effects of low temperatures. Understanding these mechanisms is essential for developing strategies to enhance cold tolerance in crops and natural vegetation, thereby improving agricultural resilience and ecosystem sustainability in regions prone to cold stress.

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ANTITRANSPIRANTS, THEIR TYPES AND ROLE IN FRUIT CROPS AGAINST ABIOTIC STRESSES

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Introduction

Antitranspirants are materials or chemical compounds that facilitate a reduction in the transpiration rate from plant leaves by reducing the size and number of stomata and gradually hardening them to stress. These compounds primarily function to enhance plant resilience to stress by mitigating the impacts of drought and salinity. By reducing transpiration, antitranspirants play a crucial role in preventing excessive water loss to the atmosphere through stomata. They primarily contain magnesium (Mg) and calcium (Ca), which are essential for increasing photosynthesis and promoting plant growth. It is estimated that approximately 95-98% of the water absorbed by plants is lost through transpiration. Therefore, antitranspirants are substances involved in enhancing drought stress resistance.

Antitranspirants are naturally applied to transpiring plant surfaces to reduce water loss. They have beneficial effects in mitigating the adverse impacts of hot climates on the growth and production of many horticultural and other crops. Efforts have been made to identify chemical compounds that can be applied to plants to reduce transpiration losses as antitranspirant materials. Since transpiration and photosynthesis involve the passage of water vapour and carbon dioxide through stomata, both processes can be affected when stomata are narrowed by the application of antitranspirants. Efforts have been made to find out the chemical compounds that are applied to the plants to reduce the transpiration losses as an antitranspirant material. Because transpiration and photosynthesis is a process that involves the passage of water vapour and carbon dioxide through stomata, and both these processes may be affected when the stomata are narrowed by the application of antitranspirants.

Anti-transpirants may reduce the transpiration in three different ways:

- **Solar Energy Absorption Reduction:** Some chemicals reduce the absorption of solar energy, thereby decreasing leaf temperature and rate of transpiration.
- **Film formation:** Certain chemicals, such as wax, latex, or plastic, can form thin, colourless, transparent films that ultimately decrease water vapour loss from the leaves without affecting gas exchange.
- **Stomatal control:** Certain compounds can control the opening of stomata by affecting the guard cells around the stomatal pore, thus reducing water vapour loss from the leaves.

PROPERTIES OF ANTITRANSPIRANTS:

1. **Non-toxicity:** Antitranspirants are safe for plants and do not cause harmful effects.
2. **Reduction in Transpiration Rate Without Reducing Photosynthesis:** These compounds effectively decrease water loss without hindering the plant's ability to photosynthesize.
3. **Cost-Effectiveness, Stability, and Longevity:** They are inexpensive, stable under various environmental conditions, and provide long-lasting effects.
4. **Non-permanent Damage to Stomatal Mechanism:** Antitranspirants do not cause lasting damage to the stomatal function, allowing stomata to operate normally once the effect wears off.
5. **Specificity to Guard Cells:** They specifically target guard cells, minimizing impact on other plant cells.

TYPES OF ANTITRANSPIRANTS:

- Stomata closing type
- Film foaming type
- Growth retardant
- Reflectance type

✓ **Stomata closing type compounds: -**

- These antitranspirants induce the closing of stomata, thereby reducing transpiration. However, this also leads to reduced CO_2 diffusion into the leaf, which can lower photosynthetic rates
- Examples: Phenyl Mercuric Acetate (PMA), Atrazine, Abscisic Acid (ABA), and high concentrations of CO_2

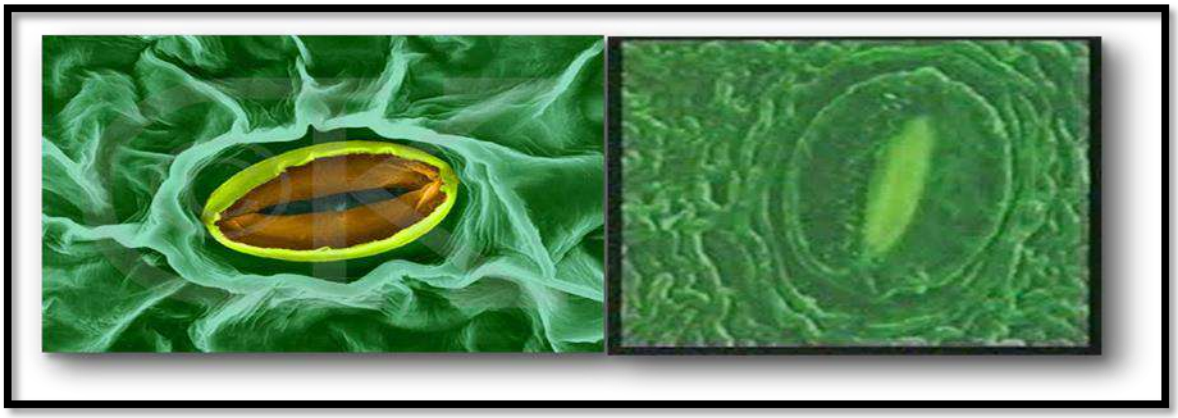

Figure 1: Activity of stomata after the application of stomatal regulating compound

FILM FORMING TYPE:

- These compounds form a colourless film on the leaf surface, reducing transpiration while allowing gas exchange to continue normally.
- Examples: Waxes, plastic films, silicone oils, hexadecanol, cetyl alcohol, methanol, paclobutrazol, brassinolide, resorcinol.
- **Disadvantages:**

✓ Effective only at low temperatures, and less so at high temperatures.

✓ Can interfere with gas exchange.

✓ Creates mechanical barriers that can impede stomatal movement.

Figure 2: Shows the application of film-forming antitranspirants (Colorless film) on the leaf surface

3. **Reflectance Type Compound:** Reflectance-type antitranspirants increase the reflection of light by the leaves, thereby reducing the temperature of the leaf and the heat load on it.

These materials reflect solar radiation, increasing the leaf albedo when applied to the leaf surface.

Properties:

- ✓ Do not cause blockage of stomatal pores when applied to the upper leaf surfaces, provided stomata are exclusively on the lower surfaces.
- ✓ Reduce transpiration loss without affecting the assimilation of CO_2.
- ✓ When Kaolin is applied, it forms a white thin film on the leaves, typically sprayed at 2-5%, creating a thin coating on the leaf.
- ✓ Coating leaves with reflectance compounds reduces leaf temperature.

Examples:

- ✓ Kaolinite (Kaolin)
- ✓ Lime water
- ✓ Calcium carbonate

4. **Growth Retardant Type Compounds:** Growth retardant antitranspirants reduce shoot growth and increase root growth, enabling plants to resist drought. These compounds may also induce stomatal closure and are useful for reducing transplantation shock in nursery plants of horticultural crops.

Examples:

- ✓ Cycocel
- ✓ Abscisic Acid (ABA)
- ✓ Herbicides
- ✓ Fungicides
- ✓ Salicylic acid
- ✓ Metabolic inhibitors like phenyl mercuric acetate
- ✓ Alkenyl succinic acids
- ✓ Colorless plastics
- ✓ Silicon oil
- ✓ Wax and plastic

IMPORTANCE OF ANTITRANSPIRANTS IN FRUIT CROPS:

- ✓ **Stress Hardening:** Antitranspirants play a crucial role in hardening plants to stress, thereby reducing the impact of drought.

- ✓ **Enhanced Efficiency in Water-Scarce Areas:** In regions where water is scarce, antitranspirants enhance the efficiency of water use, especially for crops with high water demands.
- ✓ **Yield Optimization:** Antitranspirants help optimize yield levels in conditions of infrequent rainfall.
- ✓ **Prevention of Fruit Cracking:** They are effective in preventing fruit cracking, which can occur due to irregular water availability.
- ✓ **Mitigation of Water Stress Effects:** By preventing the adverse effects of water stress, antitranspirants support crop growth and fruit development.

Applications of Antitranspirants Against Abiotic Stresses in Fruit Crops

Kaolin Foliar Applications: Kaolin applications have been effective in controlling fruit sunburn and reducing the severity of sunburn in fruits compared to untreated trees. Spraying kaolin at 3% or 4% three times during the summer months helps prevent sunburn damage and improves yield and fruit quality in Balady mandarin trees.

Enhancement of Growth and Fruit Quality: Antitranspirant treatments enhance plant growth, nutritional status, yield, and fruit quality. For instance, spraying Williams banana plants in the Aswan region with chitosan or kaolin at 2% four times (in April, May, June, and July) significantly improved fruit quality.

Reflectant Strategy: Using reflectant compounds alone can reduce heat or radiation stress and sunburn in grapefruit. While antitranspirants alone may increase leaf temperature and sunburn, the application of reflectant compounds can mitigate these negative effects.

Improvement in Photosynthesis and Water Use: Antitranspirants have been shown to increase transpiration rate (11.51%), stomatal conductance (8.80%), and photosynthesis (9.71%) in well-watered trees. In water deficit conditions, they improve photosynthesis (12.05%), stomatal conductance (7.48%), and transpiration rate (14.95%). Additionally, antitranspirants enhance the activity of antioxidant enzymes in well-watered plants.

Drought Stress Mitigation: Foliar applications of Cycocel, particularly at 1000 mg L^{-1}, mitigate the negative effects of drought stress by increasing net photosynthesis (Anet), water use efficiency (WUE), relative water content (RWC), and concentrations of compatible solutes such as proline, soluble sugars, and chlorophyll a and b.

LIMITATIONS OF ANTITRANSPIRANTS

- While antitranspirants offer numerous benefits, they may also have limitations, such as:
- Reduced effectiveness at high temperatures.
- Potential interference with gas exchange.
- Formation of mechanical barriers that impede stomatal movement.

CONCLUSIONS

Antitranspirants are valuable tools in agriculture, helping to reduce transpiration losses from the surface of fruit and leaves. Their use also helps mitigate sunburn damage to fruit crops by reducing water loss through stomata and alleviating the adverse effects of water stress. This contributes to improved yield and fruit quality, particularly under challenging environmental conditions.

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DNA MICROARRAY: BASIC PRINCIPLES AND ITS APPLICATIONS IN FUNCTIONAL GENOMICS

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Introduction

DNA microarray (also commonly known as a DNA chip or biochip) is a collection of microscopic DNA spots attached to a solid surface. It is a molecular detection method characterized by microscopic features where DNA, typically affixed to a solid substrate such as glass or silicon, is organized in a predefined grid pattern. Each DNA spot, referred to as a probe, represents an individual gene. This technology enables simultaneous examination of the expression levels of tens of thousands of genes. There are 2 types of DNA microarray, i.e., cDNA-based microarray and oligonucleotide-based microarray.

Principle of DNA Microarray

DNA microarray technology evolved from Southern blotting, wherein fragmented DNA is immobilized on a solid substrate and subsequently probed with a known DNA sequence. This method capitalizes on the principle of hybridization between nucleic acid strands, where complementary sequences specifically pair via hydrogen bonds between matching nucleotide bases. The DNA sequence of interest termed the target or sample, is contrasted against a known sequence, termed the probe, with fluorescent dyes employed for sample labeling. Typically, at least two samples are hybridized onto the microarray chip. A higher number of complementary base pairs in nucleotide sequences indicates stronger non-covalent bonding between the strands.

Following stringent washing to remove non-specifically bound sequences, only tightly paired strands remain hybridized. Consequently, fluorescently labeled target sequences that successfully hybridize with the probe emit a signal proportional to the strength of their hybridization, influenced by the number of matched bases, hybridization conditions, and post-hybridization washing. DNA microarrays utilize relative quantification, where the comparison of identical features under different conditions identifies specific characteristics by their positional arrangement. Following hybridization, the microarray surface can undergo qualitative and quantitative analysis using techniques such as autoradiography, laser scanning, fluorescence detection devices, and enzyme-based detection systems. This technology enables the screening of over 100,000 genomic or cDNA sequences in a single hybridization event on a DNA microarray platform.

Types Of DNA Microarray:

1. cDNA-based microarrays
2. Oligonucleotide based microarrays

cDNA-based microarrays:

- cDNA is used for the preparation of chips.
- cDNAs are amplified by PCR.
- It is a high throughput technique.
- It is a highly parallel RNA expression assay technique that allows quantitative analysis of RNAs transcribed from known and unknown genes.

Oligonucleotide-based microarrays:

In this method, each spot contains short, chemically synthesized sequences known as probes, typically 20-25 nucleotides long per gene. The use of shorter probes reduces synthesis errors and allows for the examination of small genomic regions and genetic variations. Despite being easier to manufacture compared to double-stranded DNA probes, oligonucleotide probes require meticulous design to ensure consistent melting temperatures (within a 50°C range) and to avoid palindromic sequences. Probes are covalently attached to glass slides to prevent significant probe loss during washing steps, as electrostatic immobilization and cross-linking methods can lead to detachment, particularly due to their small size. The attachment of probes to microarray surfaces involves modifying the 5′ to 3′ ends on coated slides, which provides functional groups such as epoxy or aldehyde for efficient coupling.

Requirements of DNA microarray

- DNA chip

- Fluorescent dyes
- Fluorescent labeled target/sample
- Probes
- Scanner

Steps involved in cDNA-based microarray:

1. Sample collection
2. Isolation of mRNA
3. Creation of labeled cDNA
4. Hybridization
5. Collection and analysis

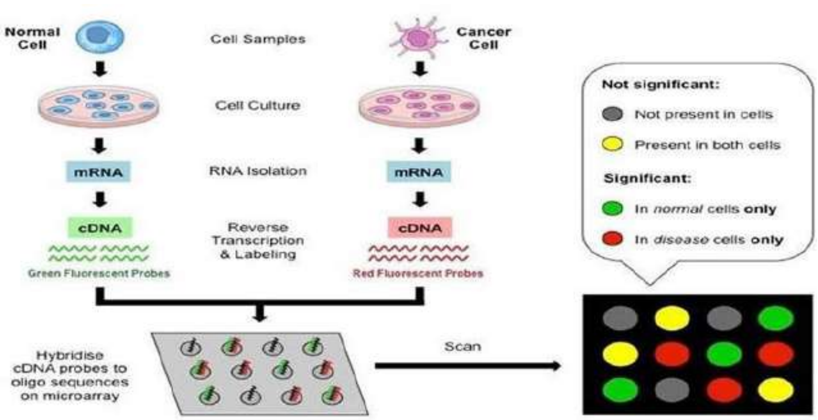
Sample preparation

Prepare two samples for hybridization to the array: An experiment and control sample

- ✓ mRNA is extracted and reverse transcribed into cDNA
- ✓ During RT, a fluorescent dye is incorporated
- ✓ Control samples are labeled with Cy3 (green fluorescence)
- ✓ The experimental sample is labeled with Cy5 (red fluorescence)
- ✓ The samples are mixed and hybridized to the slide.

Hybridization

For hybridization, an equal amount of both labeled samples are hybridized to the array under a coverslip. Complementary sequences gradually find each other preferentially over mismatched pairings.



* Saroglia et al.,2012

Fig 1: Overview of DNA microarray for differential gene expression study

Hybridization conditions like ionic strength, temperature, and concentration depend on the application. (usually, a temperature of 42 – 70 degrees Celsius will be kept for several hours overnight).

Fluorescent Scanning of Hybridized Arrays

Fluorescent hybridization signals are scanned using laser confocal scanners. The emitted fluorescence from the microarray is converted into digital signals for each dye, which are stored as distinct image files. Typically, the slide undergoes two scans for comprehensive data collection. Subsequently, specialized image analysis software is employed to quantify the individual elements within the array. These images are then superimposed to generate a unified image for further analysis and interpretation.

Expression measurement

The ratio of red and green fluorescent intensities is quantified for each spot. These intensities reflect the relative abundance of each gene within the samples. The signal intensity of each element within the microarray is extracted and utilized for analysis. A typical raw data set from a single microarray experiment is graphically represented, where each point on the graph corresponds to an individual element within the array.

Applications of DNA Microarray Gene expression profiling

The gene expression profiles can help to elucidate cellular functions, regulatory mechanisms, and biochemical pathways, not only in normal conditions but also in disease. The knowledge derived from comparative studies between diseased cells or tissues and normal counterparts may help to track the biological mechanism driving pathologic processes.

SNP detection

SNP microarray uses known nucleotide sequences as probes to hybridize with the tested DNA sequences, allowing qualitative and quantitative SNP analysis through signal detection. The probe attached to the microarray surface is hybridized to a fluorescently tagged PCR product. The complementary hybridization is used as a signal for a mutation's presence or absence. This approach is called ‘‘gain of-signal’’

Fig 2: Hybridize with a labeled target

Functional genomics

DNA microarrays can be used to study the function of genes by analyzing their expression patterns under different conditions or in different cell types. By systematically determining gene expression and observing the resulting phenotypic changes, researchers can infer the functions of genes and unravel the complexity of biological systems.

Disease diagnosis and prognosis

DNA microarrays can be used to identify gene expression signatures associated with specific diseases. These signatures can be used as diagnostic markers for disease classification and prognosis. For example, microarray-based gene expression profiling has been used to classify cancer subtypes and predict patient outcomes.

Toxicogenomics

DNA microarrays can study the toxic effects of environmental chemicals, pharmaceuticals, and other compounds on living organisms. Researchers can identify genes and pathways affected by the toxins by measuring changes in gene expression patterns in response to toxic exposure. This information can help understand the mechanisms of toxicity and develop safer chemicals and drugs.

Limitations

- Requires prior sequence information to design probes. Hence, it has restricted application.
- The results take a lot of time to analyze as the amount of data collected from each array will be huge.
- The results may be too complex to interpret and are not always quantitative.
- The results are not always reproducible
- The technology is too expensive
- A DNA array can only detect sequences that the array was designed to detect.
- To make Microarray data accessible to the public, the National Centre for Biotechnology Information – NCBI has established a Gene Expression Omnibus (GEO) data repository where we can submit the result data from our DNA microarray experiments.

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DIRECT SEEDED RICE (DSR) – AN ALTERNATIVE TO TRANSPLANTED RICE (TPR)

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Abstract

Rice (*Oryza sativa* L.) is one of the most important staple food crops for more than half of the world's population and provides about 21 per cent of the total calorie intake of the world's population. Such a rice production involves two prime methods of establishment *viz.*, transplanted rice (TPR) and Direct Seeded Rice (DSR). Transplanting is the traditional method of rice cultivation that is highly water intensive, laborious, cumbersome, time consuming and incurred a lot of expenditure on raising nursery, uprooting, and transplanting. Hence, nowadays there is a shift from transplanted rice towards direct seeded rice. The three prime systems of direct seeded rice establishment are dry seeding, wet seeding (manual seeding and drum seeding) and water seeding. DSR offers the advantages of quicker and easier planting, less labour intensive, saves labour cost by avoiding raising of the seedlings, uprooting and transplanting, 10-12 days earlier crop maturity, high tolerance to water deficit and often higher profit in areas with assured water supply further reduced methane emission offers an excellent opportunity for environmental sustainability.

Keywords: Dry seeded rice, Drum seeded rice, Manual wet seeded rice, Transplanting

Introduction

Rice (*Oryza sativa* L.) is an important staple food crop accounting major share in the total food grain production (44 per cent) and plays a vital role in food security and Indian economy.

Rice contributes to 689 and 780 kcal capita^{-1} day^{-1} of the food supply in India and Asia, respectively. India is one of the major centers for rice production and ranks second next to China contributing 22.5 per cent of overall world rice production. Globally, rice is grown in 120 countries in an area of 164.1 million hectares with a production of 756.74 million tonnes and productivity of 4.6 t ha^{-1} (FAOSTAT, 2022). In India, rice occupies 43.78 million hectares with a production of 118.43 million tonnes and productivity of 2.70 t ha^{-1}. In Tamil Nadu, area, production and productivity under rice is 3.69 million hectares, 11.04 million tonnes and 3,664 kg ha^{-1}, respectively (Government of India, 2020). About 40 per cent of the paddy is cultivated in delta districts comprising of Thanjavur, Nagapattinam, Tiruvarur, Trichy, Pudukkottai, Karur, Ariyalur and Cuddalore (Statistical Book of Tamilnadu, 2019).

Transplanting is the traditional method of rice cultivation that is highly water intensive, laborious, cumbersome, time consuming and incurred a lot of expenditure on raising nursery, uprooting, and transplanting. Shortage of labour during peak period of transplanting, erratic supply of monsoon rain, decrease of underground water and rising production cost necessitate the search for an alternative to the conventional puddled transplanting of rice (Bhandari *et al*., 2020).

Direct seeded rice (DSR) refers to the process of growing rice crop by directly sowing seeds in the field rather than by transplanting rice seedlings from the nursery. Dry seeding of rice excludes the need of puddling hence lowered the overall water demand and providing opportunities for water and labour savings. However, weeds are serious problem in dry seeding as dry tillage method and aerobic soil environment are conducive for germination and growth of weeds which cause grain yield losses to great extent. Manual wet seeding in lines requires large number of labours. Non-availability of labours during the peak season, increased labour cost and reduced benefit cost ratio are the drawbacks for the successful completion of manual wet seeded rice. Drum seeding of rice offer benefits *viz*., light in weight, easy to transport, gender-neutral, solves labour scarcity problem, sowing more area in short period, reduced production cost and increased the returns rupee^{-1} invested.

Contrary to the traditional cultivation of transplanted rice (TPR) the principal operations (transplanting rice seedlings and standing water) are outside the area of direct seeded rice and it offers the advantages of quicker and easier planting, less labour intensive, saves labour cost by avoiding raising of the seedlings, uprooting and transplanting, 10-12 days earlier crop maturity, high tolerance to water deficit and often higher profit in areas with assured water supply further reduced methane emission offers an excellent opportunity for environmental sustainability. Direct seeded rice is a feasible alternative to conventional puddled transplanted rice as in the conventional system of transplanting of rice, puddling of the soil disturbs the soil aggregates, reduces the soil permeability and creates hardpans at shallow depths which adversely affect the soil structure (Bhardwaj and Sidana, 2019).

Methods of direct seeded rice establishment

Dry seeded rice

The field was ploughed to fine tilth and levelled for sowing of seed dressed dry paddy seeds at the rate of 40 kg ha^{-1}. Seeds were manually line sown at 3 seeds $hole^{-1}$ with a spacing of 20 cm between the intra rows and 10 cm within inter rows. Optimum sowing depth of 2-3 cm was followed and the seeds were covered by thin soil layer for appropriate germination and to avoid bird's damage.

Drum seeded rice

The field was ploughed to fine tilth and made to puddled condition. Paddy seeds (ASD 16) at the rate of 40 kg ha^{-1} were soaked in water for 24 hours and stored in gunny bags for 24 hours. The seeding drums were filled with the pre-germinated seeds up to three-fourths of its capacity and sown in the field with a spacing of 20 cm between the rows and 10 cm between the plants of rows.

Manual wet seeded rice

The field was ploughed to fine tilth and made to puddled condition. Paddy seeds at the rate of 40 kg ha^{-1} were soaked in water for 24 hours and stored in gunny bags for 24 hours. Sprouted seeds were manually sown at 3 seeds $hole^{-1}$ with a spacing of 20 × 10 cm.

Common practices

The field was irrigated after sowing, and was kept saturated during the first 10 days. There was no water ponding at any stage, hence irrigation comprised of alternate wetting and drying followed by intermittent irrigation at seven days intervals up to 15 days before harvest. A fertilizer schedule of 120:40:40 NPK kg ha^{-1} respectively was applied. Fifty per cent N, full dose of P_2O_5 and fifty per cent K_2O were applied as basal. The remaining fifty per cent each of N were top dressed in two equal splits at active tillering and panicle initiation stages. The balance fifty per cent of potassium was top dressed at panicle initiation stage. The fertilizer materials used were urea, single super phosphate and muriate of potash to supply nitrogen, phosphorus and potassium respectively.

Weeds are the main yield limiting factor that can potentially reduce crop yields and is one of the main constraints in the larger scale implementation of direct seeded rice compared to transplanted rice (Suganya *et al.,* 2022). Hence effective control of weeds is an essential condition for better growth and productivity of rice in DSR. Chemical weed management is the most common practice in DSR because it is more selective, cheaper, labour and time saving than other weed management strategies. Due to the complexity and variety of weed species in DSR, no single herbicide can control all types of weeds. Thus, effective control of grasses, sedges and broad-leaved weeds requires sequential application of various premixed herbicides followed by hand weeding.

Application of pre-emergence herbicide, bensulfuron methyl 0.6% + pretilachlor 6% GR (ready mix) @ 10 kg ha^{-1} on 8 DAS fb post emergence application of metsulfuron methyl 10% + chlorimuron ethyl 10% (ready mix) @ 20 g ha^{-1} on 25 DAS fb one hand weeding on 45 DAS is an ideal combination for broad-spectrum weed control in DSR. Otherwise, application of bispyribac sodium 10% SC @ 250 ml ha^{-1} on 20 DAS fb one hand weeding on 40 DAS can be recommended. Calculated quantity of herbicides was mixed with water @ 500 liters ha^{-1} and sprayed through knapsack sprayer fitted with flood jet nozzle. The granular herbicide was applied with dry sand @ 50 kg ha^{-1}. A thin film of water was maintained at the time of both liquid and granular herbicide application. Need based plant protection measures were taken up against pests and diseases. Crop was harvested, threshed, dried, winnowed and the grain yield, straw yield was also recorded plot wise after the sun drying for three days.

Conclusion

Considering the above practices, drum seeding method of direct seeded rice cultivation can be recommended to increase the rice production with minimum use of inputs like seeds, water and labour thereby achieved the maximum net income and benefit cost ratio compared to transplanted rice.

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IMPORTANCE OF BIO-FORTIFICATION IN VEGETABLE CROPS

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Introduction

Bio-fortification is the process or method of breeding crops to increase their nutritional value in the edible organs during the growth and development of the plant. It is genetically increase the bio-availability of minerals in the food crops. The word bio-fortification derived from two languages. The word **"Bios"** derived from Greek word which means **"Life"** and **"Fortificare"** derived from Latin word which means **"Make strong".** It is a technique where the edible parts like roots, fruits, and tubers are enriched with micronutrients and vitamins through the appropriate breeding method and biotechnological tools (Saltzman *et al.* 2013).

Bio-fortified staple food may not contain a high level of essential vitamins and micronutrients as compared to industrially fortified foods. It can help to reduce **"Hidden Hunger"** by increasing the daily adequacy of micronutrients uptake by the individual throughout the life cycle. (Bouis *et al.* 2011).

Why we need bio-fortification?

- It can be easily reach the malnourished rural population who may have limited access to diversified food habits, vitamins supplements and commercially fortified foods (Fig 1.).
- It may reach consumers first in rural population and then urban areas.

How it differs from fortification?

- In respect to ordinary fortification, the nutrient enrichment were taking place of after the harvest of the produce, whereas the bio-fortification it can be increased when the plants are growing in the field (Fig 2.).

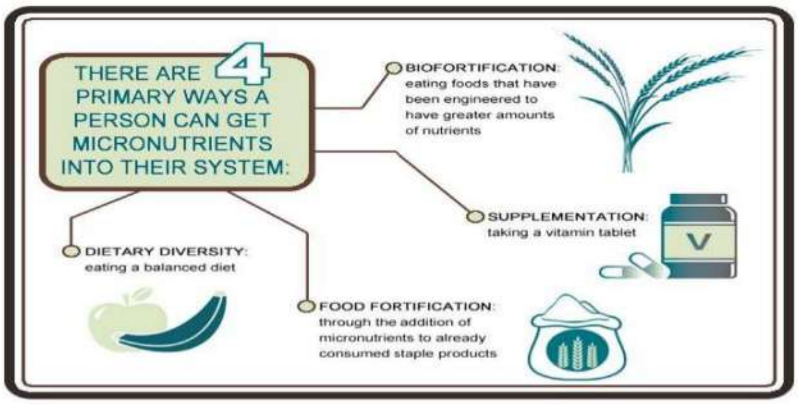


Fig 1. Four primary ways a person can get micronutrients into their system

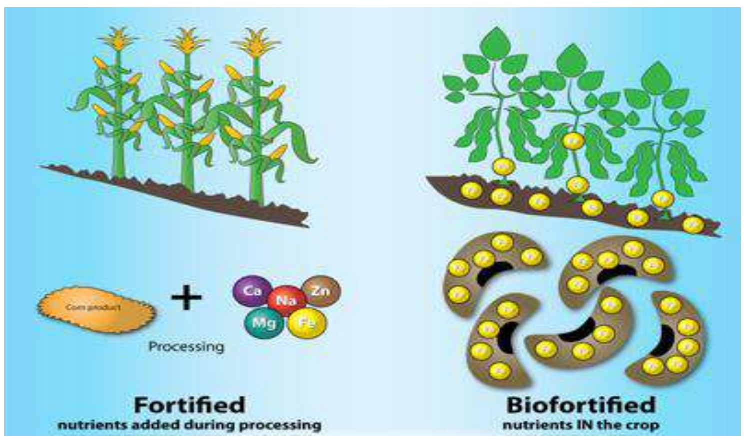


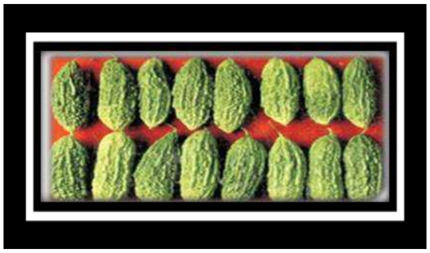
Fig 2. Fortified vs. Bio-fortified

Advantages of bio-fortification

- Cost effective method (provides at)low cost
- Process to enhance the vitamins, nutrient content and antioxidant in the produce.
- It can be improve the bio-availability of vitamins and nutrients.
- Sustainable and long term delivery of adequate micronutrients.
- It can eliminate the malnourished peoples.

Biofortified vegetables in India:

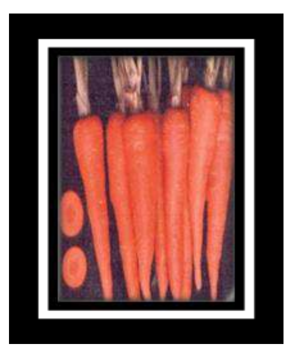
- ❖ Only one biofortified variety developed prior to 2014.
- ❖ Last five years 53 varieties were developed.
- ❖ By the National Agricultural Research System under the leadership of Indian Council of Agricultural Research (ICAR).

<table>
<tr><th colspan="2">Iron rich bio-fortified vegetables</th></tr>
<tr>
<td>Bitter gourd: Pusa Hybrid-1

♣ The fruits have high iron content - 18.20 mg/100 g
♣ It is a predominately gynoecious hybrid with high female : male flower ratio (2:1)</td>
<td>Amaranthus: Pusa Kiran

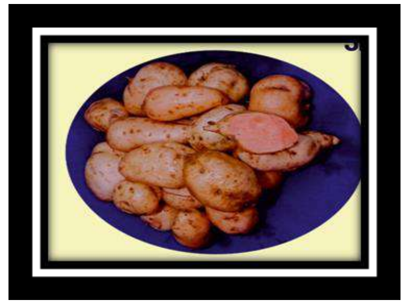
♣ It is good sources of iron content - 38.5 mg/100g</td>
</tr>
<tr><th colspan="2">β carotene rich bio-fortified vegetables</th></tr>
<tr>
<td>Tapioca: Sree vishakam

♣ It is a high yielding variety of tapioca. Hybrid.
♣ Carotene content 466 IU.
♣ Starch content in fresh tubers 25-27 %.</td>
<td>Cauliflower: Pusa Betakesari

♣ Pusa Sarad (White Curd) x Line no. 1227
♣ Vitamin A : 800 – 1000 µg/100g</td>
</tr>
<tr>
<td>Carrot: Pusa Rudhira

♣ Carotenoid (7.41 mg) and Phenols (45.15 mg 100g-1)</td>
<td>Carrot: Pusa Meghali

♣ Carotene content 11574 mg/100g</td>
</tr>
</table>

<table>
<tr>
<td>Sweet potato: Sree Rethna

♣ β carotene content 3.2 – 3.5 mg/100g
♣ Tubers are round spherical in shape
♣ Skin is purple in colour
♣ Flesh is yellow in colour</td>
<td>Sweet potato: Sree Kanaka

♣ β carotene content 8.8 – 10 mg/100g
♣ Tubers are elliptic in shape
♣ Skin is light yellow in colour
♣ Flesh is orange in colour</td>
</tr>
<tr>
<td colspan="2">Antioxidants rich bio-fortified vegetables</td>
</tr>
<tr>
<td>Cabbage: Kinner Red

♣ Heads are red in colour due to the presence of anthocyanin.
♣ Tolerant to diamond back moth.
♣ It has distinct coat of wax and produces a head of 1-2 kg,
♣ Taking about 90 days from transplanting to head formation.</td>
<td>Bhendi: Aruna

♣ Attractive red long fruits rich in anthocyanin.
♣ High yielding variety.</td>
</tr>
</table>

Carrot: Pusa Asita

- It is a tropical type having long black roots with self coloured core.
- **Roots having high anthocyanin content.**
- Roots mature in 90-110 days.

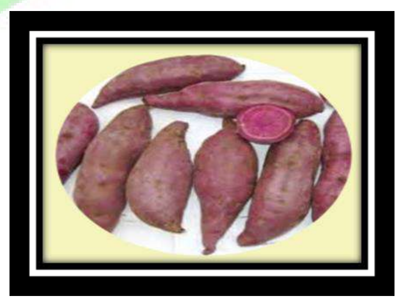
Raddish: Pusa Gulabi

- First entrie pink fleshed unique trait nutritional rich radish variety.
- Roots having **high total carotenoids, anthocyanins and optimal ascorbic acid.**
- Crop duration: 55-60 days.

Purple Yam: Sree Neelima

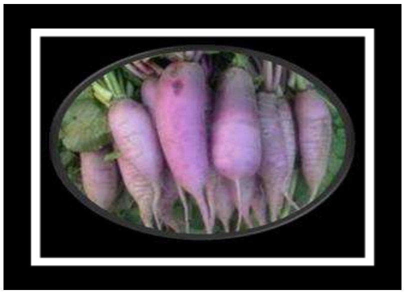
- **Anthocyanin content 7.73 mg/100g**
- Tubers are cylindrical in shape
- Skin is dark brown in colour
- Flesh is light purple in colour

Sweet potato: Bhu Krishna



- **Anthocyanin content 90 mg/100g**
- Tubers are long elliptic in shape
- Skin is dark purple in colour
- Flesh is dark purple in colour

Pusa Jamuni

- First purple fleshed unique trait nutritionally rich radish variety.
- It having high **anthocyanin and ascorbic acid content.**
- Crop duration: 55-60 days.

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MOTH FAMILIES IN INSECTS

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Introduction

Moths are a group of insects that includes all members of the order Lepidoptera that are not butterflies. They were previously classified as suborder Heterocera, but the group is paraphyletic with respect to butterflies (suborder Rhopalocera) and neither subordinate taxon is used in modern classifications. Moths make up the vast majority of the order. There are approximately 160,000 species of moth, many of which have yet to be described. Most species of moth are nocturnal, although there are also crepuscular and diurnal species.

ARCTIIDAE (Tiger moths)

- Wings are conspicuously spotted or banded. They are nocturnal and attracted to light.
- Larva is either sparsely hairy or densely hairy (wooly bear).
- e.g. (BHC) Black hairy caterpillar, *Estigmene lactinea.*

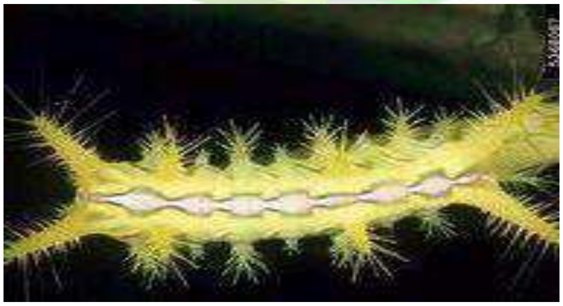
Tiger moths

BOMBYCIDAE (Silk worm moths).

- Antenna is bipectinate.
- Larvae is either with tuft of hairs or glabrous with medio dorsal horn on the eighth abdominal segment**.**
- Pupation occurs in dense silken cocoon.
- e.g. Mulberry silk worm, Bombyx mori an important source of natural silk.

COCHLIDIDAE (Slug caterpillar)

- They are medium sized moths with stoutly built body.
- Larva resembles the slug. Larva is thick, short, fleshy and stout. Larval head is small and retractile. Thorocic legs are minute.
- Abdominal segmentation is indistinct.
- Prolegs are absent. Poisonous urticating hairs are present on the body.
- Pupal cocoon is hemispherical with urticating hairs. e.g. Castor slug caterpillar, *Latoia lepida.*

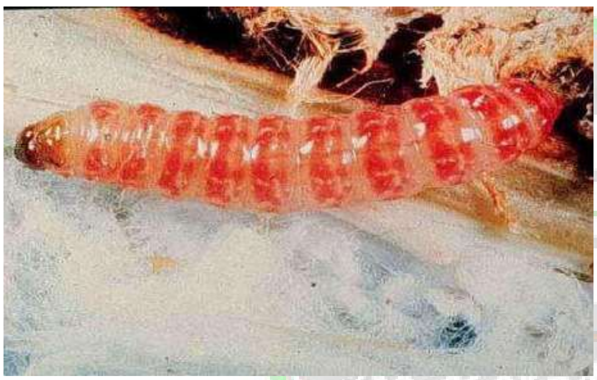


CRAMBIDAE (Grass moths)

- Labial palps are extended.Forewings are narrow and elongated. At rest they are wrapped around the body.Larva bores into root, stem or crown of graminaceous plants.
- e.g. Sorghum stem borer, *Chilo partellus.*


GELECHIIDAE

- Forewings trapezoidal and narrower than hindwings.
- Caterpillars bore into the seeds, tubers, and leaves. e.g. Cotton pink boll worm, *Pectinophora gossypiella.*




GEOMETRIDAE (Loopers)

- Both pairs of wings are angular and thin.
- Larva is naked and elongate. It shows protective resemblance to twings or stems.
- Only two pairs of prolegs are present in sixth and tenth abdominal segments.
- It walks by drawing the posterior part of the body close to the thorax, the body forming a loop. It is also called inch worm, measuring worm and earth measurer.
- e.g. Tea looper, *Biston suppressaria.*


PTEROPHORIDAE (Plume moths)

- They are small lightly built months, Forewings are elongate
- with two to four clefts or fissures. Hindwings have three divisions
- Legs are long, slender and armed with prominent tibial spurs.
- e.g. Redgram plume moth, *Exelastis atomosa.*

LYMANTRIDAE (Tussock moths)

- Antenna is bipectinate, Legs are clothed with wooly hairs.
- Female is provided with a tuft of anal hairs. Larvae is densely hairy.
- e.g. Castor hairy caterpillar, *Euproctis fraternal.*

NOCTUIDAE (Noctua moths - cut worms)

- They are nocturnal and attracted to light. Labial palp is well developed.
- Crochets on the larval prolegs are all of one size and arranged in semi-circle.
- Some larvae are semiloopers. They have either three or four pairs of prolegs.
- Larvae attack the plants during night. Larvae of some species remain concealed beneath the surface of the ground or litter on the surface during day and feed on plants during night. cut small seedlings close to the ground and hence they are called cut worms.
- e.g. Tobocco cut worm, *Spodoptera litura.*

PYRAUSTIDAE

- Proboscis is vestigial in many species. Libial palp is snout like.
- Larval habit varies. It may live among aquatic plants and bore into the stem or remain in silken web among spun up plants parts. Some larvae are aquatic and gill breathing.
- e.g. Rice stem borer, *Scirpophaga incertulas.*

SATURNIIDAE (Moon months, giant silk worm moths)

- They are large sized moths. Antenna is bipectinate.
- Transparent eye spots are present near the centre of each wing.
- The spots are either circular or crescent shaped. Larva is stout and smooth with scoli.
- Cocoon is dense and firm. e.g. Tussor silk worm, *Antherea mylitta.*

SPHINGIDAE (Death's head **Hawk moths, Sphinx moths, Horn worms)**

- They are large sized stoutly built moths.
- Antenna is thick towards middle and hooked at the tip. Proboscis is very long.
- Forewings are elongated and pointed with very oblique outer margin.
- Hindwings are reduced in width fitting into the indendted margin of forewings. They are **powerful fliers.**

- Larva is smooth with a **middorsal horn (anal horn)** on the **eighth abdominal segment**. Pupation takes place in **earthern cells.**
- Markings present on the thorax of the adult moth resemble human skull.
- e.g. Death's head moth, Acherontia styx is a defoliator on gingelly.

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NATURAL PEST CONTROL: HARNESSING THE POWER OF ESSENTIAL OILS

Article ID: AG-V04-I07-77

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Introduction

Plants have long been a significant source of medicines throughout human history. Despite substantial advancements in allopathic medicine during the 20th century, plants remain crucial in both modern and traditional medicine worldwide. Approximately one third of all pharmaceuticals originate from plants, with over 60% of pharmaceuticals being plant-based. The demand for botanicals of Indian origin in Western countries is rising, as is domestic demand for raw materials used in biopesticides units. This surge is driven by concerns over the harmful effects of synthetic chemical drugs. Geographically well-positioned, India could become a major supplier of these botanicals.

Green Pesticides

Green pesticides are defined as environmentally beneficial pest control materials that contribute to reducing pests and diseases while enhancing food production. They are safe, eco-friendly, and compatible with environmental components compared to synthetic chemicals. Green pesticides encompass nitrogen compounds (primarily alkaloids), terpenoids, phenolics, proteinase inhibitors, and growth regulators.

Actions of Green Pesticides

Green pesticides act on pests and diseases in various ways:

- They control pests through killing and repellent activities.

- They affect insect growth and development.
- They exhibit antifeedant and arrestant effects, among others.

Actions Against Diseases

Antifungal: Many plants essential oils and their constituents demonstrate antifungal activity against a wide range of plant pathogenic fungi, including those responsible for pre and post-harvest diseases. Essential oils like palmarosa, red thyme, clove bud, ginger, Salvia officinalis, Melissa officinalis, various Cymbopogon spp., oregano, peppermint, lavender, mint, cinnamon, basil, marjoram, citronellal, and eugenol show effectiveness against fungal pathogens such as Botrytis cinerea, *Monilinia fructicola, Rhizoctonia solani, Fusarium spp.,* and others.

Antiviral: Essential oils from plants like *Ocimum sanctum*, *Melaleuca alternifolia*, and others have shown inhibitory activity against viruses such as cowpea mosaic virus, mung bean mosaic virus, bean common mosaic virus, and tobacco mosaic virus.

Antibacterial: Essential oils from plants like *Psidium guajava* and *Picrasma spicata* exhibit strong antibacterial activity against both gram-negative and gram-positive bacteria.

Plant Extracts and Essential Oils

Aromatic plants and essential oils have a historical use in Flavors, fragrances, medicines, and as agents against microbes and insects. They contain terpenoids and aromatic compounds that defend against pests and fungi. Essential oils also attract pollinators and serve as signalling molecules. They are eco-friendly, easily extracted, biodegradable, and generally non-toxic to vertebrates, making them promising for weed, pest, and disease management.

Actions of Essential Oils against Pests and Diseases

Essential oils interfere with the metabolism, biochemical processes, physiological functions, and behaviours of insects and pathogens, thereby controlling pests and diseases. They act through neurotoxicity against insect pests and pathogens.

Essential oil in pest control: The Essential oils are used in the forms of

a) Fumigants: Monoterpenes, which are volatile, are particularly effective as insect fumigants. Numerous studies have explored the potential of essential oils and their components for this purpose. For instance, in vapor phase toxicity bioassays against *C. cautella* larvae, rosemary and niaouli oils exhibited effectiveness with LC50 values ranging from 64.6 to 64.7 mg/l air after 24 hours.

b) Chemosterilants: Extracts from medicinal and aromatic plants that contain chemical compounds causing sterility in insects are known as chemosterilants. For example, essential oil derived from Acorus calamus, which contains ß-asarone as an active principle, induces sterility in various insect species.

c) Repellents: Certain essential oils have long been observed to repel insects that infest stored products and households. Plants producing these oils include citronella, cedar, verbena, geranium, lavender, pine, cinnamon, rosemary, basil, thyme, black pepper oil, and peppermint. Most of these essential oils provide short-lasting protection, typically less than two hours. For instance, essential oils from Eucalyptus globulus and *Ocimum basilicum* demonstrate repellent activity against major stored-grain insect pests such as the red flour beetle *Tribolium castaneum* and the rice weevil Sitophilus oryzae adults. The repellency against these pests increases with concentration, from 0.05% to 0.40%, over a four-hour exposure period.

d) Antifeedents & Deterrents: Chemicals that deter insects from feeding can either repel insects without direct contact or suppress feeding upon contact. For example, essential oil constituents like thymol, citronellal, and α-terpineol are effective feeding deterrents against pests such as the tobacco cutworm and *Spodoptera litura*. Additionally, synergistic effects from combinations of monoterpenoids found in essential oils have been reported to enhance their effectiveness against *S. litura* larvae.

e) Larvicides: Many plant oils, including neem, basil, cinnamon, citronella, camphor, eucalyptus, lemon, and pine, exhibit larvicidal activity. Combined formulations of different essential oils, containing more active substances than individual oils, have been explored as larvicides, with some mixtures proving more effective than neem (*Azadirachta indica*) extract. For example, essential oils from Eucalyptus camaldulensis, E. viminalis, E. microtheca, E. grandis, and E. sargentii were found to be toxic to larvae of T. confusum and T. castaneum, suggesting their potential as natural pesticides for controlling these pests.

f) Ovicides: Various essential oils and their constituents exhibit ovicidal activity and deter oviposition by insects. For instance, the essential oil of Chloroxylon swietenia and its constituents geijerene and pregeijerene deter oviposition in *S. litura*. Volatiles from garlic oil have been reported to have ovicidal effects on eggs of several cotton insect pests, including the spotted bollworm, *Earias vitella*, *D. koenigii*, *S. litura*, and *H. armigera*. Garlic oil also serves as an oviposition deterrent and is highly toxic to eggs of *P. xylostella*, with a recorded 99.5%

reduction in egg hatching in S. obliqua using essential oil from *Aegle marmelos*. A. calamus oil at a concentration of 0.1% prevents oviposition by C. maculatus, and similar activity has been observed against the melon fly.

g) Attractants: Certain essential oils or their components attract insects. For instance, 1,8-cineole attracts the banana weevil Cosmopolites sordidus, the cudweed grasshopper Hypochlora alba, and the Mexican fruit fly *Anastrepha ludens*. Methyl eugenol has been utilized to trap the oriental fruit fly Dacus dorsalis, while geraniol and eugenol act as attractants and lures in traps. Aphids like *Carvariella aegopodii* are attracted to aromatic Apiaceae species during summer due to the presence of the attractant carvone. Limonene, found in sour oranges (Citrus aurantium), is toxic to adult bean weevils (*Callosobruchus phasecoli*) but highly attractive to male Mediterranean fruit flies.

Conclusion

Medicinal and aromatic extracts and botanicals play a crucial role in pest and disease management. They are locally available, easy to prepare and use, eco-friendly, and biodegradable. Essential oils can effectively serve as fumigants against storage pests and soil-borne pathogens. Neem-based botanicals are predominantly used in India. Although botanicals face challenges such as limited availability of raw materials and lower efficacy compared to synthetic pesticides, advancements in technology, biotechnology, and nanotechnology can enhance their effectiveness. Further exploration of many other medicinal and aromatic plants is warranted to improve the efficacy of botanicals.

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ROLE OF MOBILE APPS FOR PROMOTION OF IMPELMENTATION OF POST HARVEST TECHNOLOGY

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Abstract

Agriculture stands as a cornerstone of human sustenance and prosperity, with its significance underscored by collaborative efforts among various institutions worldwide. In India, contributing approximately 17.01% of the GDP, agriculture remains pivotal for economic growth. However, to fully leverage its potential, robust tools and technology are imperative. Mobile applications emerge as transformative assets, offering tailored agricultural information and connectivity to farmers. While India's rural smartphone adoption surges, with projections of 820 million users by 2022, mobile applications become a potent avenue for reaching rural populations. These apps, exemplified by platforms like Plantix and Golden Paddy, Pusa Krishi, Agri app, IFFCO Kisan, Shetkari, Kisan Suvidha *etc.* offer solutions ranging from soil analysis to market intelligence, revolutionizing post-harvest operations and increasing crop yields. Despite advancements, challenges persist in India's m-agriculture landscape. Digital illiteracy, interface inefficiencies, and limited farmer integration hinder widespread adoption. To address these hurdles, strategies such as enhancing digital literacy, improving app interfaces, and organizing farmers into collectives for training are vital. Additionally, agricultural universities must spearhead app development and diffusion initiatives, fostering a culture of innovation and connectivity in farming communities.In navigating these challenges and capitalizing on opportunities, m-agriculture can become a catalyst for agricultural growth, empowering farmers with knowledge,

connectivity, and tools for sustainable farming practices. Through concerted efforts to bridge gaps and harness the potential of mobile applications, India can pave the way for a digitally empowered agricultural sector, ensuring the resilience and prosperity of its farming communities in the face of evolving challenges.

Introduction

Agriculture and farming have always represented a fundamental necessity across the past, present, and future. The prosperity of human survival and culture hinges greatly on the advancement of the farming community. Collaborative efforts among numerous institutions such as ICAR research institutes, SAUs (State Agricultural Universities), KVKs (Krishi Vigyan Kendra), and philanthropic foundations are dedicated to enhancing the profitability of agriculture. With agriculture contributing approximately 17.01% of India's GDP (2014-15), it stands as a significant sector for economic growth. However, to fully realize its potential, agriculture must be supported by robust tools and technology, including effective connectivity and e-mobility. In the realm of Information and Communication Technologies (ICTs), access to information is paramount. Details regarding policies, best agricultural practices, market prices of commodities, current demand for various products, and beneficial agricultural schemes are essential for farmers to maximize profits.

Hence, it is crucial for farmers to access such information readily. Despite being available in the public domain, accessing this information can be arduous for farmers. Mobile applications, commonly known as apps, offer a solution by providing comprehensive agricultural information tailored to changing seasons and climates. These smartphone apps represent a platform where farmers can obtain solutions and information with a simple touch, thereby revolutionizing connectivity and facilitating the dissemination of agricultural information to farmers. Mobile application one of such technology that can be used directly in agricultural growth (Barh and Balakrishnan, 2018). Also, some studies indicate that we are facing the paucity of extension workers available for farmers in the country *eg.* Mukherjee and Maity (2015) in their study reported that we had 1 extension worker for 2879 famers in the country. Considering such a huge ratio gap, it is imperative to have certain digital platforms where one click can get the farmers' problems solved. Mobile applications are good options at the farmers' disposal. In India, rural areas of the country experienced a surge in smartphone adoption, with penetration rates increasing from 9 percent in 2015 to 25 percent in 2018. Additionally, smartphone usage in rural India exhibited a growth rate of 35 percent in 2018 (ICEA & KPMG). Projections suggest that India will boast 820 million smartphone users by the conclusion of 2022. Considering this trajectory, it is evident that smartphones serve as an effective means to reach rural populations. The proliferation of mobile applications is particularly advantageous for farmers in this context. As per a study conducted by Kumar and Chandrasekran (2020), there are 746 mobile apps dedicated to agriculture in India. These mobile apps need to be diffused among the social systems so that their potential can be harnessed in an efficient manner. The basic requirements for the diffusion of these apps are as follows:

- Connectivity
- Subscription to mobile and internet
- Affordability
- Digital literacy

The role of mobile apps in post-harvest operations cannot be overlooked either. Mobile applications can be used in getting market intelligence, value addition information, getting information about farm implement, methods of harvesting and storage, online markets, agribusiness knowhow, custom hiring *etc.* These apps provide important information necessary enough to perform post-harvest functions. According to Kakse, Mvina and Sife (2018), mobile apps have now become a more preferred way of imparting information as compared to SMS texts, given the wider availability of smartphones. But according to the reports of Costopoulou, Ntaliani, and Karetsos (2016), the use of mobile apps is still in the nascent or infant stage as they have low rating reviews possibly due to having not met the stakeholders' requirements.

AGRICULTURE AROUND THE WORLD

Switzerland, USA and Israel are the three topmost countries with most digitally skilled population (World Economic Forum, 2018). Farmers in the first world are far more technically advanced and make good use of mobile applications in post-harvest farming. In these countries mobile apps have been produced with the infusion of Artificial Intelligence (AI) to render more effective services of ICT. These apps work like an artificial expert telling the farmers to operate in an efficient way. A prime illustration of AI implementation is showcased through a mobile application named Plantix, developed by PEAT (Progressive Environment and Agriculture Technology), a tech startup based in Berlin. Plantix efficiently detects soil nutrient deficiencies, plant pests, and diseases, providing farmers valuable insights into fertilizer usage to enhance crop quality. Utilizing image recognition technology, the app allows farmers to capture plant images via smartphones, upload them, and receive immediate results indicating nutrient deficiencies, physiological disorders, or pest attacks. Operable in vernacular languages, Plantix maximizes accessibility for farmers, offering tailored recommendations for fertilizer, pesticide, and herbicide doses suitable for specific crops and regions.

Furthermore, the app offers guidance on soil restoration techniques through concise instructional videos, covering a diverse range of crops. You can find solutions to your problem by raising up queries that are to be answered by community members connected through the app. The 'Dukaan' feature of the app helps you connect with nearby agri retailers where you can buy or sell your products. It has more than 1 crore downloads in Google Playstore.

The Golden Paddy app, alternatively referred to as "Shwe Thee Nhan" in Myanmar, is a complimentary web and mobile application created by Impact Terra, a social enterprise specializing in agricultural technology, aimed at delivering digital solutions to farmers. Similar to other agricultural applications, it furnishes users with weather forecasts, up-to-date farming techniques, and pertinent agricultural updates. Additionally, it offers insights into input and product prices, along with details about sellers and financial institutions. Notably, this service is accessible offline, and certain features are accessible through direct messaging, which redirects users to additional functionalities (Thar *et al.*, 2021).

Though not related to post-harvest, another notable advancement is an AI-powered sowing app developed by Microsoft Corporation in collaboration with ICRISAT, Hyderabad. This application aids farmers in determining optimal sowing dates, land preparation, fertigation based on soil analysis, FYM (Farm Yard Manure) requirements and application, seed treatment, and selection, as well as optimizing sowing depth. According to a report by FAO (2019), this innovation has led to a remarkable 30 percent increase in average crop yield per hectare in Andhra Pradesh. These developments underscore the significant potential of mobile agriculture (m-agriculture) in shaping the future of agriculture.

INDIAN SCENARIO:

In India, there are vast differences in mobile-cellular subscription between different states such as Delhi (National capital), Karnataka (capital being Bangalore considered to be the "Silicon Valley" of India) and Maharashtra having good mobile subscriptions per 100 people whereas, the traditionally agrarian states Bihar and Uttar Pradesh have as low as 30 mobile-cellular subscribers per 100 inhabitants (Pick and Sarkar, 2015). Nevertheless, we have so many mobile applications in place to strengthen post-harvest farming. These apps are enlisted and described as follows:

- **Pusa Krishi:** This app was launched in 2016 by GOI. Developed by Indian Agricultural Research Institute, New Delhi. It gives the farmers the information pertaining to new crop varieties developed by ICAR, best practices about conservation of resources, best farm machinery and its implementation.
- **Agri App:** It helps farmers stay upto date on best farming practices by providing them information on best methods of harvesting and storage and best online markets to buy chemicals. It has more than 10 Lakh downloads with good customer reviews.
- **Shetkari:** It is a multifunctional app which gives the farmers the access to schemes launched by GOI, agribusiness know-how, market rates of crops, success stories in the field of farming from various states across the country.
- **Kisan Suvidha:** launched in 2016 by GOI, this app is one of the best apps that enlists all central and state government schemes for farmers and provide information on weather forecasts, market rates, crop insurance information, information on retailers *etc.*
- **IFFCO Kisan:** Launched by IFFCO Ltd. in 2015, the app provides expert information on customised agricultural advisory, market prices and suitable weather conditions for crops. It has more than 10 thousand downloads on google playstore.

PROBLEMS AHEAD OF m-AGRICULTURE IN INDIA:

India is majorly an agrarian economy. Majority of our population is dependent on agriculture for their livelihood. But the growth of agriculture sector is facing a damp. Indian farmers face a set of problems in operating a farm which leads to reduced remuneration received from farming as a result of which farmers are quitting farming and opting for other ventures. But these needs to be paid a serious attention. Digital agriculture seems to be the possible way out. But again, there are certain problems in adopting digital agriculture in Indian scenario which are described as follows:

- **Digital illiteracy**: The majority of the farmers in India have a loose hand in digital technology, let alone operating mobile apps. They are hugely dependent on their children when it comes to operating a mobile phone, for example. But even that can be a positive sign if their children can operate mobiles and inform their farmer parents. Also, we have certain schemes like

Pradhan Mantri Grameen Digital Saksharta Abhiyaan (PMGDISHA scheme) launched in 2017 by GOI with an aim of digitally educating 60 million people in rural areas, targeting 40% of rural households with atleast one member per household being trained under the programme. The objective of the scheme is to provide 20 hours of basic training on digital devices and the internet, and how to use these tools to avail government-enabled e-services with a special focus on cashless transactions. So far, almost 4.79 crore candidates have been certified as digitally literate under PMGDISHA (www.pmgdisha.in).

- **Inefficiency of mobile apps in reaching out to farmers:** If we go through the number of downloads for an app, we find that very less number of apps have the download numbers crossing 1 lakh mark. Others stand at almost 10 thousand downloads. This indicates that the extension and diffusion of mobile agriculture is weak among farmers and extension agents should take a note on narrowing down these gaps.
- **Inefficient and non user-friendly interface:** The reviews present on google playstore indicate that the customers are not satisfied by the interface of the apps. The apps do not work properly or hang, sometimes the payment is not easy and all other related problems are highlighted.
- **Small landholdings of farmers.** In India, majority of the farmers are small landholders and there is a lack of farmer integration. So, individual farmers are not either aware or interested or courageous to focus on apps related to post harvest and farm machinery tools because they think that it is out of their reach and interests.
- **Lack of digitally competent agri professionals:** In agriculture, there is a lack of professionals who could get training and develop apps for farmers. Very less number of agricultural institutions are interested in developing apps for farmers in their regions. Appreciable work has been done by IARI, New Delhi or TNAU, Coimbatore but other institutes need to follow up in order to create such an environment for farmers.

SUGGESTIONS TO STRENGTHEN THE CHAIN OF m-AGRICULTURE

Mobile applications can easily foster changes that we want to see in agriculture. We need to narrow down the gaps that exist in the path of development. Following are the suggestions that can be followed in order to fill up the gaps and improve the situation:

- Agricultural universities should work on developing and diffusing mobile applications.

- For example, mobile apps can be developed in order to sell university or farmers' products like seeds, baked products *etc.*
- The interface of the applications should be made more user friendly so that farmers can easily comprehend them, make payments and perform all the functions smoothly.
- Focus on improving the digital literacy especially among youth. It can be understandabke as the youth literacy rate increased from 83 percent to 91.4 percent over two decades, while the number of illiterate youths declined from 170 million to 115 million. In 2015, the youth literacy rate stood above 95 percent in 101 out of 159 countries where data are available (UNESCO, 2017).
- Farmers can be organised into SHGs and FPOs and training can be given on how to use mobile apps.
- Diffusion of good apps is necessary to make them popular among rural people. For this, improvements on all fronts have to be made, feedback have to be obtained and worked upon.

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SUCCESS STORY ON INTEGRATED PEST MANAGEMENT IN PADDY TO COMBAT MAJOR INSECT PESTS

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Introduction

Dhalai is one of the most important and largest in terms of area among the eight districts of Tripura where rice is grown both in hills and valleys. Jhum or shifting cultivation is practiced in hill regions whereas settled farming is in plain areas. The major farming system is a rice-basedfarming system which is basically rainfed. Due to a lack of awareness majority of the farmers follows traditional cultivation method without any proper management and preventive measures against pest and pathogens. As a result, annually 20-30% yields loss due to pest infestation. The major causing problem in paddy includes stem borer (cause dead heart), brown plant hopper (cause hopper burn), Gundhi bug (cause chaffy grain) and leaf miner, etc. Further, to minimize the infestation of these pest farmers follows the indiscriminate use of systemic pesticide leads to resistance development in the pest population towards those chemicals and develop super pest.

In addition to, indiscriminate and non-judicious chemical pesticide application in the field cause the destruction or killing of non-target pests especially beneficial insects such as pollinators (honey bees) and predators (praying mantis), etc. Therefore, it is necessary to develop eco-friendly, sustainable management practices such as integrated pest management (IPM) to tackle the pest problem. IPM practice in rice production initiatives includes regular pest monitoring, optimal use of pest control chemicals, complementary weed control strategies and alternate cultural and biological controls. The current project under tribal sub plan was under taken with the following objectives.

a) Promotion of Integrated pest Management in Rice through farmers' participatoryapproach &

b) Refining the production technologies aimed at high input use efficiency

Initiative:

To overcome this problem in paddy cultivation Krishi Vigyan Kendra (KVK) Dhalai, Salema, took initiative to develop IPM module suitable for Dhalai agro climatic condition in collaboration with NCIPM, New Delhi. The strategies adopted under this module includes-

a) Community Nursery approach was adopted for easy control of pest attack.
b) Transfer of Technology with improved package & practices.
c) Balanced use of fertilizers and micro-nutrients as per local recommendations
d) Use of biological pest control measures
e) Creating mass awareness among the farmers through training, field day anddemonstration.

Package of practice Followed:

a) Clip the seedling tips before transplanting to eliminate egg masses and collect anddestroy the egg masses in main field
b) Install pheromone trap@20/ha
c) The scirpo-lure was changed at every 15 days interval after first installation which wasdone after 15 days of transplanting of rice.
d) Use light traps @ 1/ha to attract and kill the moths.
e) Need based application of chemical pesticide at ETL i.e 25 % dead heart or 2 eggmass/m2

Training cum awareness programme and input distribution:

Basic training on IPM like insect & their dominance, types of pest, economic damage level, concept of pest management, and different component of IPM is very much necessary for capacity building of farmers of Dhalai district. Along with training programme mass awareness programme is also very much needed to spread the technology to the farmers doorstep. Under the project component total 4 nos. training programme conducted covering 40 nos. of from three different GP VC which namely kochucherra, jamthum and manikbandar, which were selected on the basis of Participatory Rural Appraisal (PRA) exercise.

Monitoring and surveillance:

Regular monitoring and surveillance is one of the important components of IPM module to understand the pest behavior, time of infestation and no. of pest population to initiate the management procedure. Therefore, we surveyed at regular seven days intervals in the farmer's fields to ensure proper management strategies were followed during the vegetative stage to the milking stage of the crop.

Monitoring of farmers field by KVK Scientists

Name: Ajit Das

S/O: Anil Ch. Das

Village: Kochucherra

Qualification: 8th pass

Adopt technology: Last two years

Contact: 943618434

Before IPM

Package of practice	% pest infestation	Yield (qt/ha)	Gross Cost (Rs/ha)/	Gross Return (Rs/ha)	Net Return (Rs/ha)	BCR
Traditional	32.9	46.51	32056	65114	33058	2.03

After IPM

Package of practice	% pest infestation	Yield (t/ha)	Gross Cost (Rs/ha)/	Gross Return (Rs/ha)	Net Return (Rs/ha)	BCR
IPM module	15.6	57.14	30487	79996	49509	2.62

Name: Prasenjit Das

S/O: Prafulla Ch. Das

Village: Kochucherra

Qualification: 12th pass

Adopt technology: Last two years

Contact: 8119992815

Before IPM

Package of practice	% pest infestation	Yield (qt/ha)	Gross Cost (Rs/ha)/	Gross Return (Rs/ha)	Net Return (Rs/ha)	BCR
Traditional	29	47.15	31190	66010	34820	2.11

After IPM

Package of practice	% pest infestation	Yield (t/ha)	Gross Cost (Rs/ha)/	Gross Return (Rs/ha)	Net Return (Rs/ha)	BCR
IPM module	14.9	58.74	30122	82236	52114	2.73

Name: Rintu Das

S/O: Krishna Ch. Das

Village: Dabbari

Qualification: BA graduation

Adopt technology: Last two years

Contact: 9436318004

Before IPM

Package of practice	% pest infestation	Yield (qt/ha)	Gross Cost (Rs/ha)/	Gross Return (Rs/ha)	Net Return (Rs/ha)	BCR
Traditional	35.4	44.20	32895	61880	28985	1.88

After IPM

Package of practice	% pest infestation	Yield (t/ha)	Gross Cost (Rs/ha)/	Gross Return (Rs/ha)	Net Return (Rs/ha)	BCR
IPM module	20.73	51.29	30627	71806	41179	2.34

Name: Pradip Das

S/O: Pramod Lal Das

Village: Dabbari

Qualification: 12th pass

Adopt technology: Last two years

Contact: 8729943018

Before IPM

Package of practice	% pest infestation	Yield (qt/ha)	Gross Cost (Rs/ha)/	Gross Return (Rs/ha)	Net Return (Rs/ha)	BCR
Traditional	29.90	46.88	33863	65632	31769	1.93

After IPM

Package of practice	% pest infestation	Yield (t/ha)	Gross Cost (Rs/ha)/	Gross Return (Rs/ha)	Net Return (Rs/ha)	BCR
IPM module	12.08	59.22	31895	82908	51013	2.59

Name: Sunil Das

S/O: Lt. Mahadev Das

Village: Kochucherra

Qualification: 9th pass

Adopt technology: Last two years

Contact: 6033231607

Before IPM

Package of practice	% pest infestation	Yield (qt/ha)	Gross Cost (Rs/ha)/	Gross Return (Rs/ha)	Net Return (Rs/ha)	BCR
Traditional	31.45	45.80	32741	64120	31379	1.95

After IPM

Package of practice	% pest infestation	Yield (t/ha)	Gross Cost (Rs/ha)/	Gross Return (Rs/ha)	Net Return (Rs/ha)	BCR
IPM module	18.20	58.78	30270	82292	52022	2.71

Impact:

The IPM strategy was implemented in farmers' fields as a pilot project basis in a demonstration unit in selected areas and its use was extended in the adjoining villages too. It was observed that, earlier farmers apply 3 – 4 times chemical spray in a week. Now, after using this IPM module chemical sprays reduce from 3-4 times to once in a week. Labor requirement decreased for those farmers who adopted this IPM technology. Farmer's profit margins and production level increased significantly. Due to less use of chemical sprays reduced the environmental risk associated with pest management and provides economic benefits due to sustained development, increased productivity and reduced pest damage. The majorities of the farmers were happy as this technique is environment friendly, improve the crop quality, reduces the chemical sprays and preserved the soil fertility level. After seeing this result, now they want to expand more areas under paddy cultivation by using the IPM technology.

1. What did you learn in this process? What is difficult or challenging?

The lesson learnt in this process is that farmers are ready to adopt the IPM technology which provide higher yield than the conventional method. The major challenges are the lack of awareness about management strategies and preventive measures against pest diseases and unavailability of IPM kits in the local market.

2. How did you face these challenges?

Motivate the farmers through various training and awareness programme using video images and also create a linked with scientist of all farmers through whatsapp application to detect the insect pest quickly and their proper management strategies.

3. If you were to do it again, what would you do differently?

Select major paddy cluster areas to develop model village under IPM technology for rapid and wider dissemination of technology in different areas.

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ROLE OF TRANSCRIPTION FACTORS IN PLANT DISEASE RESISTANCE

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Abstract

Transcription Factors (TFs) are the essential part of plants' complex defensive mechanisms against various stresses. These specialized proteins act as molecular conductors, exerting control over the transcriptional activity of target genes through the precise recognition of specific DNA sequences. In the context of disease resistance, TFs emerge as indispensable regulators, capable of either stimulating or inhibiting the transcription of key genes involved in immune responses. TFs, are activated by distinct signal cascade pathways and have a direct or indirect role in agricultural plant resistance against a variety of pathogenic microorganisms. The major TF families, including WRKY, NAC, bZIP, MYB, and bHLH have become better understood throughout time in plant disease resistance.

Keywords: Transcription Factors, NAC, MYB, bZIP, Signal Transduction

Introduction

Plant diseases pose a major threat to agricultural crops globally which cause huge yield losses every year. These diseases are caused by a variety of pathogens, including bacteria, fungus, viruses, and nematodes. The extent of this problem is highlighted by a recent survey, which shows that crop losses due to pests and diseases differ significantly between main crops. On an approximate, rice and maize faces losses of up to 41%, while wheat experiences losses of up to 28 %, soybean registered losses of up to 32.4% and pulse crops loss up to 10%. These highest recorded values underscore the significant impact of plant diseases on crop yields, necessitating urgent measures for effective disease management and agricultural sustainability. Plant diseases still cause anywhere from 20 to 30 percent of real production losses annually, despite the fact that scientific advances and technical developments have significantly decreased yield and productivity losses.

Plants have evolved a sophisticated and diverse set of defense mechanisms to protect themselves from environmental threats and pathogen attacks. Plants, unlike animals, lack a mobile immune system to fight off pathogens. However, they've evolved with sophisticated defense strategies, including physical, chemical, and molecular means, to ensure their survival. Physical barriers include waxy cuticle, cell wall, stomata and lenticels. Chemical deterrents encompass a diverse arsenal, nutrient deprivation tactics, manipulation of local pH, and production of defensive compounds like phytoanticipins and plant defensins. Molecular defense strategies include *R*-gene-mediated resistance and systemic acquired resistance. Plants identify certain proteins produced by invading pathogens called Avr effectors using special receptor proteins (R proteins) made from the plant's R genes. This recognition triggers a defense response. Additionally, Plants that have developed broad-spectrum resistance to pathogens have developed systemic acquired resistance, or SAR. The quick creation and transmission of mobile signal(s) brought on by the original infection "prepares" the remainder of the plant for future infections during SAR.

Plant Transcription Factors (TFs)

TFs are among the most crucial genetic elements for controlling gene expression and a number of other biological processes in plants. Transcription factors are specialist proteins that bind to DNA at specific sequences, acting like switches to turn nearby genes on or off. Important transcription factor families, such as WRKY, ERF, MYB, NAC, and bZIP, play key roles in helping plants respond to various stresses. Numerous databases now offer extensive and detailed information on these and other transcription factor families across a wide range of plant species (Table 1).

Table 1. Important Plant transcription factor (TF) databases

S.No	Database Name	Targeted Plant Species	Web accession
1	PlantTFBD	165 different plant species	https://planttfdb.gao-lab.org/

2	SorghumFBD	Sorghum	https://ngdc.cncb.ac.cn/databasecommons/database/id/1955
3	AthaMap	Arabidopsis	http://www.athamap.de/gene_ident.php
4	Phytozome	401 annotated plant genomes	https://phytozome-next.jgi.doe.gov/
5	Plant CARE	435 different plant species	http://bioinformatics.psb.ugent.be/webtools/plantcare/html/
6	GrassTFDB	Maize, Sorghum Sugarcane, Rice,	https://grassius.org/grasstfdb
7	iTAK	different plant species	http://itak.feilab.net/cgi-bin/itak/index.cgi
8	PLACE	Vascular Plants	http://www.dna.affrc.go.jp/PLACE/index.html
9	DATF	Arabidopsis	http://datf.cbi.pku.edu.cn/
10	wheatFBD	Wheat	http://xms.sicau.edu.cn/*wheatTFDB*/
11	TOBFAC	Tobacco	http://compsysbio.achs.virginia.edu/tobfac/
12	DBD	*Arabidopsis, Rice, Maize, Sorghum, Grapes*	https://transcriptionfactor.org/
13	CicerTransDB	*Chickpea*	http://www.cicertransdb.esy.es
14	FmTFDb	*foxtail millet*	http://59.163.192.91/FmTFDb/index.html
15	PlantPAN	115 plant species	http://plantpan.itps.ncku.edu.tw/plantpan4/index.html

Molecular Mechanism of Transcription Factors in Plant Disease Management

Plants have evolved with complex response systems against stresses. These systems use networks of molecules controlled by signal chains. The main steps in these stress responses are signals perception, signals transduction, activation of TFs, expression of disease responsive genes and that help the plant cope (Figure 1). Initially, the plant uses sensors in its membrane or cell wall to identify stress. Subsequently, the external signal is converted into internal signals within the cell, which frequently include ion or molecular chains. Important signaling molecules includes reactive oxygen species (ROS) and calcium ions (Ca2+). Plant hormones like salicylic acid, abscisic acid, jasmonic acid and ethylene also help in coordinating these signals. These signals trigger an array of pathways, often involving enzymes that add or remove phosphate groups. Plants initiate two major signaling pathways in response to stress: the mitogen-activated protein kinase (MAPK) pathway and the calcium-dependent protein kinase (CDPK) pathway. Finally, specific proteins called transcription factors are turned on or off. The activity of stress-related genes is altered or increased when these TFs bind to DNA regions near to stress related genes. Figure 1 shows how TFs are activated and work. TFs are crucial because they control genes important for the plant's stress response.

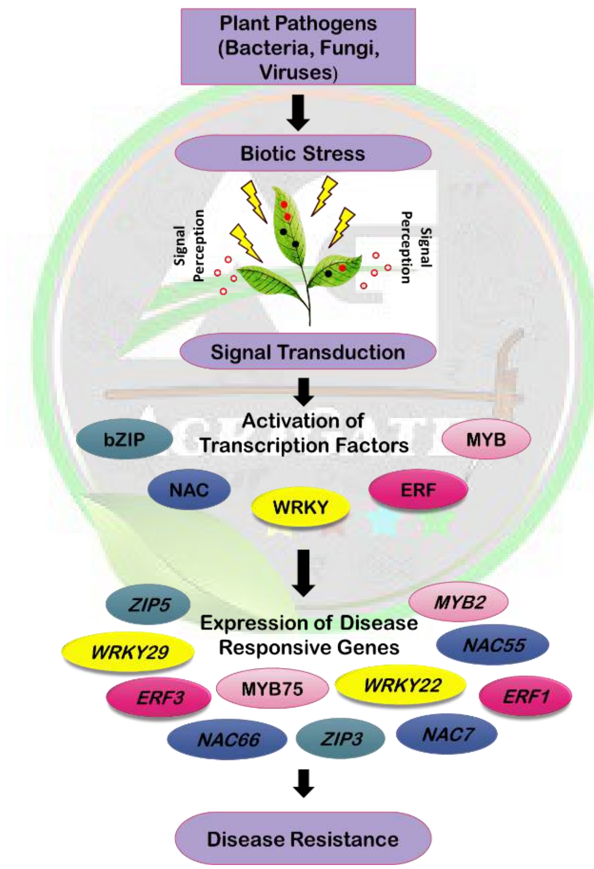

Figure 1. Key signaling pathways involved in plant defense against biotic stressors

Important Transcription Factors involved in Biotic stress

WRKY: They have conserved WRKY motif and a number of zinc finger structures. They are active part of PAMP-triggered immunity and effector-triggered immunity in plant cells. *OsWRKY93*, *CsWRKY22*, *BnWRKY70*, and *WRKY16* are some of the potential TF genes targeted for disease resistance in rice, grapes, brassica and wheat.

ERF: Also called as AP2/ERF, they belong to the subfamily of AP2 transcription factor genes called ethylene response factor (ERF) that have only one DNA-binding domain. Plant disease resistance is facilitated by inhibiting the expression of genes linked to hormone signaling pathways, secondary metabolite production, and other related processes. *OsERF83* and *OsERF83* are the two examples of ERF TF genes regulating rice blast resistance.

MYB: They are specialized by conserved MYB, DNA binding domain. MYB TFs regulate resistance genes in plants through various signaling processes and pathways including biosynthesis of flavonoids, lignin, and cuticular wax, hormone defense signaling, polysaccharide signaling, and the hypersensitivity response. Ex. *ZmMYBC1, MYB30, MYB55 and MYB110*

NAC: One of the biggest families of transcription factors in plants, NAC transcription factors are essential for controlling both development and the response to stress. NAC TFs enhance resistance against various pathogens through regulating the biosynthesis of various phytohormones.

Ex. *ZMNAC10, HvNAC1, OsNAC6, OSNAC58*

bZIP: They belong to basic leucine zipper family, regulate important cellular processes in all eukaryotes. They enhance disease resistance in plants through regulating the biosynthesis and deposition of various compounds like salicylic acid, phytoalexins and callose. Ex. *TabZIP1, GmbZIP15, StbZIP61, OsbZIP79*

Conclusion

The global population is projected to hit 9 billion by 2050, innovative solutions are essential to enhance the food production and meet to the rising demand. One promising strategy lies in engineering crops with enhanced stress tolerance. TFs, known for their crucial role in stress response, offer a potential avenue for manipulation. Recent decades have seen significant strides in identifying and characterizing key TF families like bZIP, MYB, NAC and WRKY, paving the way for engineering crops resilient to both environmental and biological stressors.

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TOBACCO CATERPILLAR, *SPODOTERA LITURA* FAB. (NOCTUIDAE: LEPIDOPTERA) ATTACK ON DAINCHA, *SESBANIA ACULEATA* L. FROM CAUVERY DELTA ZONES OF TAMIL NADU

Article ID: AG-VO4-I07-81

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Introduction

Spodoptera litura, commonly known as the tobacco cutworm, tobacco caterpillar or cotton leaf worm, is a nocturnal moth belonging to the Noctuidae family. This species, first described by Johan Christian Fabricius in 1775, is a significant polyphagous pest in regions including Asia, Oceania, and the Indian subcontinent. Before mineral fertilizers became widely available, green manuring was seen as essential in crops such as rice, sugarcane, potato, wheat, and mustard. *Sesbania aculeata* L. is a highly valuable green manuring crop. When incorporated into the soil, it contributes approximately 60-80 kg of nitrogen per hectare. The decomposition of Sesbania green manure increases soil humus and available nitrogen while reducing the C:N of the soil. In the Cauvery delta zones of Tamil Nadu, rice farmers cultivate daincha as a green manure crop following the kuruvai and thaladi seasons. When cultivating daincha using the broadcasting method for sowing, a dense population of plants can develop. This dense growth can attract pests such as the tobacco caterpillar, leading to potential pest attacks.

Host range: Groundnut, citrus, soybean, cotton, tobacco, castor, pulses, millets, safflower, banana, cabbage, tomato, sweet potato, bhendi, chillies, etc.

Life cycle of Tobacco caterpillar:

The length of *S. litura* life cycle can vary somewhat across different regions, a typical *S. litura* will complete around 12 generations annually. *S. litura* has complete metamorphosis with four stages in their life cyle (Egg, larva, pupa, adult). Each generation typically lasts about a month. However, temperature causes slight variations: during winter, life cycles tend to last slightly longer than a month, whereas in summer, they are usually shorter than a month

Scientific classification of Tobacco caterpillar:

Domain	Eukaryota
Kingdom	Animalia
Phylum	Arthropoda
Class	Insecta
Order	Lepidoptera
Superfamily	Noctuoidea
Family	Noctuidae
Genus	*Spodoptera*
Species	*S. litura*

Tobacco caterpillar feeding on Daincha

Daincha field attacked by Tobacco caterpillar

The eggs of *S. litura* are spherical and slightly flattened, measuring around 0.6 mm in diameter, and they have an orange-brown or pink color. These eggs are deposited in large batches on leaf surfaces, with each cluster typically containing several hundred eggs. Females generally lay between 2000 and 2600 eggs. When the eggs are laid, the female covers the batches with hair scales, giving them a golden-brown appearance. The total diameter of the egg masses ranges from 4 to 7 millimeters and the eggs hatch within 2 to 3 days of being laid.

The body length of *S. litura* larvae ranges from 2.3 mm to 32 mm, with color variation depending on their age. Younger larvae are generally lighter green, while older larvae develop a dark green or brown hue. A bright yellow stripe along the dorsal surface is a distinct characteristic. The larvae are also hairless. Newly hatched larvae can be identified by scratch marks on leaf surfaces. Being nocturnal, the larvae feed at night and typically hide in the soil around the plant during the day. There are six instar stages in the larval development, with the final instar reaching a weight of up to 800 mg.

Pupation lasts about 7 to 10 days and occurs in the soil near the base of the plant. The pupa is typically 15–20 mm long and has a red-brown color. A distinctive feature is the presence of two small spines at the tip of the abdomen, each approximately 0.5 mm long. Adult *S. litura* moths are typically 15–20 mm in length, with a wingspan ranging from 30 to 38 mm. Their bodies are gray-brown, and their forewings feature patterns in dark gray, red, and brown. The hindwings are grayish-white with a gray outline. On average, female moths live for 8.3 days, while males have a slightly longer lifespan of 10.4 days.

Damage caused by Tobacco caterpillar:

The young caterpillars are light green with a black head or black spots and tunnel into leaf tissues. Fully grown caterpillars are gray or dark brown with a distinctive white "V" shape on the front of their black heads. They feed voraciously along leaf veins and are also capable of cutting small, tender seedling stems and present an appearance to the field as if grazed by cattle. Since this pest is nocturnal in habit larvae hide under the plants, cracks and crevices of soil and debris during the day time. Faecal pellets are seen on the leaves and on the ground which is the indicator of the pest incidence. Because of this behavior, they are commonly referred to as cutworms. Infestations can lead to significant crop losses, ranging from 80 to 100%.

Integrated Pest Management Strategies:

1. **Economic Threshold Level**: The ETL is 8 egg masses per 100 meters of crop row. Monitor regularly to keep track of egg mass counts.
2. **Summer Ploughing:** Deep summer ploughing can damage the pupa and reduce the rate of adult emergence.
3. **Light Traps**: Place light traps in the field at one per ha to monitor and kill adult moths attracted to the light. This helps in reducing the number of moths that can lay eggs.
4. **Sex Pheromone Traps**: Install sex pheromone traps at a rate of 5 traps per acre. These traps help in monitoring the activity of the pest by attracting and capturing the males.
5. **Border Plants**: Grow castor plants along the border and irrigation bunds of your crop fields. Castor acts as a trap crop, attracting pests away from your main crops.
6. **Egg Mass Removal**: Regularly inspect the crops for egg masses. Remove and destroy any egg masses you find to prevent them from hatching.
7. **Larval Control**: Remove and destroy early-stage larvae manually. This reduces the number of larvae that can grow and cause damage.
8. **Handpicking**: Hand pick and destroy grown-up caterpillars to directly reduce the pest population.

9. **Biocontrol:** In severe infestation apply *Bacillus thuringenesis* 2g/lit, entomopathogenic fungus *Nomuraea rileyi* and field release of egg parasitoid such as *Telenomus spodopterae* and *Telenomus remus*. Spray Azadirachtin 1.0 % EC (10000 ppm) 2.0 ml/ lit.
10. **Bait:** During cyclonic weather, tobacco caterpillar, *S. litura* can also be controlled by putting jaggery and rice bran baits. This is prepared by dissolving 6.25 kg jaggery in 12.5 litres of water and adding to this emamectin benzoate 5 SG 200 ml. To this 25 kg rice bran is slowly added by mixing it thoroughly with a smooth stick so that the bait is made into small balls. The bait is broadcasted on the nursery beds during evening hours to effectively control the caterpillars.
11. **Insecticide Application**: When the pest population reaches the ETL, apply one of the following insecticides:
    - **Diflubenzuron 25% WP**: 120-140 grams per acre
    - **Chlorantraniliprole 18.5% SC**: 60 ml per acre
    - **Spinetoram 11.7% SC**: 168-188 ml per acre
    - **Emamectin benzoate 5% SG:** 100 g per acre
    - **Novaluron 10% EC:** 200 ml
    - **Nuclear Polyhedrosis Virus (NPV)**: 6 x 10^{11} POB 2.5 Kg + crude sugar + 0.1 % teepol per acre. Ensure to follow safety guidelines and instructions on the insecticide labels for application. Regular monitoring and timely intervention are key to managing pest populations effectively.

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ZINC'S CONTROL AND UTILITY IN PLANT NUTRITION

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Abstract

A deficiency in zinc, a mineral essential to numerous physiological processes in plants, would result in lower crop yields. The most common micronutrient shortage is zinc deficiency, which affects practically all crops and is predicted to be present in calcareous, sandy, peat, and soils with high levels of silicon and phosphorus. In order to achieve a notable increase in grain yield, the best zinc foliar spray rate fell between 1.0 and 1.5 kg Zn/ha. The possible harm that animals, humans, and plants may suffer from inadequate zinc bioavailability in soil. Moreover, proteins and other macromolecules may contain zinc as a component. Zinc is a component of proteins and serves as a structural, functional, or regulatory cofactor for numerous enzymes. Plants require zinc as a micronutrient. It promotes the synthesis of proteins and carotenoids, helps with hormone biosynthesis, and increases the activity of enzymes. In order for chlorophyll to develop, zinc functions as a catalyst. Symptoms of zinc deficiency include yellowing of the leaves of the wheat plant, white stripes forming on newly formed maize leaves, and chlorosis between the veins of the leaves. In sufficient zinc. The symptoms of chlorosis and iron deficiency are similar; however, white patches appear at the base of leaves in zinc deficiency, where as interveinal chlorosis extends the whole length of the leaf in iron deficit. Many factors, including soil pH, soil organic matter, soil moisture, soil temperature, and environment, all have an impact on zinc availability. Fertilizers high in zinc can be used to make up for soil zinc deficiencies.

Keywords: Zinc, plant nutrition, bioavailability, Zinc deficiency

Introduction

Plant nutrition is significantly influenced by micronutrients. Zinc is a crucial element that is essential to plant nutrition. In recent years, research on zinc has focused on finding ways to improve crop zinc levels and so lower human malnutrition, taking into account the quantity and quality of food grains produced to feed the growing population. Therefore, it is crucial to find methods for enhancing zinc in order to boost the production of food grains. The extraction of significant amounts of nutrients from the soil has negatively impacted soil fertility, even as crop production is rising. Because of the Green Revolution, the amount of microelements in high-yielding grain crops that are genetically poor in microelements decreases even more when they are cultivated on soils lacking in microelements. Zinc mining is a product of intensive agriculture and the subsequent micronutrient extraction. Fertilizers provide some of the essential elements, but because zinc-rich fertilizers are not used as much, soils are becoming more and more deficient in zinc. The low zinc content in the grains of high yielding cultivars is also declining. As a result, both humans and animals are negatively impacted by the declining production of grains, pulses, and vegetables, as well as by their declining quality. Consequently, in order to properly manage zinc, it is important to understand the symptoms brought on by this element's insufficiency as well as the factors that affect it.

Zinc's function in plant nutrition:

- It aids in the synthesis of proteins and carotenoids.
- The biological production of hormones benefits from zinc.
- Enzyme activity can be increased by zinc (like cysteine, enolase, disulfides etc.)
- In order for chlorophyll to develop, zinc functions as a catalyst.

Common symptoms of zinc deficiency:

1. It is very important to diagnose zinc deficiency in crops at the right time. Zinc deficiency in crops is determined on the basis of soil test, tissue test and visible symptoms in plants. In which we can get information about the right time and method of supplying zinc in plants. Generally, its deficiency causes chlorosis between the veins of the leaves.

2. The disease caused by its deficiency in paddy is known as Khaira disease. New leaves have bronze-colored spots;

zinc insufficiency is characterized by yellowing of the wheat plant's leaves and the appearance of white stripes on the newly formed maize leaves.

3. Generally speaking, it is also observed that when plants lack the element zinc, the plants do not exhibit any outward signs. "Hidden Hunger" is the name given to this illness. In such a scenario, crop productivity will suffer if zinc is not provided to the plant.

4. The intervenes of newly formed leaves exhibit leaf chlorosis. The area next to the veins, however, stays green. The leaves are curled, and the nodes are tiny. In vegetable crops, abnormal alterations in the color of the new shoots are observed. The leaves are bright, twisted, and speckled. The signs of iron shortage are comparable to foliar chlorosis brought on by zinc deficiency.

5. However, this discrepancy is easily explained by the fact that white spots are seen at the base of the leaves when there is a zinc shortage, whereas interveins and chlorosis are shown throughout the leaf when there is an iron deficiency.

6. Citrus plants exhibit aberrant interveinal chlorosis of the leaves, which makes the leaves appear tiny, pointed, and twisted. Fruit development is also significantly reduced. Apical leaf chlorosis is observed in old leaves of pulse crops, and at the same time, chlorotic patches cause the tissues to degrade and fall off.

7. The paddy plants' third or fourth leaf from the top has brown spots that, when zinc levels in the soil drop, eventually grow larger and cover the entire leaf blade. Roots grow stunted and there are fewer tillers. Growth halts. Earrings can cause infertility. Consequently, crop productivity declines. In gram, the leaves take on a reddish-brown (rust-like) look three to four weeks after seeding. The stem's remaining length between two nodes is decreasing. The plants continue to be little as a result.

Primary factors influencing zinc availability

Making sure zinc is available for plants is crucial. Zinc availability is influenced by physical, chemical, and biological activities that take place in soil.

1. Elements influence zinc's bioavailability

Zinc absorption is affected by dietary variables. These include "intrinsic" factors relating to the chemical makeup of zinc, which may increase or reduce its biological availability, and "external" factors, i.e., other chemical components of the diet that may impede or boost zinc absorption.

2. Soil pH value (acidity/alkalinity)

In soils with a pH of less than 0.6, zinc becomes more soluble and readily available. On the other hand, regions where paddy is planted on acidic soil have reported zinc deficiencies. Continuous irrigation of rice fields causes the soil's ability to reduce oxygen, which in turn causes sulphur to reduce and mix with zinc to generate zinc sulphide, which is less soluble in water. Zinc is less readily available as a result. Zinc is no longer as readily available in soil when the pH rises above 7.0.

3. Organic materials in the soil

Zinc can be effectively chelated by humic and fulvic acids, phenols, phenolic acids, and aliphatic acids found in soil organic matter. Its availability in plants therefore rises as a result. Organic acids produced by bacteria are in charge of oxidation-reduction and have an impact on zinc availability. Higher soil moisture content increases the deficit of calcium. Zinc availability is often decreased by water logging.

4. Environment

Zinc availability is often negatively impacted by cold and damp environments. Zinc is often more available when soil temperature rises. Occasionally, excessive levels of manganese and phosphorus in the soil might also cause zinc deficiency.

Several approaches can be used to correct zinc shortage in plants:

Soil amendments: You can raise the amount of zinc in your soil by adding fertilizers or amendments that contain zinc. If low soil zinc availability is the cause of the deficit, this strategy works well.

Foliar sprays: By directly applying zinc to leaves, deficiencies can be promptly remedied and soil-related absorption problems can be avoided. This technique works especially well for crops that are at key growth stages.

Crop rotation and management: Over time, increasing zinc availability can be achieved by crop rotation, soil pH management, and organic matter management.

Genetic selection: Reducing reliance on outside inputs can be achieved by breeding crops for increased zinc uptake efficiency.

Conclusion

Even though zinc is critical for plant health, soil availability can present challenges. Plants require appropriate zinc nutrition, which can only be achieved by using tailored management techniques and an understanding of soil conditions.

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PREDACITY OF *ARTHROBOTRYS DACTYLOIDES*: UNDERSTANDING ITS EFFICACY AND TRAPPING STRUCTURES

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Introduction

Arthrobotrys dactyloides, a species of carnivorous fungus belonging to the order Orbiliales, exemplifies nature's ingenious adaptation to acquiring nutrients through predation rather than traditional methods of absorption. Found in soil environments worldwide, particularly in nutrient-poor conditions, this fungus employs sophisticated trapping mechanisms to capture and consume microscopic prey such as nematodes. Its predacious behavior is not only a testament to evolutionary strategies but also offers insights into ecological balances and potential applications in biological control.

Habitat and Distribution

*Arthrobotrys dactyloides*_thrives in various terrestrial habitats, including forests, grasslands, and agricultural soils. It prefers environments where organic matter and nematodes are abundant, often found near plant roots or decaying plant material. This distribution reflects its adaptation to nutrient-depleted soils where conventional fungi might struggle to survive, thereby highlighting its ecological niche as a nematode predator.

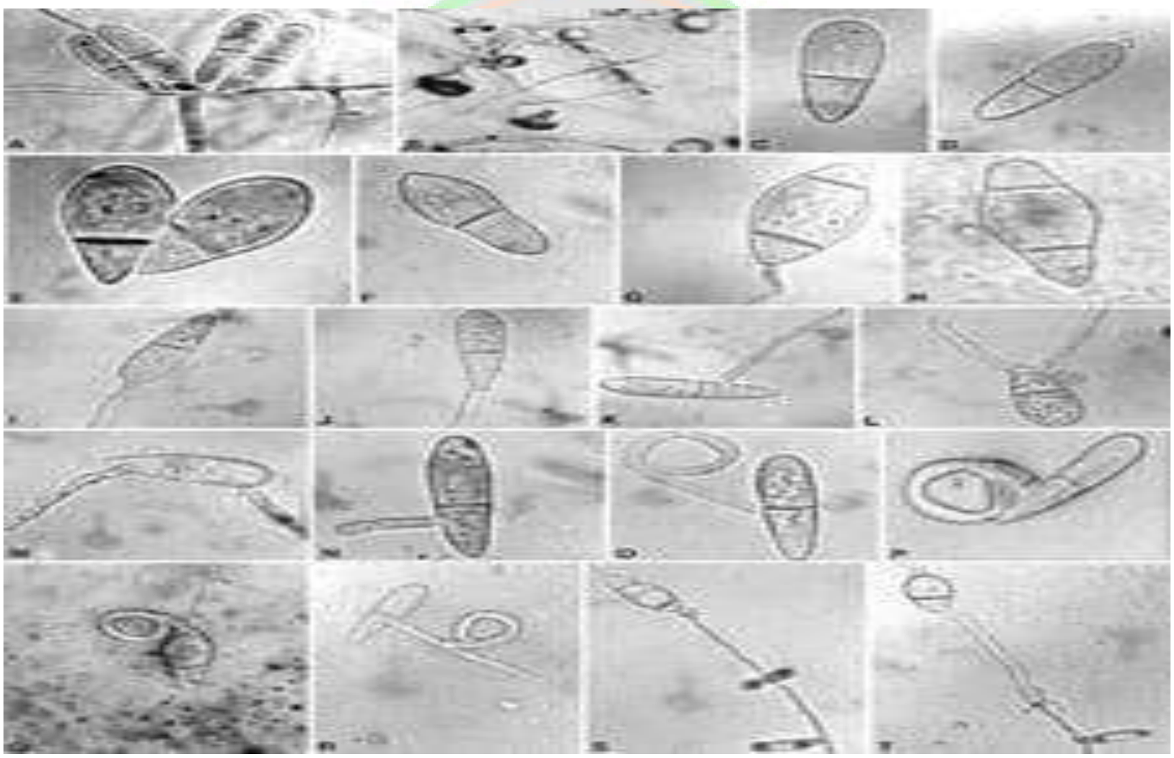
Trapping Mechanisms

The efficacy of *Arthrobotrys dactyloides* as a predator lies in its specialized trapping structures, which are finely tuned to capture nematodes actively. These structures include:

1. Adhesive Networks: One of the most distinctive features of *Arthrobotrys dactyloides* is its production of sticky networks composed of hyphal loops. These loops are equipped with adhesive knobs or rings that adhere to passing nematodes. As nematodes move through the soil, they inadvertently come into contact with these networks, becoming ensnared by the adhesive properties of the fungal hyphae.

2. Three-Dimensional Labyrinths: Beyond mere adhesive traps, some species of *Arthrobotrys dactyloides* construct intricate three-dimensional labyrinths. These labyrinths consist of hyphal loops arranged in a maze-like pattern, increasing the chances of nematodes stumbling into traps and reducing their ability to escape once ensnared.

3. Constricting Rings: In addition to adhesive traps, certain species within the genus Arthrobotrys possess specialized hyphal rings that can constrict around trapped nematodes. This mechanism functions similarly to a lasso, tightening upon contact with the nematode and preventing its escape. Once constricted, the nematode is immobilized and eventually digested by the fungus.



Trapping structure formed by spores and hyphae of *Arthrobotrys dactyloides*

Efficacy in Biological Control

The predatory nature of *Arthrobotrys dactyloides*_holds significant implications for agricultural and ecological applications, particularly in biological control strategies. By preying upon nematodes, which can be detrimental to plant health and soil fertility, this fungus offers a natural means of managing nematode populations without the need for chemical interventions.

This biological control method is eco-friendly and sustainable, aligning with modern agricultural practices that prioritize minimizing environmental impact

Fungal Morphogenesis

The ring formation and closure mechanism in *Arthrobotrys dactyloides* exemplifies a sophisticated adaptation to its predatory lifestyle. When a nematode comes into contact with the specialized hyphal loops of the fungus, triggered by chemical cues or physical contact, the fungal hyphae rapidly respond. The hyphal loops, equipped with adhesive knobs or rings, ensnare the nematode. As the nematode struggles to free itself, the hyphae exert tension, tightening the loop around the nematode's body. This constricting action is facilitated by the elasticity and structural integrity of the fungal hyphae, which are capable of exerting significant force relative to their size. Once the nematode is securely trapped within the ring, the fungus begins the process of digestion, secreting enzymes and absorbing nutrients from its prey. This mechanism not only demonstrates the fungus's ability to actively capture prey but also showcases its evolutionary adaptation to efficiently exploit nutrient resources in nutrient-poor environments.

Diversities in Arthrobotrys species

The genus Arthrobotrys encompasses a diverse group of fungi known for their predatory behavior towards nematodes. Within this genus, there exists considerable variability among species in terms of morphology, trapping mechanisms, ecological roles, and genetic characteristics. This variability allows different *Arthrobotrys* species to occupy various ecological niches and exhibit distinct adaptations for capturing and utilizing nematodes as a nutrient source. Here are some key aspects of variability observed among *Arthrobotrys* species:

1. Morphological Diversity: Arthrobotrys species exhibit a range of morphological adaptations that facilitate nematode predation. This includes variations in hyphal structures, such as the presence of adhesive loops, constricting rings, or three-dimensional labyrinths. Some species may also differ in the size, shape, and arrangement of their trapping structures, reflecting adaptations to different environmental conditions and prey types.

2. Trapping Mechanisms: While all Arthrobotrys species are predatory, the specific trapping mechanisms can vary significantly. Some species, like *Arthrobotrys oligospora*, are known for their adhesive networks and hyphal loops with adhesive knobs or rings that capture nematodes through physical entanglement. Others, such as *Arthrobotrys dactyloides*, may additionally employ constricting rings that tighten around trapped nematodes, immobilizing them for digestion. These variations in trapping mechanisms highlight the evolutionary diversity within the genus.

3. Ecological Niches: Different Arthrobotrys species occupy diverse ecological niches, ranging from terrestrial soils to aquatic environments. Their distribution and abundance often correlate with the availability of nematodes and other potential prey organisms in their habitat. Some species may specialize in particular soil types or plant associations, influencing their ecological roles and interactions within their ecosystems.

4. Genetic Diversity: Recent advances in molecular genetics have revealed genetic variability among Arthrobotrys species. Studies have identified genes responsible for the production of adhesive proteins, enzymes involved in nutrient acquisition from prey, and regulatory factors controlling trap formation. Understanding these genetic differences provides insights into the evolutionary history and adaptation of Arthrobotrys species to predatory lifestyles.

5. Biotechnological Applications: The variability among Arthrobotrys species extends beyond ecological and genetic realms to potential biotechnological applications. Certain species may hold promise for biological control of plant-parasitic nematodes in agriculture, while others could be studied for their enzymes or bioactive compounds with pharmaceutical or industrial uses. Exploring and harnessing this variability could lead to innovative solutions in agriculture, biotechnology, and environmental management.

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FUNCTIONAL FOODS AND NUTRACEUTICALS HEALTH BENEFITS

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Introduction

The foods classified as "functional" offer health benefits that go beyond simple nourishment. Functional food proponents assert that their products lower the risk of illness and encourage optimum health. Muesli is a well-known example of a functional food because it includes soluble fibre, which has the potential to decrease cholesterol. The Food and Drug Administration controls the claims that food makers are permitted to make regarding the nutritional value of functional foods and their impact on health, disease, or bodily functions.

A food that has more components or more of already-existing elements is referred to as functional food. The phrase can also refer to features intentionally included into already-existing food plants, such as purple or gold potatoes with higher levels of carotenoid or anthocyanin, respectively. According to the definition, "functional foods may be similar in appearance to conventional food and consumed as part of a regular diet; they may be specifically designed to have physiological benefits and/or reduce the risk of chronic disease beyond basic nutritional functions." Foods for Specified Health Use (FOSHU), a government-approved programme for functional foods, is where the word was originally used in Japan in the 1980s.

The phrase nutraceuticals was coined in 1989 by Stefen De Felice, who combined the words nutrition and pharmaceutical. He demonstrated how nutraceuticals are foods or dietary ingredients that have health or medicinal benefits, such as the ability to prevent sickness or treat it. They are available as tinctures, tablets, and capsules. A variety of items fall under the category of nutraceuticals, including functional drinks, genetically modified foods, herbal/protein/mineral/vitamin supplements, and other processed goods. underlined that food, or a portion of food, is utilised to create functional foods and nutraceuticals. These may resemble traditional meals in appearance. However, nutraceuticals are typically thought of as isolated or purified food forms that are sold as medications.

Many natural plant sources (fruits and vegetables, herbs, cereals), mal sources (dairy products, meat, eggs, animal foods), marine sources (crustaceans, fish, and fish waste), microalgae, fungi, algae/seaweed, and cyanobacteria/extremophiles with biologically active substances can all be used in the development of novel nutraceuticals products and functional foods. These substances can be used to fight against cancer, chronic disease, neurodegenerative diseases, and other health-related diseases.

Difference between nutraceutical and functional foods

Nutraceuticals and functional foods are the two main terminology used to characterise foods that promote health and nutrition. Nutraceuticals are nutritious materials that have been separated, refined, and created. They are sold as medicines and are typically not combined with food. They can be taken as pills, tinctures, or capsules. On the other hand, functional foods are consumed normally as part of a unique diet rather than in a dose that offers physiological advantages above and above those of basic nourishment. Otles and nutraceuticals, which include dietary supplements and other food types, are linked to medical claims that both prevent and cure disease; on the other hand, functional foods are common foods that just lessen sickness rather than both prevent and cure it.

Functional foods are those that include essential nutrients (vitamins, proteins, fats, carbs, etc.) that the body needs to survive in a healthy state. A functional food is referred to as a nutraceutical when it is used to prevent or treat any disease or disorders other than anaemia.

Definitions of Functional Food

Functional foods go beyond their fundamental nutritional content to provide extra or improved benefits. Certain functional foods, such as those with probiotics, prebiotics, plant stanols, and sterols, are centred around a specific functional ingredient. Breakfast cereals and bread fortified with folic acid are two examples of other functional meals or beverages that are fortified with a vitamin that is not typically present in significant amounts. A diversified, well-balanced diet and a healthy lifestyle should not be substituted by functional foods.

Foods with additional health-promoting qualities beyond their nutritional content are referred to as functional foods. The term "functional foods" refers to a very wide range of products, from staple everyday foods fortified with a nutrient that would not normally be present to any great extent to foods created around a particular ingredient, such as Stanols (sterol-enriched reduced), Low Fat Spreads, and Dairy Products containing Probiotic Bacteria.

History

The phrase "functional foods" was first used in Japan in the middle of the 1980s to describe processed foods that include nutrients together with substances that support particular body functions. Let food be thy medicine, as Hippocrates advised more than two millennia ago. While the idea of functional foods is not new, it has changed significantly throughout time. One of the earliest attempts at fortifying food to make it useful was when American food makers began adding "Iodine to Salt" in the early 1900s in an attempt to avoid goitre.

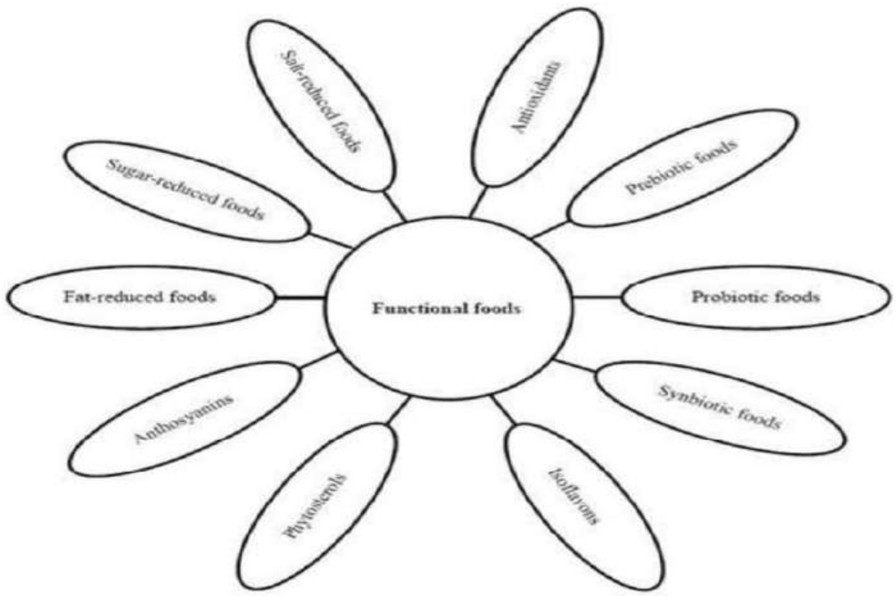
Other examples from the 20th century include fortifying milk with vitamins A and D, niacin, and folic acid in grains. However, the goal of these early examples of fortification was to lower the risk of deficiency-related disorders. Customers started to pay more attention to wellness and the decline in chronic illness in the later half of the 20th century. Nowadays, a lot of research focuses on how various lifestyle aspects, such as eating an ideal diet, might promote health. Hundreds of dietary ingredients have been shown to have functional properties as of 2002, and research into the many advantages of phytochemicals in food is still ongoing.

Benefits of Functional Foods

A traditional cuisine that we eat as part of our regular diets may also be a functional food. Because it includes bioactive chemicals, it has been demonstrated to offer physiological advantages and lower the risk of chronic disease.

A functional food is a regular food that has been supplemented with particular nutrients, such as probiotics, prebiotics, fibre, vitamins, or minerals. This generally refers to something used for a certain purpose.

When ingested at effective levels as part of a diverse diet on a regular basis, whole, fortified, enriched, or enhanced foods can offer health advantages beyond the provision of necessary elements, such as vitamins and minerals. These foods are referred to as functional foods. Replicated, randomised, placebo-controlled intervention trials involving human subjects are the "gold standard" for linking the use of functional foods or dietary constituents with health claims. But not every item that is sold as a functional food today actually is. This evaluation classifies a range of functional meals based on the kind, quality, and suggested intakes of the evidence that supports the food's functioning. In the field of food and nutrition sciences, functional foods are one of the topics that are now being researched and pushed the most. It is important to note that these meals and nutrients do not work as miracles or cure-alls for unhealthy lifestyle choices. A complete approach to optimal health consists of more than just diet.



Types of Functional Foods

1. Whole Food: It includes Oats, Soya, Fish, Garlic, Flaxseeds and Nuts, Grapes, Fruits and Vegetable.
2. Fortified Foods: It includes the following;
   - Fortified foods are natural foods fortified with other nutrients.
   - Cereal and Cereals-Based products fortified with Folic Acid.
   - Milk and Milk products are fortified with Vitamin B.
   - Fats and Oils are fortified with Vitamin D and E.
3. Enhanced foods are foods that have more of a functional component through traditional breeding, genetic engineering, etc., for example dairy product with probiotics. The benefits derived by these foods are as follows:
   - Reduce risk of Colon Cancer.
   - Treatment of Respiratory Allergies.
   - Control of Diarrhea and Dysentery Disorders.
   - Decreases the Cholesterol level thus reducing the risk of Heart Disease.

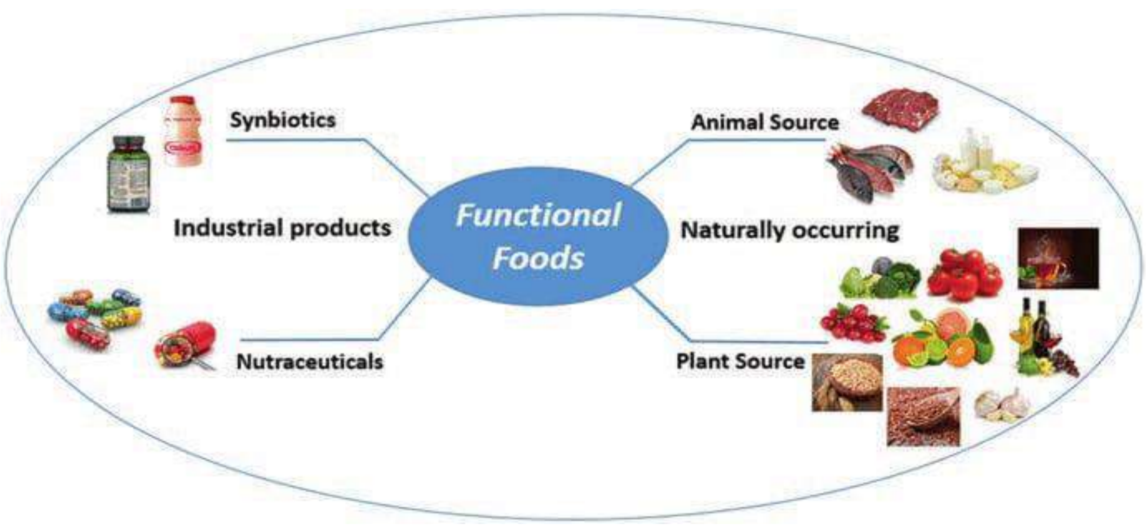
Sources

There are two categories of sources: (a) endogenous and (b) exogenous. For a source to be categorised as a prebiotic, it must be demonstrated that it benefits the host. Prebiotics that are fermentable and produced from xylans and fructans are the best studied; lactose is the starting point for the enzymatic synthesis of galacto oligosaccharides. Prebiotic sources can also be found in external dietary sources and extra endogenous prebiotics. Another form of prebiotic food is functional foods that contain prebiotic food components. Nevertheless, food sources include very little FOS and inulin, making it challenging to get enough prebiotics from diet alone.

Dietary fibre is the main prebiotic source. They can be found in fruits and vegetables by nature. However, not every dietary fibre can be categorised as a source of prebiotics. Prebiotics have been shown to provide certain health benefits, however the prevalent kinds of dietary fibre found in most plant-based meals and grains are not as selectively fermented by gut bacteria.

Endogenous: Human breast milk, which includes oligosaccharides structurally identical to GOS and known as Human Milk Oligosaccharides (HMOs), is an endogenous source of prebiotics in humans. It was discovered that these HMOs boosted the Bifidobacterium bacterial population in breastfed babies and fortified their immune systems. Moreover, HMOs contribute to the development of a newborn's gut microbiota's balanced makeup.

Exogenous: Digestible carbohydrates that are categorised as prebiotics can be categorised as dietary fibre because they are a form of fermentable fibre. Still, not all dietary fibre falls into the prebiotic category. Prebiotic fibre sources include raw oats, unpolished barley, yacon, and whole grain breakfast cereals, in addition to the foods listed in Table 1.3 below.



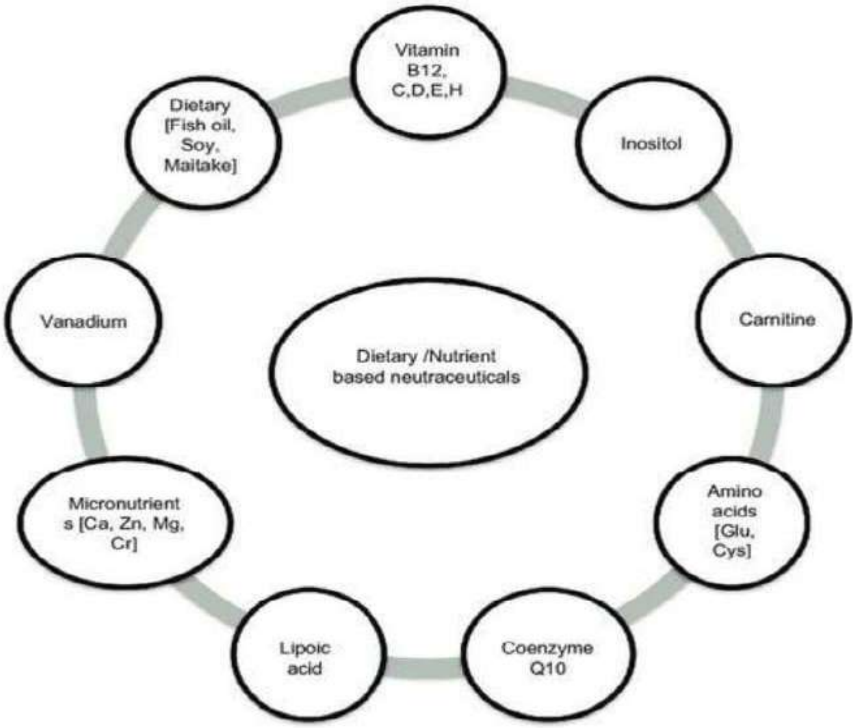
Depending on the meal, different prebiotic fibre types may predominate. For example, fruits and berries include pectin, seeds contain gums, onions and Jerusalem artichokes are rich in inulin and oligofructose, while bananas and legumes contain resistant starch. Oats and barley are also high in beta-glucan.

Nutraceutical

The term "nutraceutical" was first used in 1989 by Stephen L. DeFelice, the chairman and creator of the Foundation of Innovation Medicine. It combines the phrases "nutrition" and "pharmaceutical." Unlike the natural herbs and spices that have been used for generations in Asian folk medicine, the nutraceutical sector has developed in tandem with the advancement and investigation of contemporary technology. A pharmaceutical substitute that offers physiological advantages is called a nutraceutical or bioceutical. The Food and Drug Administration (FDA) asserts that "nutraceuticals" are essentially unregulated since they fall under the same category as dietary supplements and food additives, as permitted by the Federal Food, Drug, and Cosmetic Act (FFDCA). Nutraceuticals are unique food-derived products that offer additional health advantages beyond the fundamental nutritional content found in food; as such, they are also referred to as functional foods. These nutraceutical or bioceutical goods can postpone ageing, enhance health, prevent chronic diseases, lengthen life expectancy, or support an organ's structure or function, depending on the relevant jurisdiction. During processing, functional foods are supplemented or fortified to offer some advantage to the customer. Supplementary nutrients, such vitamin D, are occasionally added to milk.

Health Benefits:

Since they can lower arthritis pain, increase energy, strengthen immunity, improve liver function, prevent cancer and heart disease, suppress AIDS, regulate appetite, and protect cells from X-ray or heavy metal-induced cell damage, spirulina and kelp have both been dubbed "miracle cures." These two seaweeds, kelp and spirulina, are healthful additions to a vegetarian or macrobiotic diet because they offer important elements like minerals, protein, and carotenoids. Since they can lower arthritis pain, increase energy, strengthen immunity, improve liver function, prevent cancer and heart disease, suppress AIDS, regulate appetite, and protect cells from X-ray or heavy metal-induced cell damage, spirulina and kelp have both been dubbed "miracle cures." These two seaweeds, kelp and spirulina, are healthful additions to a vegetarian or macrobiotic diet because they offer important elements like minerals, protein, and carotenoids.



Nutraceuticals as Remedy/Therapy

Nutraceuticals are broad-spectrum biological treatments that are intended to enhance health, avert cancerous developments, and manage symptoms. These fall under the three main groups listedbelow:

- Elements: The materials having known nutritional properties, such as vitamins, minerals, amino acids, and fatty acids, are referred to as nutrients.
- Herbals: Plant-based materials like extracts and concentrates.
- Dietary supplements: substances obtained from different sources (such as pyruvate, chondroitin sulphate, and steroid hormone precursor) that are used for sports, nutrition, supplements for weight loss, and meal replacements.

Nutraceuticals and functional foods market in India

In recent decades, functional foods have aggressively entered the global food market and quickly increased their market share due to the fast growing consumer knowledge of healthful diets. The market for nutraceuticals, which include body building tools, weight loss products, sports and energy beverages, and dietary supplements, is expanding rapidly. The United States, Europe, and Japan account for about 93% of the world's nutraceuticals market, which was estimated to be worth $160.6 billion in 2013 and increased to $171.8 billion in 2014. The market is anticipated to increase at a compound annual growth rate (CAGR) of 7.0% from 2014 to 2019 to reach $241.1 billion.

The demand for nutraceuticals and the functional food industry in India are expanding quickly due to consumer awareness of health and fitness, as well as customer willingness to pay for these foods and additives. The functional food and beverage segment accounts for 68% of the Indian nutraceuticals industry, while dietary supplements make up 32%. The expanding middle class in India is driving the emergence of the functional food and beverage business, mostly because of the country's increased purchasing power and belief in Ayurveda and traditional wisdom.

The nutraceutical market is estimated to be worth USD 2.2 billion. The southern regions of the nation, such as Tamil Nadu and Andhra Pradesh, dominate the nutraceutical market, which is followed by West Bengal and the eastern states. By 2019–2020, the Indian nutraceuticals market is expected to grow at a 20% annual rate to reach $6.1 billion. By 2018, the fortified food industry is expected to grow at a compound annual growth rate (CAGR) of 21.7%. In India, the neutraceutical market is dominated by vitamins and minerals with around 36% of the market share, probiotics with 9.0%, and ω-3 fatty acids with 5.0 per cent.

Merck, BASF, and DSM dominated the vitamin and mineral market. Additionally, DSM controls a large portion of the w-3 fatty acid industry. In contrast, Danisco, Chr. Hansen, and Yakult control the probiotic market.

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MONACROSPORIUM: A KEY PLAYER IN SUSTAINABLE NEMATODE MANAGEMENT FOR AGRICULTURE

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Introduction

Monacrosporium is a genus of fungi known for its unique ability to trap and consume nematodes, making it a subject of interest in both agricultural and ecological studies. These fungi employ specialized structures such as adhesive networks, adhesive knobs, and constricting rings to capture their prey, which they then digest and absorb for nutrients. This predatory behavior helps regulate nematode populations, offering potential benefits in natural and agricultural systems by controlling nematode pests. *Monacrosporium* species is broad and encompasses various environments where nematodes are abundant. These fungi are commonly found in soil, where they play a role in the natural suppression of nematode populations. They inhabit agricultural soils, contributing to the control of plant-parasitic nematodes, and can also be found in forest soils, grasslands, and decaying organic matter. Beyond terrestrial habitats, *Monacrosporium* species are present in aquatic environments, including freshwater and marine sediments, where nematodes also thrive. Their widespread occurrence highlights their ecological importance and potential utility in biological control strategies against nematodes.

Classification

- **Kingdom**: Fungi
- **Phylum**: Ascomycota
- **Class**: Orbiliomycetes
- **Order**: Orbiliales
- **Family**: Orbiliaceae
- **Genus**: *Monacrosporium*

Habitat

Monacrosporium species are a group of nematophagous (nematode-trapping) fungi that inhabit a variety of environments where their prey, nematodes, are found. These fungi can be found in diverse habitats such as soil, decaying organic matter, and compost. They are widespread in agricultural soils, forest soils, and grasslands.

The fungi employ different mechanisms to trap nematodes, including adhesive networks, adhesive knobs, and constricting rings. Their presence in these environments is often associated with the abundance of nematodes, as they rely on these organisms for nutrients. Additionally, *Monacrosporium* species are also found in aquatic environments like freshwater and marine sediments where nematodes are prevalent.

Nematophagous Nature

Mechanism of Nematode Trapping

Monacrosporium fungi use several methods to capture nematodes. These include:

1. **Adhesive Networks**: *Monacrosporium* forms adhesive hyphal networks that ensnare nematodes as they move through the soil.
2. **Constriction Rings**: Some species produce constricting rings that close tightly around a nematode when it tries to pass through, trapping it.
3. **Adhesive Knobs**: Certain species develop specialized adhesive structures called knobs that stick to nematodes upon contact.

Media and incubation

For the isolation of nematophagous fungi and the induction of trapping organs with added nematodes, water agar (WA) was used: 2% agar, tap water. For most other purposes half-strength cornmeal agar (CMA:2) was used: 8.5 g cornmeal agar, 12.5 g (additional) agar and aqua dest. ad 1 l. Potato-carrot agar (PCA) as an alternative to CMA:2 was prepared as indicated in the CBS Course of Mycology. Malt-extract agar (MEA, 10 g dry biomalt from Oxoid, 15 g agar, 10 ml KOH (10 %), aqua dest. ad 1 l, final pH 7) as a rich medium was also tested; however, most isolates formed more aerial mycelium and fewer conidia on this substrate. Fungi were usually cultivated on agar media in Petri dishes (9 cm diam.). To obtain more biomass for ubiquinone analyses, fungi were grown in liquid cultures on malt-extract solution in 1 litre conical flasks. Colonies were generally incubated at room temperature (approx. 23 ºC) under daylight. All measurements, unless indicated otherwise, were made from CMA:2 cultures, on which the fungi usually sporulated well. The isolates were then preserved on the same medium as agar slants and stored at 6 ºC with annual transfers. Herbarium specimens were made from CMA:2 cultures, which were killed by a drop of formalin (37 %) and dried at room temperature.

Trapping organ formation in different species of monacrosporium

species	Trapping organ	Production in culture	conidia
M. cionopagum	hyphal branches	+	-
M. bembicodes	constricting rings	-	-
M. doedycoides	constricting rings	+	+
M. drechsleri	stalked knobs	+	+
M. ellipsosporum	stalked knobs	+	-
M. gephyropagum	hyphal branches	+	+
M. mammillatum	stalked knobs	+	-
M. parvicolle	proliferating knobs	+	+
M. phymatopagum	unstalked knobs	+	-
M. reticulatum	adhesive network	+	+
M. rutgeriense	adhesive network	+	+
M. thaumasium	adhesive network	+	+

Significant role of *monacrosporium* fungi in field crops for nematode control

Nematophagus fungi, such as *Monacrosporium*, play a crucial role in the management of nematode populations in field crops. These fungi are natural predators of nematodes, which are microscopic roundworms that can cause significant damage to crops by feeding on plant roots. *Monacrosporium* fungi capture and kill nematodes through various mechanisms, including the production of specialized structures like adhesive networks or constricting rings. By reducing nematode populations, these fungi help improve plant health and increase crop yields.

The use of nematophagus fungi as a biological control agent offers several advantages over chemical nematicides. It is environmentally friendly, reducing the need for chemical inputs and minimizing the risk of soil and water contamination. This approach also helps maintain soil biodiversity, as it targets specific pests without harming beneficial soil organisms. Additionally, the fungi can establish a sustainable presence in the soil, providing long-term protection against nematodes. incorporating *Monacrosporium* fungi into integrated pest management (IPM) strategies can enhance the overall effectiveness of pest control programs. By combining biological control with other practices such as crop rotation, resistant crop varieties, and organic amendments, farmers can achieve more sustainable and resilient agricultural systems. The use of nematophagus fungi aligns with the principles of sustainable agriculture, promoting healthy soils and reducing dependency on synthetic chemicals. research continues to explore the potential of *Monacrosporium* and other nematophagus fungi in various cropping systems. Studies focus on understanding their ecology, optimizing their application methods, and evaluating their efficacy under different environmental conditions. The development of commercial formulations and application technologies is also underway to facilitate their adoption by farmers. The significance of *Monacrosporium* and similar nematophagus fungi in field crops lies in their ability to provide an effective, environmentally friendly solution for managing nematode pests. By integrating these fungi into crop management practices, farmers can enhance crop productivity, reduce chemical inputs, and contribute to the sustainability of agricultural ecosystems.

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VULNERABILITY OF AGRICULTURE TO CLIMATE CHANGE IN UTTARAKHAND

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Abstract

Traditional agriculture is the main industry in Uttarakhand's mountainous regions. Almost two-thirds of the population lives in difficult hillside communities with difficult living circumstances and typical topography, and works in this agrarian economy. Due to its limited capacity for adaptability, the impracticability of rainfed agriculture, structural limitations, and fluctuating rainfall patterns, the agricultural sector risks vulnerabilities and outmigration. The population dynamics in areas of origin are greatly affected by outmigration, as the aging of younger generations poses a challenge to the viability of rural agriculture because of the reliance on family labor. The geography of Uttarakhand has an impact on the degree of infrastructural development required for agricultural expansion, which in turn affects how vulnerable rural communities are. Limited capacity for adaptation, dependency on rainfed agriculture, and ecological, infrastructural, human, and financial constraints all contribute to the region's vulnerability and migration. Agricultural vulnerability can be decreased by supplying techniques for adaptation and bolstering community capacities. Reducing topographical restrictions on agriculture can be achieved by embracing multiple livelihood alternatives. In order for farmers to live sustainably, they need to develop their knowledge, abilities, and practices in order to boost food grain output, productivity, and quality. These factors are critical to agriculture's profitability and sustainability.

Keywords: vulnerability, rainfed agriculture, outmigration, adaptation, sustainability

Introduction

The majority of agriculture in Uttarakhand's mountainous regions is traditional in nature, with a variety of intricate elements. This area has an agrarian economy, with almost two thirds of the population working in agriculture either directly or indirectly. These people live in traditional hillside communities with challenging living conditions and typical geography. The primary occupation of households in this region is agriculture, along with horticulture and animal husbandry, which places a significant strain on the population living on arable land (Joshi *et al*. 2023).

Because they are typically the ones to stay, women and the elderly will bear a disproportionate amount of the consequences of climate change, which are predicted to be especially severe in the sensitive mountainous areas. (GU 2014; Joshi 2018; Upadhyay *et al* 2021).

The size and makeup of the populations in the areas of origin are significantly impacted by the shift in population dynamics brought about by outmigration. The aging population that results from younger people migrating away from home villages threatens the viability of rural agriculture, which depends on family labor.

Vulnerability due to climate change

Vulnerabilities and outmigration are caused by the agricultural sector's limited potential for adaptation. The unviability of rainfed agriculture and the absence of any other viable means of subsistence are major factors in the decisions made by many households about migration. Other structural constraints (road access, irrigation infrastructure, limited land holdings) and shifting rainfall patterns that impact crop production further exacerbate this (Mishra 2014; Joshi 2018).

While social and economic reasons, such as the availability of financial resources, market accessibility, and the absence of facilities for education and communication, play a significant role in determining outmigration, agricultural and ecological variables also play a significant role. The local environment and circumstances determine which vulnerability variable is most pertinent.

In Uttarakhand, the majority of villages lack the socioeconomic resources, forests, and other natural resource bases needed to sustain agriculture. The region's topography has significantly influenced the degree of infrastructure development required to sustain agricultural growth. The state's geography has a significant impact on how vulnerable agricultural towns are by nature (Shukla *et al*. 2016).

Challenges in agriculture

The state of Uttarakhand's agriculture industry is subject to a number of restrictions. Geographical factors, insufficient irrigation, marketing issues, and transportation issues are to blame (Verma *et al*. 2022).

Major challenges in agriculture sector are:

- Small Size, Fragmented, and Terrace Fields
- Low fertility of soil
- Lack of Modern Technology
- Irrigation as an issue
- Use of Traditional Seed and Fertilizer
- Traditional Cropping Pattern
- Threats to Wild Life
- Change in Climate
- Geohydrological Disasters
- Marketing Constraints

Conclusion

The primary factor influencing vulnerability and migration in the region is limited adaptation capacity, specifically the region's significant reliance on rainfed agriculture combined with ecological, infrastructural, human, and financial constraints. Higher vulnerability is associated with younger migration, a greater tendency toward short-term migration, and an increasing use of migration as a reaction to livelihood hazards and structural vulnerabilities. Young boys leaving their towns of origin have a significant impact on them since the population they leave behind ages and becomes more feminine (Biella *et al*., 2022).

It is vital to strengthen community capacities and provide them with the tools they need to put appropriate adaptation strategies into place in order to lessen the inherent vulnerability of agricultural communities. Nevertheless, by pursuing a variety of livelihood opportunities that could take advantage of the area's abundant natural resources, topographical constraints on agriculture can be lessened (Shukla *et al*. 2016).

Profitability and sustainability are essential for agriculture to maintain steady production growth. In order for farmers to survive and make a sustainable living, there is a need to raise widespread understanding of the knowledge, skills, and practices that can be used to increase food grain output, productivity, and quality (Verma *et al*. 2022).

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BIOLUMINESCENCE A NATURAL MICROBIAL PHENOMENON

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Introduction

The phenomenon of light emission that occurs in living things as a result of an oxidation reaction catalyzed by an enzyme is known as bioluminescence. With a variety of luciferases and luciferins, the enzymes and light-emitting molecules involved in light emission, respectively, bioluminescence may be found in almost all kingdoms of life. Bioluminescent species emit light between 400 and 700 nm, ranging from blue to red. The most prevalent hues in light emission are various shades of blue, closely followed by green. Very few species have light that is violet, yellow, orange, or red. This affinity for a particular color stems from the fact that bioluminescent organisms are primarily found in saltwater, which is best penetrated by blue light (λmaxca. 475 nm).

Bioluminescence has appeared independently in nature on several times. This characteristic has been documented for close to 700-800 genera across 13 phyla, encompassing both bacterial and eukaryotic species in many situations, the evolutionary patterns of bioluminescence demonstrate exceptional convergent evolution, either because the characteristic serves almost identical goals in numerous species or because the biochemistry of the chemicals involved is comparable (Dunlap *et al.*,2008). Bioluminescent creatures can be found both on land and in water. Nevertheless, aquatic species are found only in marine environments.

Bacterial bioluminescence

It is widely believed that bacterial bioluminescent systems were among the earliest to emerge in natant. Around the world, bioluminescent bacteria can be found in both aquatic and terrestrial environments. In reality, these bacteria can be easily obtained from any tissue or detritus found on beaches, as well as from raw fish. These microbes produce the amazing effect of shimmering oceans, which can be seen-or rather, enjoyed-in many different places across the globe (Widder, 2010).

Bioluminescent bacteria are classified as Gamma proteobacteria and can be found in three genera: Vibrio, Photobacterium, and Xenorhabdus. Vibrio and Photobacterium are primarily found in marine areas, while Xenorhabdus lives in terrestrial habitats. Bioluminescent bacteria can exist in free-living, symbiotic, or even pathogenic forms. For example, *Vibrio fischeri* has been observed to colonize specialized "light organs" in the fish *Monocentris japonicus*, and it also demonstrates mutualistic connection with Hawaiian squid. *Euprymnia scolopes* and other Photobacterium species have been shown to symbiose with numerous fish, molluscs, and other organisms, as well as cause disease in some of them (Labella *et al.,* 2017). There has been no genetic change in the bacterial genome for the aforementioned symbiosis. According to one theory, bioluminescence in bacteria developed because it encourages symbiotic behaviour and gives the microorganisms a survival edge. The symbiotic activity may be aided further by the bacteria's luminous machinery, which aids in the elimination of reactive oxygen species produced in host tissue. The symbiotic bacteria are received from outside sources, and the hosts exhibit some selectivity towards the symbiont. It appears that the host organisms 'select' the colonizing symbiont based on the availability at the depth where they live. In addition, the aforementioned hosts have the option to discard the symbiont cells in order to manage their population.

Fungal bioluminescence

Approximately 71 to 80 fungal species have been reported to display bioluminescence out of all the fungal species that have been studied to date. According to Kotlobay *et al.,* (2018), all of the aforementioned species have been arbitrarily divided into four separate lineages that are not very closely related. Common examples of bioluminescent mushrooms are Jack-o-Lantern Mushrooms from the Omphalotus family and Honey Mushrooms of the Armillaria lineage, which are the species responsible for the foxfire phenomena. Fungal bioluminescence can be traced back to a single evolutionary ancestor, as demonstrated by cross-reactions between distant lineages' luciferins and luciferases that successfully yield light.

Why Bioluminescence?

Camouflage

Many animals that live in the deep waters of the world's seas and oceans employ bioluminescence as a form of camouflage against illumination. From above, the organism appears to blend into the background thanks to photoreceptors in specialized light organs that adapt to the light levels in their surroundings. For instance, a number of squid species use this bioluminescence technique.

Defence

Bioluminescence is a defence mechanism employed by numerous phytoplankton species against their predators. It is believed that this feature evolved to ward off predators who do not want to attract other predators, as potential carnivores will release any light-emitting phytoplankton species. Predatory fish in deeper waters have black stomach linings, which block the glow from any bioluminescent species they may have eaten. This observation lends more credence to this theory.

Attracting prey

Certain types of fungus gnats live in cave habitats, and their larvae create silk webs that glow blue or green to attract prey through a process known as bioluminescence. Even circadian rhythms control this type of luminescence, which turns on and off at specific times of the day.

Visualization of Prey

Certain creatures that live in the deep ocean use red bioluminescence to see reddish species of prey that are normally unseen in deeper seas. Certain species, like dragonfish, have unique retinal pigment in their eyes that causes them to see their prey as blue-green rather than red, even though they generate red bioluminescence.

Attracting mates

Many insect species employ bioluminescence to entice potential mates, such as click beetles and fireflies. Similar to this, a lot of crabs use luminescence as a visual cue for possible mates, whom they entice by producing pheromones. Many species imitate other species in order to employ bioluminescence as a lure for prey. Some fish that live in deep waters, like anglerfish, have an appendage that glows in the dark to attract food.

Warning

Numerous animals employ bioluminescence as a means of alerting prospective predators of their unfitness for ingestion. This feature is seen in a wide variety of worm, jellyfish, and insect larvae as a means of scaring off potential predators.

Communication

Communicating cell density and the location of neighboring bacterial colonies is one widespread use of bioluminescence between fungal and bacterial species. The concentration of chemicals secreted into the environment controls these genes.

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HORIZONTAL GENE TRANSFER IN PROKARYOTES

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Introduction

Horizontal gene transfer (HGT) refers to the stable transfer of genetic material from one organism to another without reproduction. The significance of horizontal gene transfer was first recognised when evidence was found for 'infectious heredity' of multiple antibiotic resistances to pathogens (Paquola *et al.*, 2018). The assumed importance of HGT has changed several times but now it is consider as a major, if not the dominant, force in bacterial evolution. Massive gene exchanges in completely sequenced genomes were discovered by deviant composition, anomalous phylogenetic distribution, great similarity of genes from distantly related species, and incongruent phylogenetic trees (Nykyri *et al.*, 2012). There is also much evidence now for HGT by mobile genetic elements (MGEs) being an on-going process that plays a primary role in the ecological adaptation of prokaryotes. The dissemination of antibiotic resistance genes by HGT allowed bacterial populations to rapidly adapt to a strong selective pressure by agronomically and medically used antibiotics. MGEs shape bacterial genomes, promote intra-species variability and distribute genes between distantly related bacterial genera. Mobile genetic elements (MGEs) such as plasmids, Bacteriophages, integrative conjugative elements, transposons, IS (insertion sequence) elements, integrons, gene cassettes and genomic islands are the important vehicles in HGT.

MGEs play a significant role in HGT in three ways:

1) MGEs have evolved mechanisms that enhance the potential for gene transfer between organisms. For example, conjugative elements and viruses have evolved highly efficient mechanisms for the passage of genes into a recipient cell.

2) MGEs can alter the function of genes in the vicinity of the insertion in the host genome. These alterations can include disruption or inactivation of genes at the site of insertion. Conversely, insertional mutagenesis by MGEs can also result in benefits to the host such as provision of regulatory sequences, repair of double stranded DNA breaks, or genome restructuring and speciation.

3) HGT of MGEs can result in the transfer of additional genes through genetic piggy-backing. For example, MGEs are the primary vehicles for the spread of antibiotic genes, pathogenic determinants, and biodegradation pathways amongst bacteria (Larraín-Linton *et al*., 2006).

Mechanisms of Horizontal Gene Transfer

There are three primary mechanisms through which HGT occurs in prokaryotes:

1. **Transformation**: This process involves the uptake of free DNA from the environment by a bacterial cell. Natural competence, the ability of a cell to take up DNA, varies among species and can be induced by certain environmental conditions. Once inside the cell, the foreign DNA can be integrated into the host genome through recombination.
2. **Transduction**: In this mechanism, Bacteriophages (viruses that infect bacteria) transfer genetic material from one bacterium to another. There are two types of transduction:
   - **Generalized Transduction**: A phage accidentally packages host DNA instead of its own during replication and transfers it to a new host during infection.
   - **Specialized Transduction**: A phage integrates its genome into the host's chromosome and, upon excision, carries adjacent bacterial genes along with it to a new host.
3. **Conjugation**: This process involves the direct transfer of DNA from one bacterium to another through physical contact, typically via a pilus. Conjugative plasmids, such as the F plasmid in Escherichia coli, play a significant role in this process, often carrying genes for antibiotic resistance, virulence factors, and metabolic functions.

A fourth method of gene transfer between prokaryotes has been identified more recently called as Gene transfer agents (GTAs). These are tiny, virus-like particles that transfer random genomic fragments from one prokaryotic species to another. Genetic alterations done by GTAs are occasionally having high frequency in comparison to other evolutionary processes. The first GTA was characterized in 1974 using purple, non-sulfur bacteria. Purple, non-sulfur bacteria were used in 1974 to characterize the first GTA. These GTAs transfer random DNA fragments from one organism to another. They are believed to be Bacteriophages since they have lost the ability to reproduce on their own. The ability of GTAs to act with high frequency has been proven in controlled studies using marine bacteria. It has been estimated that the number of gene transfer events in marine prokaryotes, caused by viruses or GTAs, can reach up to 10^{13} annually in the Mediterranean Sea alone. It is believed that viruses and GTAs are effective HGT vehicles that have a significant influence on bacterial evolution.

Detection of horizontal gene transfer in bacterial genomes

There are two strategies used for detecting HGT

- **Phylogenetic methods** compare the evolutionary history of each gene
- **Compositional methods** were based on gene content, such as G+C content, nucleotide, oligonucleotide, amino acid usage or codon adaptation index, these features have been proposed as ‘**signatures**’. Any gene deviating from the ‘signature’ can be marked as a horizontal gene transfer candidate.

Although HGT can increase genetic diversity and promote the spread of novel adaptations, it can also result in excess genetic baggage and the import of deleterious genes. Therefore, organisms possess a number of physical, biochemical and genetic barriers to restrict the frequency of HGT (Kurland, 2005). Some of the barriers to HGT include the physical integrity of the cell;restriction-modification systems that recognise and hydrolyse foreign gene sequences; requirements for self-recognition sequences (*e.g.*, the genomes of *Haemophilus* and *Neisseria* have multiple copies of short sequences required for recognition and uptake by transformation); sequence specificity for integration into the recipient genome by homologous recombination; presence of inappropriate regulatory signals; nucleotide composition adaptations for optimised gene expression; mismatch repair systems; and natural selection. In general, the stringency of barriers to HGT increases proportionally with genetic distance. Consequently, the frequency of HGT is much greater within species than between unrelated or distantly related species.

Factors influencing Horizontal Gene Transfer

- The inherent capability of the parental bacterium to transfer genes
- The ability of the transgenic bacterium to survive in the environment,
- The presence of suitable recipient bacteria in the environment, and

- Various environmental factors that may affect microbial activity and transfer, such as water content, nutrient status, clay mineralogy, pH, etc.

Impact of Horizontal Gene Transfer

HGT has several significant impacts on prokaryotic populations and ecosystems:

1. **Antibiotic Resistance**: HGT is a major driver of the spread of antibiotic resistance genes among bacterial populations. Resistance genes can be acquired from other bacteria or environmental sources, leading to the rapid emergence of multidrug-resistant strains.
2. **Metabolic Adaptation**: Prokaryotes can acquire genes that allow them to utilize new substrates or adapt to different environmental conditions. For example, genes for degrading pollutants or metabolizing unusual carbon sources can be transferred via HGT.
3. **Pathogenicity**: HGT can confer virulence factors, such as toxins and adhesion molecules, enabling non-pathogenic bacteria to become pathogenic. This process is well-documented in pathogens like *Escherichia coli* and *Vibrio cholerae*.

Examples of Horizontal Gene Transfer

1. **MRSA (Methicillin-Resistant Staphylococcus aureus)**: The acquisition of the mecA gene, which encodes a penicillin-binding protein with low affinity for β-lactam antibiotics, has led to the emergence of MRSA. This gene was likely acquired through HGT from a related species.
2. **Gene Transfer Agents in Rhodobacter**: Some bacteria, like those in the genus *Rhodobacter*, produce gene transfer agents (GTAs) that package random segments of the bacterial genome and facilitate gene exchange between cells. This unique mechanism enhances genetic diversity within populations.
3. **The Evolution of Chloroplasts and Mitochondria**: HGT has played a crucial role in the evolution of eukaryotic cells. Endosymbiotic theory suggests that chloroplasts and mitochondria originated from free-living bacteria that were engulfed by ancestral eukaryotic cells. The transfer of genes from these endosymbionts to the host genome has been a key factor in the development of these organelles.

Conclusion

Horizontal gene transfer is a powerful mechanism driving the evolution and adaptation of prokaryotes. By facilitating the rapid acquisition of new traits, HGT enables bacteria and archaea to thrive in diverse and changing environments. Understanding the mechanisms and consequences of HGT is essential for addressing challenges related to antibiotic resistance, microbial pathogenicity and biotechnology applications.

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THE SECRET LANGUAGE OF PLANTS: UNVEILING THE COMPLEX WEB OF PLANT COMMUNICATION

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Introduction

Imagine a world where plants talk to each other, exchanging vital information about threats, resources, and even coordinating their growth and defense strategies. While this might sound like science fiction, the reality is that plants do communicate, albeit in ways that are often imperceptible to us. From emitting chemical signals to sending electrical impulses and even producing sounds, plants engage in a complex web of communication that shapes their interactions with the environment and other organisms.

Chemical Signaling: The Scent of Survival

When a plant is attacked by pests or damaged, it releases volatile organic compounds (VOCs) into the air. Remarkably, neighbouring plants can detect these chemical cues and prepare themselves for potential threats. This airborne communication, first documented in 1983, has since been observed in various plant species. Through VOCs, plants engage in a silent dialogue with their surroundings, influencing everything from growth and development to defense mechanisms.

Mycorrhizal Networks: Underground Connections

Beneath the soil, mycorrhizal networks (MNs) act as conduits for the exchange of resources and signals between plants. These networks, formed in partnership with fungi, facilitate the transfer of nutrients and information among interconnected plants. Recent studies have even suggested that plants can recognize and preferentially share resources with kin, highlighting the complexity of their social interactions underground. Recently, researchers delved into the concept of **"Kin Recognition"** by conducting experiments on multiple families of Douglas Fir trees planted within a specific plot. Through meticulous carbon tracing, the study revealed a fascinating discovery: trees belonging to the same family exhibited a notably higher level of carbon sharing compared to those from unrelated families. This finding suggests that these trees possess a remarkable ability to discern familial ties and prioritize support among genetic relatives within the forest community.

Electrical Signaling: Wired for Communication

Plants may lack nerves and brains, but they are far from silent observers of their environment. Through electrical signals, plants can rapidly transmit information across long distances, coordinating responses to external stimuli such as damage or changes in temperature. The phloem, often described as a 'green cable,' serves as a conduit for these electrical impulses, enabling plants to communicate with precision and speed.

Bioacoustics: The Symphony of Plant Life

While the idea of plants making sounds may seem far-fetched, emerging research suggests otherwise. Plants emit and respond to acoustic vibrations, potentially playing a role in their growth and development. Though the mechanisms behind plant acoustics remain elusive, scientists are increasingly recognizing the importance of sound and vibrations in understanding plant physiology.

Communication with Microbiota: Partners in Growth

Below ground, plants engage in complex dialogues with microbial communities residing in their roots. Through chemical signals and quorum sensing mechanisms, plants and microbes collaborate to improve nutrient uptake, fend off pathogens, and enhance overall plant health. This symbiotic relationship offers potential for boosting agricultural productivity and sustainability. Plant growth promoting rhizobacteria (PGPR) are non-pathogenic microbes that directly benefit plants, while rhizosphere bacteria indirectly support plants by addressing various stressors and activating defense mechanisms. Communication between plants and microbes operates through intricate signaling pathways at different interaction levels, spanning across species and kingdoms.

PGPR contribute significantly to establishing a robust defense mechanism in plants called rhizobacteria-mediated ISR (Induced Systemic Resistance). This interaction shapes the composition of the "core root microbiome," influenced by the selection pressure exerted by plants on root-associated microbial communities.In the rhizosphere, where roots interact with soil, bacterial activity, abundance, and diversity are notably higher compared to bulk soil. This is fueled by the secretion of root exudates containing phenolic compounds, which attract and support the growth of specific plant-associated microbiota. Communication within the rhizosphere occurs mainly through quorum sensing (QS) molecules, such as N-Acyl Homoserine Lactones (AHLs) in Gram-negative bacteria. These molecules enable synchronized responses of microbial communities to environmental cues, fostering coordinated behaviors essential for plant-microbe interactions.

The Future of Plant Communication in Agriculture

As we uncover the secrets of plant communication, we unlock new opportunities for agricultural innovation. From enhancing crop resilience and precision farming to harnessing biological pest management strategies and optimizing plant-microbe interactions, the implications are vast. However, as we venture into this uncharted territory, it's essential to consider the ethical and ecological implications of manipulating plant communication pathways. In a world where communication is often associated with words and gestures, the silent conversations of plants remind us of the intricacies of the natural world. By listening to the language of plants, we gain insights that can shape the future of agriculture and ensure food security in a changing world.

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NFTS REVOLUTIONIZING DIGITAL OWNERSHIP IN INDIAN CRYPTO LANDSCAPE

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Introduction

Non-fungible tokens (NFTs) have taken the Indian cryptocurrency ecosystem by storm, offering a unique blend of digital ownership and investment opportunities. In 2023, the Indian NFT market witnessed a staggering growth of 138%, reaching a valuation of ₹3,500 crores (Sharma, 2024). This surge in popularity has attracted artists, collectors, and investors alike, transforming the way digital assets are perceived and traded in the country.

NFTs represent ownership of unique digital items, such as artwork, music, or even virtual real estate. Unlike cryptocurrencies like Bitcoin or Ethereum, which are fungible and interchangeable, each NFT is one-of-a-kind. This uniqueness has sparked a new wave of digital creativity and entrepreneurship in India, with local artists and content creators finding innovative ways to monetize their work.

NFTs and the Indian Art Scene

The Indian art community has embraced NFTs as a means to reach a global audience and secure their digital rights. Renowned artist Amrita Sethi's NFT collection "Voice Note Art" sold for over ₹2 crores in 2023, highlighting the potential for Indian creators in this space (Kumar, 2024). NFTs have also opened doors for emerging artists, providing them with a platform to showcase their work without the need for traditional galleries or intermediaries.

Gaming and Virtual Worlds

The gaming industry in India has been quick to adopt NFTs, with in-game assets and virtual land becoming increasingly valuable. Popular mobile games like "Crypto Cricket" have integrated NFTs, allowing players to own and trade unique player cards and stadiums. This fusion of gaming and blockchain technology has created new revenue streams for developers and enhanced player engagement.

Challenges and Regulatory Landscape

Despite the rapid growth, the NFT market in India faces several challenges. Regulatory uncertainty remains a key concern, with the government yet to establish clear guidelines for NFT taxation and ownership rights. The Reserve Bank of India (RBI) has expressed caution regarding the speculative nature of NFTs, urging investors to exercise due diligence (Gupta, 2023).

Additionally, the environmental impact of NFTs, particularly those minted on energy-intensive blockchain networks, has raised concerns among environmentally conscious investors and creators. This has led to a growing interest in eco-friendly NFT platforms and green blockchain solutions within the Indian crypto community.

The Future of NFTs in India

As the NFT ecosystem in India continues to evolve, experts predict a shift towards more utility-driven tokens. Rahul Pagidipati, CEO of ZebPay, forecasts that "NFTs will move beyond digital art and collectibles, integrating with real-world assets and services" (Singh, 2024). This could potentially revolutionize sectors such as real estate, intellectual property rights, and supply chain management.

The integration of NFTs with emerging technologies like augmented reality (AR) and virtual reality (VR) is expected to create immersive experiences for Indian consumers. Virtual fashion shows, digital land ownership in the metaverse, and blockchain-based identity verification are just a few examples of how NFTs could shape the future of digital interactions in India.

In conclusion, NFTs have emerged as a powerful force within India's cryptocurrency ecosystem, offering new avenues for creativity, investment, and digital ownership. As the technology matures and regulations evolve, NFTs are poised to play an increasingly significant role in shaping the country's digital economy and cultural landscape.

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TRANSFORMING INDIAN FINANCE: THE ROLE OF ESG INVESTMENTS IN MARKET AND MINDSET SHIFTS

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Introduction

Environmental, Social, and Governance (ESG) investing has taken the global financial world by storm, and India is no exception. This approach to investing, which considers a company's environmental impact, social responsibility, and governance practices alongside financial metrics, has seen explosive growth in recent years. According to a 2023 report by CRISIL, ESG assets under management in India grew by an impressive 25% in the fiscal year 2022-23, reaching ₹19,686 crore (CRISIL, 2023).

The Drivers of Change

Several factors are propelling the ESG movement in India:

1. Regulatory Push: The Securities and Exchange Board of India (SEBI) has mandated ESG disclosures for the top 1,000 listed companies, effective from the 2022-23 financial year.

2. Investor Demand: Both institutional and retail investors are increasingly seeking sustainable investment options.

3. Global Trends: International pressure and the need to align with global sustainability goals are influencing Indian businesses.

4. Climate Risks: The growing awareness of climate-related financial risks is driving companies to adopt more sustainable practices.

Challenges and Opportunities

While the ESG sector is growing rapidly, it still faces hurdles:

- **Data Reliability:** The lack of standardized ESG reporting frameworks makes it challenging to compare companies accurately.
- **Greenwashing Concerns:** Some companies may exaggerate their ESG credentials, leading to skepticism among investors.
- **Limited Options:** The number of ESG-focused funds in India remains relatively small compared to developed markets.

Despite these challenges, the opportunities are immense. A 2022 study by Bain & Company found that 90% of Indian investors express interest in ESG investing, with 60% willing to pay a premium for ESG-compliant products (Bain & Company, 2022).

The Impact on Corporate Behavior

The rise of ESG investing is reshaping how Indian companies operate. Firms are increasingly focusing on:

- Reducing carbon footprints
- Improving labor practices
- Enhancing board diversity
- Strengthening corporate governance

This shift is not just about attracting investors; it's about long-term sustainability and resilience. Companies that embrace ESG principles are better positioned to navigate future challenges and capitalize on new opportunities.

The Road Ahead

As ESG investing continues to gain traction, several trends are likely to shape its future in India:

1. Technology Integration: The use of AI and big data to assess ESG performance will become more prevalent

2. Sector-Specific Focus: ESG criteria will be tailored to address the unique challenges of different industries

3. Regulatory Evolution: Expect more stringent ESG disclosure requirements and potential incentives for sustainable practices.

4. Retail Participation: As awareness grows, retail investors will play a larger role in driving ESG investments.

A recent report by KPMG India predicts that ESG assets in the country could surpass $240 billion by 2030, highlighting the sector's enormous growth potential (KPMG India, 2023).

Conclusion

The rise of ESG investing in India represents a fundamental shift in how businesses and investors approach finance. As sustainability becomes increasingly central to economic decision-making, companies that fail to adapt risk being left behind. For investors, ESG offers the opportunity to align their portfolios with their values while potentially reaping long-term financial benefits.

As India continues its journey towards a more sustainable future, ESG investing will undoubtedly play a crucial role in shaping the country's financial landscape and corporate behavior. The green revolution in Indian finance is not just a trend – it's the new normal.

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HI –TECH CULTIVATION ON HORTICULTURAL CROPS: A PROFITABLE FARMING SYSTEM

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Introduction

Thiru. J.Saravanan, 41 years old young progressive farmer, studied VIII Std from Kottaipatti village, Aathoor block, Dindigul District of Tamil Nadu. He has been practicing agriculture and started helping to his father since childhood. Due to overage of his father, he led the farming from 2008 onwards. He owned 2.5 acres of land of fertile soil under irrigated condition. He is cultivating crops such as vegetables (Tomato, Bhendi, Chilli, *Aggregatum* Onion and Gourds) loose flowers, fruits (Guava + Papaya) and Coconut. In the beginning, he obtained poor yield and less net return due to non adoption of new technologies, water scarcity and higher labour cost. He also expressed that conventional farming of horticultural crops resulted in poor yield and low net return due to aforesaid problem.

1. Plan implement and support

He made visit to KVK, Dindigul during 2012 and the KVK Scientists gave advisory services, trainings and implemented demonstrations as depicted below

a. Skill enhancement training on Friends of Coconut Tree's (05.01.2015 to 10.01.2015) for six days
b. Skill enhancement training on protected cultivation techniques and hi-tech cultivation techniques on horticultural crops (22.10.2018 to 27.10.2018)
c. KVK and Ministry of Textile, Govt. of India jointly supported for erection of 500 Sq.m. of Shade net unit and 1000 Sq.m of mulching unit (Farmer contribution- 10%) during 2017.

d. Regular updating the skills and technical knowledge, he started and adopting advanced cultivation techniques in 2.5 acres of his land. During 2017 onwards , he adopted the hi-tech cultivation systems of drip irrigation with fertigation and mulching system on vegetables (Tomato – 0.2 ha, Bhendi - 0.2 ha, *Aggregatum* Onion – 0.2 ha), high density planting of Guava with intercrop in Papaya (0.2 ha), drip irrigation system with drought management practices in coconut (0.2 ha)

2. **Output and Outcome**

Advisories and training received from KVK Scientists, the farmer adopted hi-tech cultivation techniques in horticultural crops with integrated farming system viz., farm yard manure, compost from coconut dried leaves and adopted important cultivation techniques such as drip irrigation, fertigation, crop rotation, mulching, scientific rearing techniques of poultry and advanced cultivation techniques in vegetables, flowers and fruit cultivation. These techniques adopted in his field and the farmers realized the following benefits.

- Continuous cultivation of crops using minimum water with the help of drip irrigation techniques.
- Using protray nursery, mulching, drip irrigation, fertigation and IPM practices were recorded 36 per cent higher yield as compared to farmer practice in tomato cultivation
- Crop rotation, usage of organic manures and composts and natural mulching were improved the soil fertility status and water holding capacity of soil also was improved
- Use of drip irrigation system, he saved 46 per cent of water, and he was able to cultivate crops throughout the year under drip fertigation system and got higher yield and very good market price of his farm produces, due to uniform size and brighten colour of horticultural produces.
- The labour cost was also minimized due to poor weed growth. Finally the farmer got higher yield and profit through the hi-tech cultivation and he is sharing his experience and valuable suggestions to other farmers.
- Adoption of high density planting in guava with intercrop of papaya, he received higher yield, income and profit compared to wider spacing of fruit cultivation.
- In the Hi tech cultivation interventions viz., high yielding varieties/hybrids, protray nursery, chisel plough, mulching, drip irrigation, fertigation, integrated nutrient

management, integrated pest management, stacking techniques, application of foliar nutrition and grading techniques in vegetable crops, density planting in guava and intercropping under drip irrigation systems and drought management techniques with integrated crop management in coconut were also adopted in his field and received higher profit (Rs.3,29, 218 /ha/year)

Tomato cultivation – Drip and Fertigation

Onion Cultivation – High yielding variety

Guava Cultivation – High density planting

Farmers visited - Bhendi cultivation

Farmers visited - Chilli cultivation

Honourable Governor of TN interacted on 25.07.2018 Guava cultivation telecasted at DD Podhigai


வேளாண்மை மற்றும் உழவர் நலத்துறை
Farmer Award
பாராட்டுச் சான்று

திண்டுக்கல் மாவட்டம், ஆத்தூர் வட்டாரம், கலிக்கம்பட்டி கிராமத்தை சேர்ந்த திரு.ஜெ.சரவணன் அவர்களுக்கு 2021-22-ம் ஆண்டின் சிறந்த விவசாயிக்கான பரிசுத்தொகையாக ரூ.10000/- (ரூபாய் பத்தாயிரம்) ரொக்கப் பரிசாகவும் பாராட்டுச் சான்றிதழும் வழங்கப்படுகிறது.

வேளாண்மை உதவி இயக்குநர்,
ஆத்தூர் வட்டாரம்

Certificate + Cash Award of Rs. 10000/- received from Dept. of Agri and Farmers Welfare, TN (2021-2022) at KVK, Gandhigram, Dindigul

Table 1 : Effect of Hi tech cultivation on cost of cultivation of horticultural crops

Crop	Intervention	Area (ha_	Income (Rs.)	Expenditure (Rs.)	Profit (Rs.)	BC ratio
Tomato	Before Intervention	0.2	86402	38140	48262	2.27
	After Intervention	0.2	147985	49143	98842	3.0
Bhendi	Before Intervention	0.2	49248	24172	25076	2.04
	After Intervention	0.2	64836	22345	42491	2.90
Aggregatum Onion	Before Intervention	0.2	61516	31215	30301	2.03
	After Intervention	0.2	81972	29340	52632	2.8

Guava + Papaya	Before Intervention	-	-	-	-	-
	After Intervention (Guava = 80 trees Papaya = 95 trees	0.2	159290 (Guava-118160, Papaya – 41130)	51235	108055	3.1
Coconut	Before Intervention	0.2	30870	16743	14127	1.84
	After Intervention	0.2	44503	17305	27198	2.57

Figure 1: Effect of hi tech cultivation techniques on yield of vegetable crops

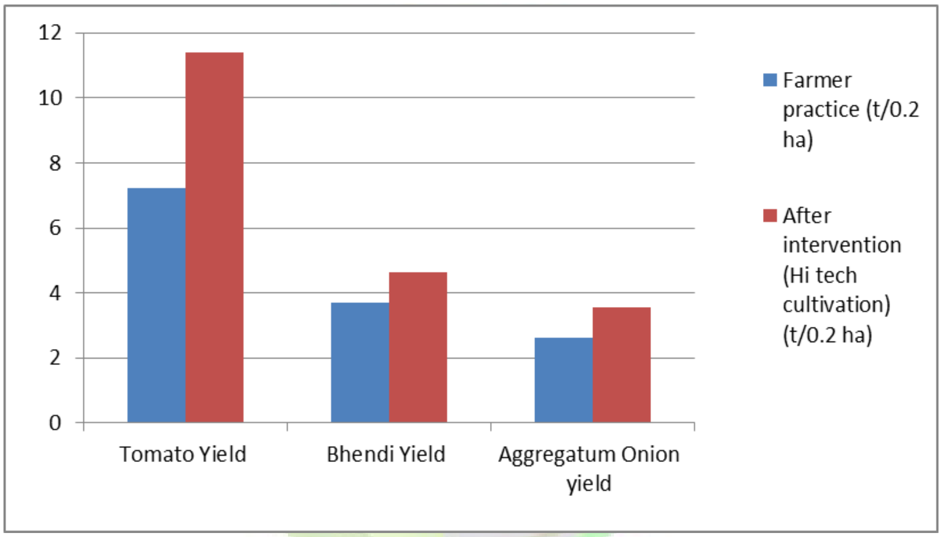
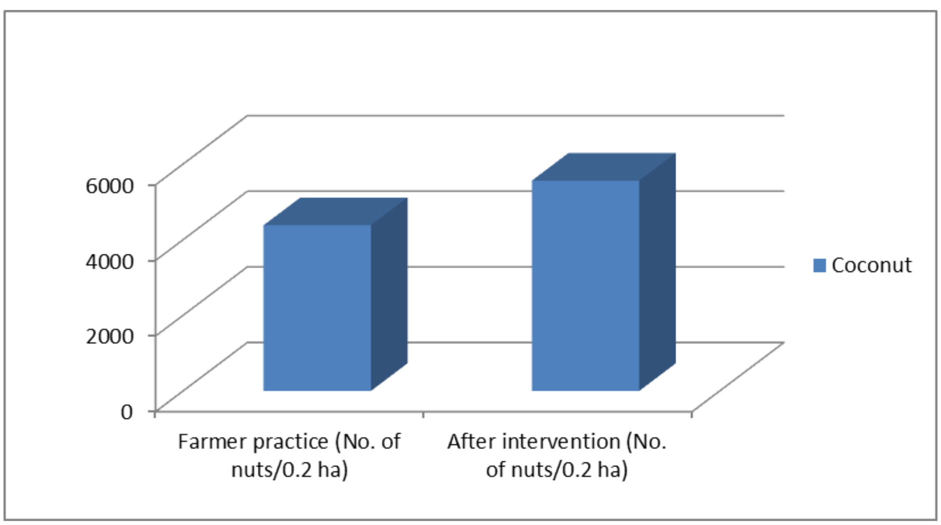


Figure 2: Effect of Advanced cultivation techniques on yield of coconut



Impact:

- 40 % of irrigation was saved in vegetable crops and it was 52 % in fruits.
- Reduced labour cost using drip fertigation and mulching system.
- 1535 farmers visited his Hi-tech cultivation unit from all over Tamil Nadu
- He also trained 523 farmers through various departments
- Based on the training, advisories and farmers visit to the field, the technologies is spreading to entire district of Dindigul and also to other districts.
- 328 farmers adopted drip fertigation techniques and 59 farmers are using mulching techniques
- The hi-tech cultivation technology dissemination through Mass Media regularly (Television :2, All India Radio -1 and Newspaper : 4)
- The farmer shared his hi-tech cultivation experience to Honourable Governor of Tamil Nadu on 25.07.2018 at Exhibition stall of GRI (DTBU), Gandhigram. The Honourable Governor Mr.Banwarilal Purohit, appreciated his water saving techniques and other hi-tech cultivation units
- Honourable Minister of Agriculture, Govt. of Pudhucherry visited his hi tech cultivation unit on 09.05.2019 and the minister appreciated the farmer and he also told, these type of techniques will be disseminated to Pudhuchery farmers.

Volume: 04 Issue No: 07

VIRUS INDUCED PLANT VOLATILES AND THEIR IMPORTANCE IN HOST PLANT RESISTANCE

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Introduction

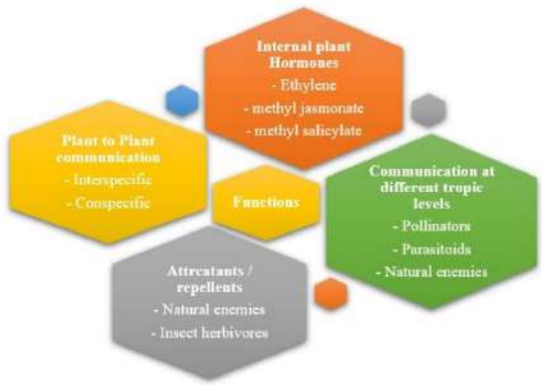
Host plant resistance (HPR) refers to a plant's inherent capability to withstand or repel the damages produced by both the insect pest and pathogens. In side of agriculture it points that these HPR strategies are known to reduce the use of pesticides and other conventional practices and thus developing more ecofriendly management strategies promoting the economic value that can be manifested in many ways through physical barriers, chemical defenses and other physiological processes within the plant system. Of these, chemical compounds play an important role in pest management acting as toxins, phytohormones, antibodies, antioxidants, and so on. VOCs are the most promising substances used in crop pest control today, and they can be incorporated into the plant genetic composition using advanced molecular techniques, allowing transgenic plants to be developed with induced resistance.

Volatile organic compounds

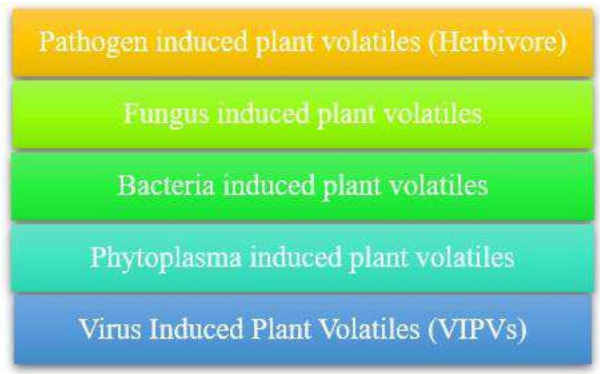
Pesticides have been a major instrument for agricultural intensification over the past few decades, greatly boosting food output. Nevertheless, the efficacy and accessibility of pesticides are restricted and inadequate to combat the growing resistance noted in diseases, insects, and weeds and they continue to undermine the sustainability of the environment. According to this theory, plants use volatile organic molecules to communicate when they are not in direct physical contact. Currently, more than 90 plant families have yielded over 1700 volatile compounds that have been found. These compounds account for around 1% of all currently known secondary metabolites in plants.

Functions

(McCormick, Unsicker, & Gershenzon, 2012)



Types



Virus induced plant volatiles

Phyto virus disease is one of the most important diseases that threatens crop yield or quality, and thus responsible for economic losses all over the world. The majority of plant viruses are known to be transmitted by insect vectors such as aphids, whiteflies, planthoppers, leafhoppers and thrips. Plant viruses can potentially influence host-vector interactions not only through direct effects on the insect vectors, but also via effects on the host plants which influence the behavioural responses of their insect vectors (indirect effects). Various effects (I – IX) produced by virus induced plant volatiles are as follows:

I. Mediates changes in the behaviour responses of the insect vectors (Indirect effects)

Viral disease	**Vector**	**Host**	**Behavioural change**
Tomato severe rugose virus (ToSRV)	*Bemisia tabaci*	Tomato	Preferential settling on infected plants
Cotton leaf curl virus disease (CLCuD)	*Bemisia tabaci*	Cotton	Preferential settling on non infected plants
Tomato spotted wilt virus (TSWV)	*Frankliniella occidentalis*	Pepper	Preferential settling and feeding on infected plants
Cucumber mosaic virus (CMV)	*Aphis gossypii*	Cucumber	Initial preference for infected plants and later (60 min) prefers feeding healthy plants.

II. Alters the performance of the insect vectors by plant viruses (Indirect effects)

Viruses	Vector	Host	Performance
Cassava mosaic disease	*Bemisia tabacci*	Cassava	Greater on infected
Rice tungro virus	*Nephotettix virescens*	Rice	Greater on non infected
Tomato spotted wilt virus (TSWV)	*Frankliniella occidentalis*	Tomato	mixed depending on vector developmental stage
Zucchini yellow mosaic virus (ZYMV)	*Aphis gossypii*	Cucumber	greater alate production
Sugar beet yellows-virus	Aphids	Sugar beet	Greater reproduction

III. Direct effects by viruses to the insect vectors

- *Frankliniella fusca* inflicts less feeding damage to the host (peanut) after acquisition of TSWV
- Acquisition of Tomato mottle virus increases oviposition by *Bemesia tabaci* .
- Tomato Yellow Leaf Curl Virus - infected *Bemesia tabaci* spend more time salivating than non - viruliferous whiteflies .

IV. Dynamic effects including insect behaviour, plant growth

Direct and indirect effects of pathogens on their vectors can interact to produce complex outcomes that can change the vector preference (conditional preference)

Virus	Host	Vector	Vector type	Preferential feeding occur on
Barley Yellow Dwarf Virus	Wheat	*Rhopalosipum padi*	Virulent	Non infected plants
			Non-virulent	BYDV-infected plants
Southern rice black-streaked dwarf virus (SRBSDV)	Rice	*Sogatella furcifera*	Virulent & non – virulent	Non infected plants
			Non-virulent	SRBSDV - infected plants

VI. Volatiles emitted by plants during virus infection that are attractive or repulsive to insect vectors

Host plant	Virus	Insect vector	Emmited volatiles	Activity
Solanum lycopersicum	Tomato Yellow Leaf Curl Virus	*Bemesia tabaci*	High level of terpenes	Attractive
Solanum lycopersicum	Tomato Chlorosis Virus		Increased levels of terpenes	Repulsive
Cucurbita pepo	Cucumber Mosaic Virus	*Aphis gossypi*	Increased emission of complex blend	Attractive
Cucurbita pepo	Zucchini yellow mosaic virus	*Acalymma vittatum*	Lower levels of complex blend	Attractive
Glycine max	Bean Pod Mottle Virus	*Epilachna varivestis*	Lower levels of complex blend	Repulsive

VII. Effects of specific plant volatiles on vector performance

Virus	Host plant	Vector	Vector type	Preference	Recorded results	Volatiles emmited	Performance	Property
Tomato Chlorosis Virus (ToCV)	Tomato	*Bemesia tabaci*	Non – virulent	ToCV infected plants	Emission of some terpenes after infection	β-caryophyllene, α-humulene, and two unidentified terpenes	High	Repellant
Tomato Severe Rugose Virus			Virulent	Non – infected plants	Changes in concentration of some tomato volatiles	α-pinene, 4-carene, α-phellandrene, terpinene, and β-phellandrene	Low	Attractant

VIII. Effects of the specific effectors of the viruses elucidating the plant volatile profiles

Molecular mechanism underlying this process is largely unexplored, and the specific effectors the pathogens employ as well as the pathways within the hosts they target are currently unknown. A non-structural protein NSs of Tomato spotted wilt orthotospovirus suppresses the biosynthesis of plant volatile monoterpenes, which serve as repellents of the vector western flower thrips, *Frankliniella occidentalis*.

IX. VIPV mediates the olfactory behaviour of its insect vectors

The effects of individual VOCs on the olfactory behaviour of both non-viruliferous and viruliferous insect vectors on green rice leafhoppers (GRLHs) *Nephotettix cincticeps* vectoring rice dwarf virus (RDV) and the results revealed that odour preference studies shows that, RDV infected rice plants were more attractive to non-viruliferous GRLHs than healthy plants due to the increased emission of two of these volatiles i.e., (E)-β-caryophyllene (EBC) and 2-heptanol (TD-GC-MS analysis). In contrast, viruliferous GRLHs were repelled more by the volatiles emitted by the RDV infected plants.

Results of behavioural bioassays shows that, non-viruliferous GRLHs exhibited greater preference for the EBC at the different concentrations acting as attractant, whereas 2-heptanol neither attracted nor repelled non-viruliferous GRLHs irrespective of the dosage. It also shows significant repellancy towards viruliferous GRLHs.

These findings where same in the case of *Nepotettix virescencs*, vector of that same Rice dwarf virus, and all these findings demonstrated a clear knowledge on virus induced plant volatiles like EBC could facilitate the acquisition of RDV by non-viruliferous N. virescens, and 2-heptanol would aid the spread of RDV by viruliferous N. virescens. Therefore virus-induced VOCs contribute to virus acquisition and transmission by insect vectors.

Conclusion

Virus-induced plant volatiles may be attractive or repulsive to insect vectors, and thus play a key role in host plant–plant virus–insect vector interactions. Plant pathogenic viruses change the physiology of their host plants, altering the volatile chemicals they emit and, hence odours, and also changing their spectral properties, which may change visual cues received by vectors .Further The specific mechanisms of influencing vector behaviors and change in volatile profile are largely unknown. Individual VOCs responsible for manipulating the behavioural responses of both non-viruliferous and viruliferous insect vectors remain largely unexplored non-viruliferous insect vectors initially preferred virus-infected plants, but once the virus was acquired by the vectors, they showed a predilection for virus-free plants, and this phenomenon may accelerate the outbreak of virus.

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ARBUSCULAR MYCORRHIZAL FUNGI AS PLANT BIOSTIMULANT FOR SUSTAINABLE AGRICULTURE

Article ID: AG-VO4-I07-94

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Abstract

Sustainable agriculture, defined by the 1990 U.S. Farm Bill, seeks to satisfy human food needs, enhance environmental quality, utilize resources efficiently, sustain farm economic viability, and improve the quality of life for farmers and society. However, modern agricultural practices have exacerbated challenges such as climate change, biodiversity loss, soil degradation, and water depletion. Arbuscular mycorrhizal fungi (AMF), ubiquitous soil-borne symbionts, play a critical role in addressing these challenges. AMF enhance nutrient uptake, improve soil structure, and increase plant tolerance to abiotic stresses like drought and salinity. As biostimulants, AMF promote plant growth through mechanisms such as osmolite production, phytohormone modulation, and increased antioxidant activity. This paper explores the multifaceted benefits of AMF in sustainable agriculture, emphasizing their role in improving soil health, crop yield, and resilience to environmental stresses. Further research and field application of AMF can significantly contribute to achieving sustainable agricultural goals.

Keywords: Arbuscular Mycorrhizal Fungi, Biostimulant, Sustainable Agriculture, Crop yield and Abiotic stress.

Introduction

Agriculture's ability to provide food and resources to a growing population is crucial for human survival. However, it faces numerous threats, including climate change, biodiversity loss, soil degradation, water depletion, pollution, rising costs, and declining rural populations. Modern agricultural practices have contributed significantly to these issues. Sustainable agriculture is defined by the 1990 U.S. Farm Bill as an integrated system of plant and animal production practices that, over the long term, aim to: Satisfy human food and fiber needs, enhance environmental quality, utilize non-renewable and on-farm resources efficiently, sustain farm economic viability and improve the quality of life for farmers and society. Sustainable farms must produce high-quality food, protect resources, and be environmentally safe and profitable, relying on natural processes and renewable resources**.** Sustainable agriculture should conserve resources, minimize waste, and promote resilience and self-regulation in agroecosystems.

Arbuscular mycorrhizal fungi (AMF) are ubiquitous, soil-borne, endophytic, obligate biotrophs that colonize the roots of 70–90% of terrestrial plants in various soil types and environmental conditions to establish mutually beneficial relationships (Branco et al. 2022). Arbuscular mycorrhizal fungi (AMF) form a symbiotic relationship with plants, wherein the fungi benefit from carbon (C) substances such as sugars and lipids supplied by the plant through photosynthesis. In return, AMF provide the plant host with essential mineral nutrients, particularly phosphorus (P) and nitrogen (N) (Wipf et al., 2019). This nutrient exchange significantly influences plant fitness, soil processes, and the carbon cycle, thereby impacting both plant and microbial ecosystems (Diagne et al., 2020; Giovannini et al., 2020).

AMF increases the total absorption surface of inoculated plants and thus improves plant access to nutrients, particularly those whose ionic forms have a poor mobility rate or those which are present in low concentration in the soil solution (Smith and Read 2008). Furthermore, AMF contributes approximately 20% to total plant water uptake (Ruth at al., 2011), highlighting the role of the symbiosis in the water status of host plants. AMF significantly improved Cucurbita maxima growth and metabolism, such as the concentrations of fat, crude protein, crude fiber, and carbohydrates in shoot and root systems of inoculated plants compared to control treatment (Al-Hmoud and Al-Momany 2017).

In addition to an improved nutritional supply, AMF interactions provide other benefits to plants, such as improved drought and salinity tolerance (Auge, 2001; Porcel et al., 2011) and disease resistance (Pozo and Azcon Aguilar, 2007). Although several works have been devoted to studying the influence of AM symbiosis on the plant response to abiotic stress such as drought, salinity, and flooding.

AMF as plant biostimulant:

The definition of plant biostimulants has been rigorously debated over the last decade, and recently under the new Regulation (EU) 2019/1009, it has been specified as follows: “A plant biostimulant shall be an EU fertilizing product whose function is to stimulate plant nutrition processes independently of the product's nutrient content with the sole aim of improving one or more of the following characteristics of the plant or the plant rhizosphere: i) nutrient use efficiency, ii) tolerance to abiotic stress, iii) quality traits, or iv) availability of confined nutrients in the soil or rhizosphere.” Based on this definition, plant biostimulants (PBs) are specified on the basis of agricultural functions claims and include diverse bioactive natural substances such as (i) humic and fulvic acids, (ii) animal and vegetal protein hydrolysates, (iii) macroalgae seaweed extracts, and (iv) silicon, as well as beneficial microorganisms, including (i) arbuscular mycorrhizal fungi (AMF) and (ii) nitrogen-fixing bacteria of strains belonging to the genera Rhizobium, Azotobacter, and Azospirillum (Rouphael and Colla, 2020).

Mechanisms of action of AMF as biostimulant:

Various notable protective mechanisms in the utilization of microbial biostimulants under different stresses are osmolite production, phytohormone level modulation, increased antioxidant activity, and secretion of extracellular polymeric substances (EPS) under water stress such as flooding and drought. phytohormone level modulation, emission of volatile organic components, ice nucleation activity antagonism, delay of senescence, and osmo and thermal protection under thermal stress such as freezing and extreme heat (Mishra et al., 2008) increased soil exploration and mineral nutrient solubilization under nutrient stress (Bhalerao et al., 2002) and induced system resistance, direct antagonism with pathogens, and phytohormone level modulation under biotic stress (Kumar et al., 2021).

Arbuscular Mycorrhizal Fungi (AMF) are soil fungi that form a symbiotic relationship with most plant species. They play a critical role as biostimulants, enhancing plant growth and resilience through various mechanisms (Mangman et al., 2015).

Enhanced Nutrient Uptake:

Arbuscular Mycorrhizal Fungi (AMF) form an extensive hyphal network that penetrates far into the soil, significantly increasing the surface area available for nutrient absorption. This enhanced network is particularly effective for the uptake of immobile nutrients such as phosphorus (P), zinc (Zn), and copper (Cu), which are otherwise difficult for plants to access. By accessing these nutrients more efficiently, plants can grow healthier and more robust.

Improved Soil Structure:

AMF produce a glycoprotein called glomalin, which plays a significant role in soil aggregation. Glomalin binds soil particles together, forming stable soil aggregates that improve soil structure. This enhanced structure increases water infiltration and root penetration, allowing plants to access water and nutrients more efficiently.

AMF- mediated plant growth promotion:

AMF enhance plant establishment and increase water and nutrient uptake, particularly of phosphorus (P), zinc (Zn), and copper (Cu) (Clark and Zeto, 2000). They protect plants against biotic and abiotic stresses and improve soil structure by forming aggregates (Smith and Read, 2008). Functionally extending the root system, AMF create a mycorrhizosphere that allows their hyphae to access soil areas roots cannot reach. Strigolactones (SLs), shoot-branching hormones, play a role in early plant–AMF interactions and have potential in weed control by inducing germination of Striga spores, leading to their death in the absence of crop plants. AMF produce Myc factors, lipo-chitooligosaccharides (LCOs), which stimulate root growth and branching, suggesting future agricultural applications Additionally, mycorrhiza helper bacteria (MHBs), like Pseudomonas fluorescens strain BBc6R8, support the pre-symbiotic survival and growth of AMF.

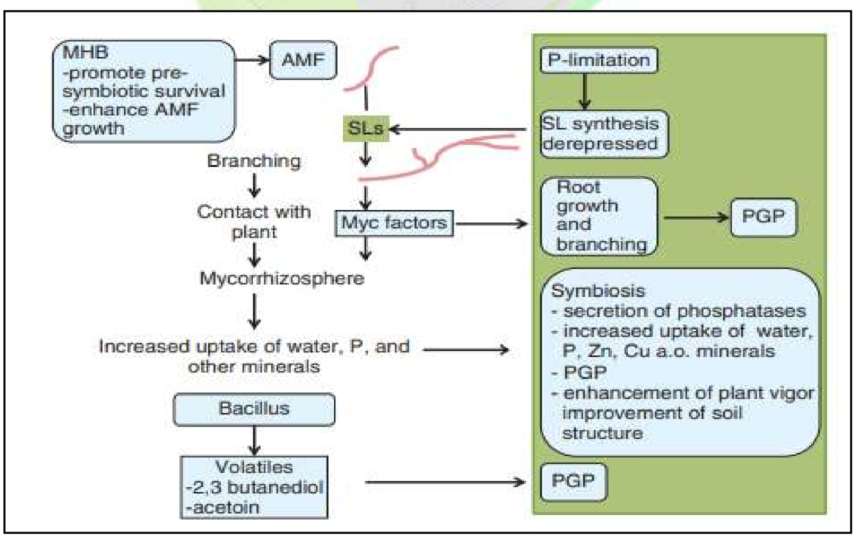

Fig. 1. Role of Arbuscular Mycorrhizal Fungi AMF in PGP. Colors: green, plant; red, microbes; blue, processes.

Benefits of using AMF mediated plant growth promotions

Improvement of Soil Quality and Health

Soil quality depends on its physical and chemical properties and the diversity and activity of soil biota. Soil health, the ability of soil to function as a living ecosystem, influences human health by enhancing crop quality. AMF maintain soil quality and health by affecting soil structure, plant physiology, and ecological interactions (Gupta et al., 2020)

Enhancement plant nutrient uptake and water use efficiency:

AMF have the capability to boost the uptake of inorganic nutrients in almost all plants, specifically of phosphate (Smith et al., 2003). AMF are also very effective in helping plants to take up nutrients from the nutrient-deficient soils (Kayama and Yamanaka, 2014). Apart from the macronutrients, AMF association has been reported to increase the phyto-availability of micronutrients like zinc and copper (Smith and Read, 1997). AMF improve the surface absorbing capability of host roots. AMF have shown increased leaf area, and nitrogen, potassium, calcium, and phosphorus contents, reflecting enhanced plant growth (Balliu et al., 2015).

Crop yield and quality:

Extensive hyphal network enhances crop yield by improving nutrient uptake, particularly phosphorus, and increasing resistance to drought and soil pathogens. For example, in maize, AMF can increase yield by up to 30% (Plenchette et al., 2005). In soybeans, yield improvements of up to 40% have been observed (Singh et al., 2011) and in wheat, AMF inoculation has been shown to boost grain yield by 20% (Zhu et al., 2010). This correlation between AMF symbiosis and increased crop yields underscores the crucial role of AMF in sustainable agriculture.

Reduces crop yield and pesticide use:

Mycorrhizal fungi play a crucial role in controlling soil erosion, enhancing phytoremediation, and eliminating harmful microorganisms, thus sustaining agroecosystems (Gosling et al., 2006). Studies have shown that mycorrhizal symbiosis can reduce chemical fertilizer use by 25–90%, depending on crop species, soil type, and management practices, while increasing productivity by 16–78% due to enhanced nutrient uptake (Rivera et al., 2007). Additionally, AMF can act as bio-controllers, reducing the need for pesticides. This highlights the importance of AMF in sustainable agriculture. Reintroducing AMF into agro-systems can improve nutrient use efficiency, water-use efficiency, and tolerance to pathogens and herbivores (Hart and Trevors, 2005).

Mycorrhizae Improve Seed Germination and Seedling Establishment:

Dormancy is one of the major barriers to seed germination. When seeds are inoculated with mycorrhizae, this helps break down dormancy by avoiding environmental stresses (heat, salinity, and drought). The establishment of mycorrhizae with plant seedlings confers wider root arrangement via hyphal development and further influences growth by increasing the root length, diameter, surface area, biomass, and shoot growth (Ellouze et al., 2012). Meanwhile, it increases the photosynthesis rate, N, P, and K content, and finally enhances the seedlings' resistance to environmental stresses, including pathogens (Xiuxiu et al., 2019).

Role in abiotic stress management:

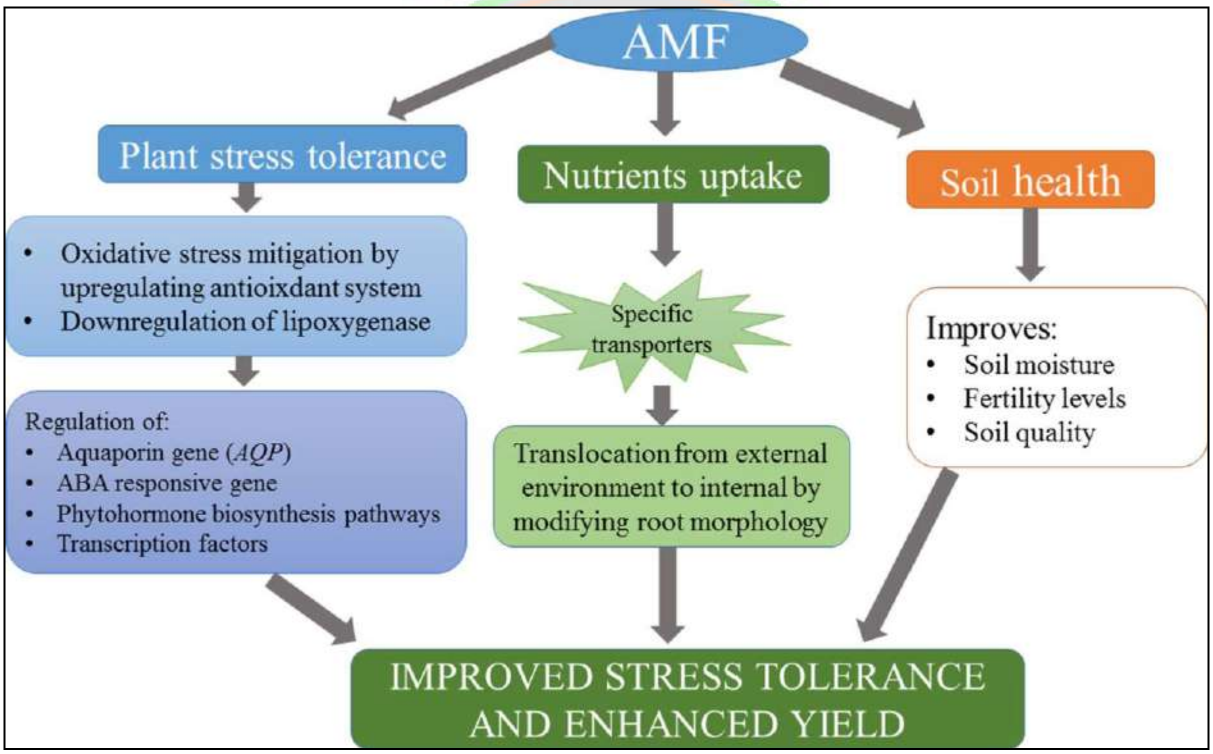

Fig. 2. A diagrammatic representation of mycorrhizal functions to regulate various processes in the ecosystem and plant growth promotion under abiotic stress condition.

Drought:

Drought stress affects plant life in many ways; for example, shortage of water to roots reduces rate of transpiration as well as induces oxidative stress. Drought stress imparts deleterious effects on plant growth by affecting enzyme activity, ion uptake, and nutrient assimilation. However, there is a strong evidence of drought stress alleviation by AMF in different crops such as wheat, barley, maize, soybean, strawberry, and onion Plant tolerance to drought could be primarily due to a large volume of soil explored by roots and the extra-radical hyphae of the fungi. Such a symbiotic association is believed to regulate a variety of physio-biochemical processes in plants such as increased osmotic adjustment, stomatal regulation by controlling ABA metabolism enhanced accumulation of proline, or increased glutathione level. Symbiotic relationship of various plants with AMF may ultimately improve root size and efficiency, leaf area index, and biomass under the instant conditions of drought. Moreover, AMF and their interaction with the host plant are helpful in supporting plants against severe environmental conditions (Ruiz-Lozano, 2003; Table 1).

Table 1. Observed responses of plants to the inoculation application of AMF on host species exposed to drought stress treatments.

Stress	**Host species**	**Fungus species**	**Observed responses**	**References**
Drought	Glycine max L.	AMF	Enhanced leaf proline, photosynthesis, leaf area index, relative growth rate, fresh weight, and dry weight of seeds	Pavithra and Yapa (2018)
Drought	Poncirus trifoliata	Paraglomus occultum	Increased hyphal length, hyphal water absorption rate, and leaf water potential	Zhang et al. (2018a)
Drought	Olea europaea	AMF	Alleviated drought impact and increased turgor potential (Ψp) and mineral uptake	Sara et al. (2018)

Salinity:

It is widely known that the soil salinization is an increasing environmental problem posing a severe threat to global food security. Salinity stress is known to suppress growth of plants by affecting the vegetative development and net assimilation rate resulting in reduced yield productivity. It also promotes the excessive generation of reactive oxygen species Attempts are being made to explore potential means of achieving enhanced crop production under salt affected soils. One such potential means is the judicious use of AMF for mitigating the salinity-induced adverse effects on plant. Several research studies have reported the efficiency of AMF to impart growth and yield enhancement in plants under salinity stress (Talaat and Shawky, 2014; Table 2).

TABLE 2. Observed responses of plants to the inoculation application of AMF on host species exposed to salinity stress treatments.

Stress	Host species	Fungus species	Observed responses	References
Salinity	Cucumis sativus L.	Glomus intraradices, Glomus mosseae	Increased biomass, photosynthetic pigment synthesis, and enhanced antioxidant enzymes	Hashem et al. (2018)
Salinity	Solanum lycopersicum L.	Rhizophagus irregularis	Enhanced shoot FW, leaf area, leaf number, root FW, and levels of growth hormones	Khalloufi et al. (2017)
Salinity	Oryza sativa L.	Claroideoglomus etunicatum	Improved quantum yield of PSII photochemistry, net photosynthetic rate, stomatal conductance	Porcel et al. (2015)

Heavy Metals:

AMF are widely believed to support plant establishment in soils contaminated with heavy metals, because of their potential to strengthen defense system of the AMF mediated plants to promote growth and development. Heavy metals may accumulate in food crops, fruits, vegetables, and soils, causing various health hazards. AMF association with wheat positively increased nutrient uptake under aluminum stress (Aguilera et al., 2014). Plants grown on soils enriched with Cd and Zn exhibit considerable suppression in shoot and root growth, leaf chlorosis, and even death (Moghadam, 2016). There are many reports in the literature on uncovering the AMF-induced effects on the buildup of metals in plants (Souza et al., 2012; Table 3).

TABLE 3. Observed responses of plants to the inoculation application of AMF on host species exposed to heavy metal stress treatments.

Stress	Host species	Fungus species	Observed responses	References
Metal—	*Sesbania rostrata*	*Glomus mosseae*	Stimulated formation of	Lin et a.,

General			root nodules, and increased N and P contents	(2007)
Metals—Cadmium	*Trigonella foenum-graecum* L.	*Glomus monosporum, G. clarum, Gigaspora nigra, and Acaulospora laevis*	Increased antioxidant enzymes activities and malondialdehyde content.	Abdelhameed and Rabab (2019)
Metals—Cadmium and zinc	*Cajanus cajan* L.	*Rhizophagus irregularis*	Improved root biomass, nutrient status (P, N, Mg, Fe.), and proline biosynthesis	Garg and Singh (2017)

Future challenges:

1. Understanding the AMF strains/crop species/environments interaction in order to select the best combinations;
2. The development of high-quality inoculation having a high concentration of infective propagules, long shelf life and 'easy to use' formulations
3. The identification of the combination of bacteria/AMF strains that interact synergistically to maximize the benefits
4. Assessing the efficiency of AMF inoculation under field conditions, and multiple stress factors.
5. Understanding interactions of AMF with chemical fertilizers and pesticides.
6. Educating farmers about the benefits and proper use of AMF biostimulants.
7. Achieving regulatory approval and standardization for AMF products.

Conclusion:

Arbuscular mycorrhizal fungi (AMF) are pivotal in promoting sustainable agriculture through their symbiotic relationships with plants. By enhancing nutrient uptake, improving soil structure, and bolstering plant resilience to abiotic stresses, AMF contribute to higher crop yields and reduced reliance on chemical fertilizers and pesticides. The integration of AMF in agricultural practices offers a viable solution to the pressing challenges of modern agriculture, including soil degradation, water scarcity, and climate change. Future efforts should focus on optimizing AMF inoculation techniques, understanding AMF-plant interactions under various environmental conditions, and educating farmers on the benefits of AMF. Regulatory support and standardization of AMF products will further facilitate their widespread adoption, ensuring sustainable and resilient agroecosystems for future generations.

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BANANA CULTIVARS FOR LEAF INDUSTRY: AN OVERVIEW

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Introduction

Banana (*Musa paradisiacal* L.) is the largest herbaceous perennial plant belongs to the Musaceae family in the order Zingiberales (Sora and Merga, 2023). It is one of the major fruit crops grown in tropical and subtropical regions of the world, and originated from the tropical region of South-East Asia. Bananas are symbol of prosperity and fertility and the plant is also referred as "Apple of Paradise". At present, bananas are produced in 135 countries and overseas territories across the tropics and subtropics (FAO) with a total annual world production of 155.2 million tonnes of which, 75 percent (115.7 million tonnes) under desert bananas and the remaining 25 percent (39.5 million tonnes) under plantains/cooking bananas. India is the top banana producing nation in the world contributing to 19.85 percent of the total world production. In India Andhra Pradesh stands first with 5.68 million tonnes from 1.09 lakh ha. having 16.5% share.

Disposable plates, cups, bowls and covers are manufactured from various plastics, including polyethylene, polystyrene, polycarbonate and melamine formaldehyde. These materials can leach toxic substances, such as bisphenol A, melamine, and vinyl chloride, into food during use posing potential carcinogenic risks linked to prostate and breast cancers, insulin resistance and heart disease. Melamine is particularly harmful, causing kidney damage. Polystyrene, a widely used plastic, is non-biodegradable, resistant to photo oxidation, suspected of being a carcinogen, and disrupts thyroid hormone levels (Rajesh, 2017). Another critical issue is microplastic pollution in marine environments, caused by durable, persistent, and slow-degrading plastic fragments less than 5 mm in length. These microplastics accumulate within the oceanic and marine food chains, serving as a sink for other persistent organic pollutants (POPs) in their vicinity. Additionally, the ingestion of plastic bags and covers by stray cows and cattle results in their accumulation in the animals' guts, often leading to death (Venkata Ramana 2018). Alarmingly, India produces approximately 26,000 tonnes of plastic waste daily, with each Indian consuming 11 kilograms of plastic annually (Seetharaman 2019).

Environmental importance of leaf plates:

The widespread use of disposable plastic ware in daily life has spurred the search for alternative renewable resources, such as plant leaves, for dining plates and food wraps, a traditional practice in India. This longstanding tradition holds significant cultural, religious, medicinal, and socio-economic importance in the country. Plates made from leaves are known by various names in different Indian languages, including patravali, vistari and vistaraku. Leaf plates are environmentally friendly, biodegradable, suitable for long-term storage, and easily disposable. They are economical and eliminate the need for cleaning with phosphate-rich soaps and detergents, a time-consuming and labor-intensive process. Additionally, the leaves possess notable antibacterial and antifungal properties, protecting against environmental and food borne pathogens (Sahu and Padhy, 2013).

Benefits of banana leaf:

The banana plant, known as kadali, arati, and kela in various Indian languages, is a tropical, corm-based, pseudo-stemmed herbaceous plant belonging to the Musaceae family. It is revered as a kalpataru, a plant with all virtues, due to the versatile use of all its parts. The leaves are large, flexible, waterproof, and typically measure approximately 2.7 × 0.6 meters (Ahmadi *et al.*, 2019). The leaves are rich source of polyphenols, flavonoids, fiber, carbohydrates, tannins, vitamin C, enzymes, and potassium (Zou *et al.*, 2022). The leaves exhibit antioxidant, antidiabetic, aphrodisiac, antibacterial, antifungal, and anticancer properties. In India, serving food on banana leaves is a longstanding tradition, particularly in the southern states of Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, and Telangana. This practice is healthy, traditional, and auspicious, especially during festivals, weddings, traditional feasts, and religious occasions. Banana leaves are preferred as dining plates due to their abundance of polyphenols, which act as antioxidants and aid digestion by releasing nutrients such as vitamin C and potassium when hot food is served. Moreover, the large blade size of the leaf accommodates multi-course meals, including rice, curries and sweets. These sustainable leaves are water and leak-proof, free from detergent residues, and impart a specific flavor and aroma to the food.

The banana leaf industry has become a vital source of livelihood for many marginal and small-scale farmers in South India. The commercial production and harvesting of banana leaves provide a year-round, sustained income for farming families, helping to stabilize the price fluctuations in the fruit industry and adapt to varying production systems. With the ban on use of plastics, leaf industry has viewed as a potential alternative for various uses and applications. In recent times, the banana leaves are exported in bulk and the demand is in rise. Hence, there is a need to evolve cultivars specific for leaf industry to meet the growing demand in the domestic as well as international markets. Some of the desirable characters of banana cultivars/varieties for leaf production include:

- ✓ Production of large number of quality leaves in given span of time,
- ✓ Production of soft and flexible leaves with least mid rib thickness
- ✓ Generation of marketable quality leaves free from leaf spot diseases, and
- ✓ Profuse suckering habit.

Fig. 1 Experimental field view of banana cultivars for leaf industry

Based on these criteria, Dr. YSRHU-Horticultural Research Station, Kovvur has evaluated the 9 banana cultivars/varieties for leaf production purpose. Among them, Nellore Aakuarati (ABB) has recorded highest leaf production with lowest mid rib thickness and minimum number of phyllacron days

Fig. 2 Nellore Aaku arati (youngest banana leaf) and bundles prepared for market sale.

Conclusions

Compared to plastic plates, banana leaf plates offer numerous advantages, including renewability, biodegradability, non-toxicity and an abundance of antioxidants. Additionally, they hold significant religious, medicinal, and socio-economic importance in Indian culture. Nellore Aakuarati (ABB) has the great potential for leaf production due to its desirable qualities like highest sucker production, highest leaf production with lowest mid rib thickness, minimum number of days taken for new leaf formation and free form leaf spot disease.

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CYPERUS ROTUNDUS-A NOTORIOUS SEDGE WEED IN CROP AND NON-CROP LANDS

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Introduction

Cyperus rotundus has been considered as one of the world's worst weeds. It has been reported in more than 90 countries where it grows as a weed infesting at least 52 different crops worldwide. It grows in all types of soils and can also survive high temperatures. It can be found in a wide variety of habitats including cultivated fields, waste areas, roadsides, pastures, riverbanks, sandbanks, irrigation channels, river and stream shores and natural areas. Purplenut sedge is a perennial sedge weed that seriously impacts in crop production and has been called the world's worst weed. It is considered a headache for gardeners and farmers because of its insidious and rapid growth and its herbicide tolerance. It produces an extensive system of underground tubers from which they can regenerate and consequently is very difficult to control once it is established. It has become a major weed of vegetable, row and plantation crops in tropical and warm temperate climates around the world, is very difficult to manage with either organic or conventional weed control strategies. It is one of the most extensively researched non-cultivated plant species on the planet, yet the complexities of its life cycle, and its multiple adaptations to environmental extremes and weed control tactics are as yet incompletely understood.

Purple nutsedge is a grass-like weed with top growth 4–30 inches tall, an extensive underground network of basal bulbs, fibrous roots, thin wiry rhizomes and tubers borne in chains of 2–6 or more on rhizomes, with tubers spaced 2-10 inches apart. The leaves are mostly basal, dark green, 0.1–0.25 inches wide with a prominent midrib, and abruptly tapered at the tips. The purplish to red-brown inflorescence is borne on a culm (stem) that is triangular in cross section and usually taller than the foliage. The inflorescence itself consists of an umbel of spikes, some of which are sessile, and others are borne on stalks of unequal length.

2. Biology

Purple nutsedge initiates its seasonal growth cycle almost entirely from tubers, as viable seeds rarely occur. Each tuber has multiple buds, most of which remain dormant and act as a reserve in the event that the active shoot is destroyed. Tuber chains show apical dominance, so that the terminal tuber initiates active growth while many or all of the others on the chain remain dormant unless the terminal tuber is destroyed or the chain is broken. Dormant tubers commonly persist in the soil for 3–4 years and can remain viable for as long as 10 years in some conditions.

The tuber sprout consists of a sharp pointed rhizome, which grows toward the soil surface, then differentiates into shoot and leaves in response to light. The plant forms a subterranean basal bulb, which contains the shoot. Basal bulbs form mostly within 3 inches of the soil surface, although bulbs have been observed at 4–8 inches. Bulbs develop fibrous root systems that may extend 4 feet deep in the soil profile. Because the shoot growing point remains in the basal bulb, leaves regrow readily if severed at the soil surface. .

Within 2–3 weeks after shoot emergence, basal bulbs send out new rhizomes that form additional bulbs and daughter plants. The cycle repeats several times during a growing season, so that a single sprouting tuber can give rise to hundreds of shoots. Plants usually flower about 7–8 weeks after emergence, although flowering can occur as early as 3 weeks. New tubers begin to form at about the time of flowering. Most tubers are set in the top 8 inches of the soil profile, with a few forming at greater depths. After flowering, purple nutsedge undergoes a marked shift from aboveground to belowground development, so that tubers continue to form for several weeks after shoot growth ceases. This species has the C_4 photosynthetic pathway, which contributes to its ability to grow and spread rapidly in hot weather and high light levels. The weed shows tremendous heat tolerance in field conditions. Like most C_4 plants, purple nutsedge is shade intolerant and can be suppressed by a closed crop canopy, although tubers remain viable and send up new shoots when the canopy is removed.

3. Impacts on Crop production

Purple nutsedge competes vigorously against most crops for soil moisture and nutrients and against low-growing or slow-starting crops for light. It is especially competitive during warm seasons with ample moisture and becomes less so in cooler, drier conditions. High levels of available nutrients and moisture seem to intensify purple nutsedge competition against crops. Based on its occurrence, its capacity to cause substantial yield losses. Substances released from living or decaying below-ground parts of purple nutsedge have shown allelopathic activity against rice, barley, mustard, and cotton and sweet potato. The large underground biomass in a heavy purple nutsedge infestation, the possible contribution of allelopathy to this weed adverse impacts on crops.

4. Prevention and control

Once established, *Cyperus rotundus* can be such an intractable problem that preventative strategies should be employed to avoid its introduction and spread. Intensive use of the same weed management protocols, can promote the establishment of high populations. Integrated control, such as crop rotations should be considered as part of the management strategy. Whatever methods are used, modelling the population dynamics of *Cyperu. rotundus* indicates that at least 95% control would be required to eliminate this weed.

Physical/Mechanicalcontrol

Successful cultivation depends on destroying the tubers of *Cyperus rotundus* by exposing them to desiccation or by exhausting the food reserves. It is most effective on dry soils but it must be sustained to avoid re-establishment of the fragmented and dispersed rhizome/tuber network. This could necessitate cultivating every 2-3 weeks until the crop forms a canopy to suppress further growth of the weed. Organic mulch made from crop residues, such as coir dust provides temporary suppression of *Cyperus rotundus*. Soil solarization by polyethylene cover sheets can control too some extent. Soil solarization seems potentially effective on tuber sprouting, as long as it resulted not only in a soil temperature shift, but also to a high diurnal temperaturevariation.

Chemicalcontrol

Few herbicides kill *Cyperus rotundus,* but several have been used to suppress growth until after crop establishment, but one of the most effective products is glyphosate. Applied post-emergence at the flowering stage, glyphosate is taken up by actively growing shoots and translocated to the tubers.

Biologicalcontrol

Several fungi are promising candidates for classical biocontrol, including *Puccinia conclusa*, *P. philippinensis* and *Phytophthora cyperi*. The fungal pathogen, *Dactylaria higginsii*, has promise as a bioherbicide for the control of *Cyperus rotundus*.

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DRY FLOWER ARRANGEMENT

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Introduction

The art of making arrangements with dried flowers and leaves was a flourishing craft from seventeenth century in England and America. But now it has passed from the hobby stage to big business in most of the countries. In recent years, there has developed a trend to fragrance a mixture of flowers for keeping in rooms, kitchens, toilets etc. The concept of using dry flowers for decoration indicates immortal.

Advantages of dried arrangement

- It is not dependent on once good materials are collected.
- It lasts almost indefinitely.
- It helps the individuals to improve their skill in designing and composing the artistic products which cannot be afforded by fresh materials
- Dried arrangements are familiarly called as time savers as they can be made in advance and then enjoyed as needed.

Indian Dry Flower Market

The most promising area in floriculture is the dry flower industry. Dried flowers and plants have been exported for the last 40 years to till now. India is one of the leading countries in the dry flower exporting field. Over Rs 150 crores worth of dried flowers and plants are exported from India annually. The flower industry exports 500 types of flowers to 20 different nations, and the US and UK markets are big consumers of dried flowers. The dried flower potpourri variant has dedicated processing facilities and is solely focused on exports. India has a clear edge due to its abundance of resources, wide range of goods, and expertise in the production of dried flowers and plants. In the dried flower sector, Tamil Nadu is the front-runner.

Products made from dried flowers are highly sought after and enhance the value of the booming sector. Handmade paper, lampshades, wall quilts, decorations, books, candle holders, and other items are examples of different dried flower goods. The beauty of dried flowers is enhanced by flower arrangements made with dried samples of cone, leaf, rose buds, lilies, and other similar plant material, which raises the industry's export value.

Harvesting flowers

Flowers or leaves for drying may be collected at any time during the growing season. The best time of day to cut is midmorning, after the dew has dried but well before any flowers wilt. Dampness can lead to mould and slows drying. During rainy weather, plants should be harvested when they are dry even if it means cutting them a little early. Damp or over matured plants should not be harvested. If harvesting flowers when wet is unavoidable, the excess moisture should be gently blotted off with a soft paper towel or tissue. Only the most perfect forms should be used.

Poor shapes dry as poor shapes. Plants and flowers free of damage due to pest and disease incidence should be selected. This is because any such damage becomes only more obvious after drying. It is sometimes difficult to develop graceful lines when making dried flower arrangements. Therefore, while collecting material for dry flowers, branches and stems with sweeping curves or lines that will add distinctiveness to the arrangement should be selected. If none can be found, curves or other lines can be made by shaping the branches or stems into the desired positions while they dry.

Natural stems do not give the flower enough support when dry and may be difficult to manipulate and position. So, most of the stem is cut, leaving only about an inch. Stems can be replaced with florist's wire after drying. Flowers should be wired before drying them because drying may cause shattering in some cases.

Materials for dried arrangement

The materials usually employed for dried arrangement can be grouped into three categories as follows.

- Cultivated flowers and vegetable including seed, pods, vines and grains.

- Naturally available materials like flowers, seed pods, fern leaves, certain weeds and grasses.
- Pods, cones, capsules, fruits, branches, leaves, berries and flowers of broadleaved evergreen trees and shrubs. (Mishra *et al*., 2003)

Pre Drying Flowers

Flowers that dry well are typically colorful, compact, strong-stemmed and relatively low in moisture content. Before the flowers are put into the drying process there are several measures to be taken for successful drying of the flowers.

i) Cleaning

After the plants are harvested or gathered, they must be cleaned. Cleaning may involve screening, washing, peeling, or stripping leaves from stems. Any unnecessary parts are removed prior to drying to avoid wasting time and energy. Cleaning is often done by hand.

ii) Stem Supports

Many flower heads are too heavy for the dried stems to support during the drying process. The stems have to be cut and wired before hanging them out to dry. The wired stems have to be covered with floral tape after the flowers are dry. Some flowers can be wired after they are dried, but it is easier to wire them when they are fresh, because the wire slips through the moist heads more easily. Several stems of one type of flower or seed pod are wired together for a denser, brightly colored effect. If a flower head falls off during the drying process, a floral stem wire should be hot glued to the head or calyx of the dried flower, and the wired stem covered with florist tape.

iii) Adding Wire Stems

Each flower head from the spray has to be cut so that the stem is approximately 1-1/2" long. Using 20-gauge wire, the wire should be cut to the desired length, allowing extra for bending and for the part of the stem to be inserted into the floral foam. The tip of the wire with pliers has to be bent to form a 'shepherd's hook'. The wire should be hooked around the calyx, where the flower head joins the stem, and squeezed tightly with needle nose pliers.

Drying Techniques

Various methods are employed to dry flowers and foliage. The method adopted for drying depends largely on the character of the plant, that is to say whether the plant is glabrous, succulent or not succulent, hardy or delicate in nature. (Rava *et al*., 2020)

i) Air drying

Air drying flowers is one of the easiest methods of preservation and gives plants a crisp look that lasts for years. Air drying flowers make a fabulous decoration by themselves, but when they are dry, they make more beautiful and exotic flower arrangements. This is commonly referred to as the "hang and dry" method. It is the oldest and easiest drying technique. No special equipment is needed. The stems of flowers and their foliage are tied and hung upside down. The rooms should be warm, dark and dry with good air circulation. However, it is one of the longest drying methods. It usually takes three to four weeks for the flowers to dry completely. The flowers are hanged upside down so that the stem remains straight. If they are hanged with right side up, they would bend over and the result will be dried flowers with distorted stems.

The ideal place for hanging the flowers is a place with ideal conditions like:

- Darkness
- Very good airflow
- Perfect humidity levels

Flowers are then sprayed with hair spray or clear varnish to retain their form. Air dried products tend to loose their original colour faster.

ii) Water drying

Water drying is a method of preserving in which the leaves are stripped off and the flower stems placed in five centimeters of water. This is then, placed in a warm place, out of direct sunlight. The water is absorbed and evaporates as the flower dries. Hydrangeas, heathers, hybrid delphiniums, acacia, gypsophila, bells of Ireland, proteas and yarrow dry well this way. The best way to dry hydrangea flowers is by water drying.

iii) Press drying

One of the most popular methods for drying flowers is to put them under pressure, to remove the moisture out while leaving the color of the flowers and structure intact. There are several ways to apply pressure to flowers. The easiest method is placing them in heavy books and allow for drying. Flower presses can also be used. Unglazed paper, such as newsprint or an old telephone book, is best for pressing. Pressed flowers are especially suitable for flower pictures, as well as decoration on note paper, place cards and many other items (Dilta *et al*., 2011)

iv) Drying by embedding in dessicants

A desiccant is simply a substance with a high affinity for water which can be used as a drying agent. Embedding the flowers in a granular, desiccating material is probably the most commonly used method and many consider it the best all around method. Several materials are used as drying agents. All the agents used vary in cost and in the results they produce. It is important to use the correct procedure when covering the flowers so that their form is maintained. Most well known is silica gel and borax but clean dry sand can also be used. Usually an airtight container is used; the flower heads are placed in the drying mixture face up, and very carefully covered with the mixture. The container must be kept closed during the drying process. After 5-15 days, depending on the thickness of the flower, the flower will be dry.

Burying in sand or borax: Fine and dry sand are poured to a depth of 10 cm into a box or pan. The flowers which should be dry are stripped of all foliage and may be kept upside down on the sand and then covered with a layer of sand over them. After two weeks of time, the sand may be poured off carefully and the flowers may be taken out after gently wiping them free of sand with a soft brush. They are then ready for arrangement. Borax may be used in almost the same way as sand and is a good medium for preserving materials when space is limited. Alum and silica gel are also used in the place of borax. The form of flowers are also well preserved in borax method. Candytuft, daisies, marigold, narcissus, chrysanthemum, snapdragons, sunflowers, tithonia, all roses and coleus leaves dry well in sand or borax.

v) Glycerin drying

In this method moisture in a flower or foliage is replaced with glycerin and water. The flower is preserved and not dried. Dried materials (whole bunches or single leaves) retain their natural shape and flexibility. They last indefinitely and can be dusted or even wiped with a damp cloth without risk owing to the leathery texture of leaves. Glycerin drying involves the following process. The bark of the stem is removed and the cut end is smashed using a hammer. This portion of the stem is immersed in the glycerin and water solution. The leaf turns brown with glossy appearance after a month. Many types of foliage can be successfully preserved to maintain softness and flexibility. This is done by immersing leaves or placing stems in a 33 per cent glycerol solution.

vi) Microwave oven Drying

Microwave drying is quick and relatively simple. It takes only a few minutes and provides dried flowers that look fresher and more colorful than obtained by other methods. Flowers with thick petals like magnolia are not suitable for drying in microwave. Since flowers vary in moisture content, texture and density, care should be taken to use the same sized flowers from one species at a time. It has been found that many flowers held almost true to life color and form using this process. Brightly colored flowers are best to dry. Flowers such as lilies, roses, violets, zinnias, and dahlias work well with this process.

Precautions for Microwave oven Drying:

- Start with a low setting
- Set the oven for a few seconds at a time.
- Different settings will produce different colour variations.
- Microwave friendly container should be always used.

vii) Freeze drying

Freeze drying (technically known as "lyophilization") is the process of lowering the temperature of an object and then using a vacuum to extract all the moisture from the item. It is a state-of-the-art technique and the most effective method for flower preservation today. It is an innovative vacuum process that takes approximately four weeks depending on the flower. Freeze dried flowers go through a process in which water is removed as vapor directly from ice, without passing through the liquid state. This process is called sublimation, and requires reduced pressure to occur. All other drying methods use evaporation. In other words, water is removed as vapor from liquid water with heated air. The freeze drying machine drops the temperature to a -7^0 then it slowly returns the freeze dried flowers to room temperature over a four week period. This slow preservation process allows the freeze dried flowers to retain their original form, while the colors become enriched (Dubois and Joyce 2005).

Bleaching and Dyeing

The major drawback of dried arrangements and other dry flower products is that they are dull and lack the brightness of fresh flowers. To overcome this problem, flowers are bleached and dyed. This enhances the visual appeal of the product. Bleaching is essentially whitening or decolourizing. It is an important step in the processing of dry plants. This chemical action removes the discolouration occurring during the dehydration phase of preservation of plants. It allows the effective use of dyes for colouring. Various chemicals like sodium hypochlorite, hydrogen peroxide and sodium chlorite to be the most commonly used bleach for plant foliage. Both chemical and natural dyes can be used. Enamel paints, interior paints, poster paints and tube paints could be employed for this purpose.

Skeleton Leaves

Skeleton leaves are semi-transparent leaves, also called fossil leaves. They are prepared by soaking the fresh leaves in bleached water and then by hand rubbing the soft green flesh from the network of veins. The leaves can be then dyed to variant colors to give them a beautiful and pleasing appearance. Although delicate by nature, they are actually sturdy and can easily be glued to a variety of surfaces. They come in several colors and sizes to meet a complete line of crafting needs. The delicate beauty of these leaves is sometimes meant to capture life, hope and memories. These delicate, gorgeous skeleton leaves are a perfect accent for all craft projects. They make a beautiful and elegant statement when they adorn your wedding invitations. They work surprisingly well on gift tags, greeting cards, scrapbooks, collages, papermaking, stenciling, and stamping. They are perfect for decorating bridal bouquet, wedding reception table, candles, and wedding favors.

Design for dried arrangement

The same basic principles of design apply both to dried as well as fresh arrangement. Here beauty is lacking as against in some fresh flowers, design is given much important in dried arrangement. Before deciding on a design, one has to consider the composition to be a line or mass arrangement. In line arrangement, the main emphasis is a definite outline with restrained use of interesting forms of leaves, stems, buds or seed pods. On the other hand, in mass effect in colour and form.

The pattern most frequently used are the crescent, S-curve, Triangle, fan, Round, Oval, Pyramid, L-Vertical and horizontal. The other considerations viz, balance, harmony, scale, repetition, focal point, rhythum and unity are also important in dried arrangement. The focal point or center of interest, where all important lines meet is the spot where the eyes come to rest. This is a natural place for the largest flowers, the key note of the whole composition. The focal point should be in proper scale to the rest of the composition. Hydrangeas, Celosia, Magnolia blossoms make good focal points.

Colour in dried arrangement

Flowers and foliage properly dried retain much of their colour and variety in colour may be brought out by choosing correct materials. The commonly used colour blends are monochromatic, analogous, complementary and triad. When on hue with its light and dark values or tones are brought in an arrangement, it is 'monochromatic'. When neighbouring and closely related colours, those adjacent on the colour wheel say blue and green, yellow and orange are combined it is called 'analogous'. On the other hand, contrasted opposite on colour wheel, as green and red are combined, it is known as 'complementary'. Three colours equidistant on the colour wheel, as yellow, blue and red are combined it is a 'triad'. Containers made up of dull metals like copper, brass or earthern pots and wooden vessels, old lamps and three caddies also make excellent containers.

Bases

Dried arrangements are made 'distinctive' by keeping them over a proper base. A commercial base of round, oval or rectangular blocks of any good wood is preferred. Bases give formality and dignity. A well-proportioned base is essential for any dried arrangement. The surfaces of the base blocks may be polished to make them shining.

Dry Flower Products

Potpourii

Dry flower vase

Greeting card

Photo frames

Wall-hangings

Candle holder

The kinds of mechanism to hold the materials in fresh arrangements may also be used for dried arrangement. The dust noticed on the arrangements may be cleaned gently with a small water colour brush or wiped with a slightly moistened cloth or brush

Potpourri

Potpourri is a mixture of dried, sweet-scented plant parts including flowers, leaves, seeds, stems and roots. The basis of the potpourri is the aromatic oils found within the plant. These oils are not confined to the flowers but they are at their peak at flowering time. So they should be harvested just as the plant begins to flower. A properly blended potpourri will last for months. Its uses are unlimited. Pot pourri are used to perfume the air with their continual fragrances, scent drawers and closets, make sweet smelling stationery, add a final touch to room decorations with attractive baskets or create personal gifts to share with friends. Apart from being widely used for fragrance and beauty, potpourris are also used to repel moths and protect woollen garments in storage (Cook *et al*., 2015).

Conclusion

There are many reasons for drying plant materials and one of them is the abundance of available materials. It is estimated that about 80% of flower species can be dried and preserved successfully. Sophisticated training and expensive equipment are not needed to come up with variety of designs. Unlike fresh flowers that easily lose their marketable value and quality, dried ornamentals offer longer periods of sale if properly preserved, packaged, and handled. Another unique characteristic of dried ornamental is their versatility. They can be arranged into different crafts according to one's preferred style, design, and use. The dry flower industry is waiting to be explored and needs to be popularized.

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PROTECTED CULTIVATION OF FLOWERS IN INDIA: A CONTEMPORARY OVERVIEW

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Abstract

The floriculture industry in India has made significant strides by adopting protected cultivation methods, including greenhouses, polyhouses, and shade nets. These techniques allow for the control of environmental conditions, leading to higher yields and improved quality of flowers such as roses, gerberas, carnations, chrysanthemums, orchids, anthuriums, lilies, geraniums, and gladiolus. Effective marketing strategies emphasize quality and consistency, year-round availability, and targeting specific markets. Building strong branding and packaging, offering value-added products like ready-to-sell bouquets and subscription services, and implementing competitive pricing strategies are crucial. Efficient distribution channels and robust promotion and advertising efforts support market expansion. Emphasizing sustainable practices and obtaining certifications appeal to environmentally conscious consumers. Additionally, strong customer relationship management fosters loyalty and repeat business. This holistic approach ensures the successful commercialization and sustained growth of flower crops cultivated under protected conditions in India.

Key words: Protected Cultivation, Green house, Flowers crops, Marketing

Introduction

India's floriculture sector has seen substantial growth due to the adoption of protected cultivation methods. This technique, which includes greenhouses, polyhouses, and shade nets, allows farmers to control environmental factors, leading to improved yield and quality of flowers. This article explores the current state of protected cultivation in India, focusing on suitable flower crops, their cultivation aspects, and the marketing strategies essential for success.

What is Protected Cultivation?

Protected cultivation involves growing crops in controlled environments such as greenhouses, polyhouses, and shade nets. These structures help regulate temperature, humidity, light, and other environmental factors, creating optimal conditions for plant growth. This method is particularly beneficial for floriculture, where the quality and uniformity of flowers are paramount.

Benefits of Protected Cultivation

1. **Year-Round Production:** Controlled environments enable farmers to grow flowers throughout the year, regardless of seasonal changes.
2. **Improved Quality:** By managing environmental conditions, farmers can produce flowers with better color, size, and shelf life.
3. **Increased Yield:** Protection from adverse weather conditions and pests leads to higher crop yields.
4. **Efficient Resource Use:** Drip irrigation and fertigation systems in protected cultivation reduce water and fertilizer wastage.
5. **Reduced Pesticide Use:** Controlled environments help in minimizing pest attacks, thereby reducing the need for chemical pesticides.

Supporting studies

1. **Productivity and Quality Improvement:**
    - A study by Singh et al. (2015) demonstrated that roses grown under polyhouses showed a significant increase in yield and quality compared to open-field cultivation.
    - Research conducted by the Indian Council of Agricultural Research (ICAR) indicated that gerbera flowers grown in greenhouses had superior quality, with larger blooms and longer stems.
2. **Economic Viability:**
    - A cost-benefit analysis by Choudhary et al. (2018) revealed that the initial investment in protected cultivation structures is high, but the returns are substantial due to increased productivity and market value of the flowers.

- The study also noted that farmers could recover their investment within 2-3 years due to higher and consistent yields.

3. **Adoption and Challenges:**
   - Adoption rates of protected cultivation techniques have been increasing, especially in states like Karnataka, Tamil Nadu, and Maharashtra. However, challenges such as high initial costs, lack of technical knowledge, and maintenance issues remain.
   - Training and support from agricultural extension services have been crucial in addressing these challenges and promoting wider adoption.
4. **Environmental Impact:**
   - Research by Patel et al. (2017) indicated that protected cultivation systems are more sustainable as they use water and fertilizers more efficiently and reduce the carbon footprint by minimizing the need for pesticide application.

Suitable Flowers for Protected Cultivation and Their Cultivation Aspects

Roses (Rosa spp.) thrive best in polyhouses or greenhouses where the temperature is maintained between 15-28°C. They require good light intensity, sometimes supplemented during shorter days, and a relative humidity of around 60-70%. Drip irrigation is preferred to keep consistent moisture levels, and balanced NPK fertilizers with micronutrients should be applied through fertigation.

Gerbera (Gerbera jamesonii) grows optimally in polyhouses or greenhouses at temperatures ranging from 20-25°C. They need 12-14 hours of light, and shading may be necessary during peak summers to prevent excessive light exposure. The ideal relative humidity is between 70-80%. Gerberas should be irrigated using a drip system to avoid waterlogging, and they require regular fertigation with a balanced NPK mix.

Carnations (Dianthus caryophyllus) are best cultivated in greenhouses with proper ventilation, where temperatures are maintained between 10-25°C. These flowers need high light intensity but should be protected from direct sunlight. A relative humidity of 60-70% is ideal. Drip irrigation is recommended, and they benefit from balanced fertilizers with additional calcium and magnesium.

Chrysanthemums (Chrysanthemum spp.) are suitable for cultivation in polyhouses or greenhouses with an optimal temperature range of 15-25°C. They require good light exposure, although shading might be necessary during periods of intense sunlight. The recommended relative humidity is 70-80%. Using a drip irrigation system is beneficial, and a balanced NPK mix with micronutrients should be used for fertilization.

Orchids (Orchidaceae) flourish in greenhouses with controlled humidity and temperature, typically between 18-30°C depending on the species. They require filtered light and should be shielded from direct sunlight. Maintaining high humidity levels of 60-80% is crucial. Misting and drip irrigation are effective for keeping humidity and soil moisture levels adequate, and regular feeding with balanced orchid fertilizers is necessary.

Anthuriums (Anthurium andraeanum) grow well in shade nets or greenhouses at temperatures between 20-30°C. They need diffused light, which is often provided by shading nets. High humidity levels of 70-90% are essential. Regular misting and drip irrigation help maintain these conditions, and they should be fertilized with phosphorus-rich balanced fertilizers.

Lilies (Lilium spp.) perform best in polyhouses or greenhouses with an optimal temperature range of 15-25°C. They require good light exposure, with shading during peak summer months. Maintaining relative humidity at 70-80% is important. Drip irrigation should be used to keep the soil consistently moist, and regular fertigation with balanced NPK fertilizers is necessary.

Geraniums (Pelargonium spp.) are well-suited for greenhouses or polyhouses, where temperatures are maintained between 15-25°C. They need bright, indirect light and a relative humidity of around 60-70%. Drip irrigation with good drainage is crucial, and they should be regularly fertilized with balanced nutrients.

Gladiolus (Gladiolus spp.) can be effectively cultivated in polyhouses or greenhouses at temperatures between 15-25°C. These flowers require full sun to partial shade, and moderate humidity levels of 50-60% should be maintained. Drip irrigation helps prevent waterlogging, and a balanced NPK fertilizer, particularly rich in potassium, should be applied.

By adopting these cultivation practices, farmers can optimize the growth and quality of these flowers, leading to higher yields and increased profitability in protected cultivation environments.

Marketing Aspects of Flower Crops in Protected Cultivation

The marketing of flower crops grown under protected cultivation involves several strategic approaches to ensure successful commercialization and profitability.

Quality and Consistency: Emphasizing the high-quality and uniformity of flowers produced under protected cultivation builds trust and reputation among buyers.

Year-Round Availability: Highlighting the ability to supply fresh flowers throughout the year, especially during off-season periods when prices are higher, can attract steady demand.

Target Markets: Identifying and targeting local markets (florists, event organizers), national markets (wholesalers, retail chains), and international markets ensures wide reach and higher sales.

Branding and Packaging: Creating a strong brand identity and investing in attractive, eco-friendly packaging can enhance product appeal. Clear labeling that communicates superior quality and sustainable practices adds value.

Value Addition: Offering ready-to-sell bouquets, exotic varieties, and subscription services increases marketability and profitability.

Pricing Strategies: Competitive pricing based on production costs, market demand, and premium pricing for high-quality or exotic flowers ensures profitability.

Distribution Channels: Efficient distribution channels, including direct sales, wholesale markets, retail outlets, and exports, ensure flowers reach the market in optimal condition.

Promotion and Advertising: Utilizing social media, professional websites, events, exhibitions, and partnerships with wedding planners and interior designers can effectively promote flower products.

Sustainability and Certification: Highlighting sustainable practices and obtaining certifications such as organic or Fair Trade attract environmentally conscious consumers.

Customer Relationship Management: Building strong customer relationships through excellent service, understanding preferences, and offering personalized solutions enhances customer satisfaction and loyalty.

Conclusion

Protected cultivation has revolutionized the floriculture industry in India, providing numerous benefits in terms of productivity, quality, and sustainability. While the initial investment and technical challenges can be daunting, the long-term gains make it a viable option for farmers. Continued research, training, and support from government and agricultural bodies will be essential in promoting the adoption of protected cultivation techniques and ensuring the growth of India's floriculture sector. The marketing of flower crops grown under protected cultivation involves a strategic approach that highlights quality, year-round availability, and sustainability. By focusing on branding, value addition, competitive pricing, efficient distribution, and effective promotion, growers can successfully penetrate both domestic and international markets. Ensuring customer satisfaction through reliable supply and excellent service will help build a loyal customer base, leading to sustained profitability.

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MANAGING *RALSTONIA SOLANACEARUM:* A DEVASTATING BACTERIAL PATHOGEN THREATENING VEGETABLE CROPS

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Introduction

Ralstonia solanacearum, a Gram-negative soilborne bacterium, poses a significant threat to vegetable production worldwide. It incites bacterial wilt disease, a devastating pathogen affecting a broad host range, with a particular emphasis on solanaceous crops in tropical, subtropical, and warmer temperate regions. This disease can inflict significant yield losses due to its lethal effects on host plants. Despite numerous attempts to manage bacterial wilt at the field level, limited success has been achieved, primarily attributed to the complex nature of the pathogen itself.

Economic Importance

R. solanacearum is a major bacterial plant pathogen with a significant global economic impact. Its broad host range, particularly affecting solanaceous vegetables, has ranked it the second most important plant-pathogenic bacterium worldwide (Mansfield et al., 2012). Annual crop losses due to *R. solanacearum* infections are estimated to reach US$1 billion in potato alone (Elphinstone, 2005). In India, studies have reported yield losses ranging from 2% to 95% in tomato, 80% to 100% in eggplant, 20% to 100% in chili and 50% in potato. These findings highlight the devastating economic impact of *R. solanacearum* on various agricultural sectors.

Symptomatology

Identifying disease symptoms is a crucial step in diagnosing plant pathology, often providing the initial clue for pathogen identification. *R. solanacearum* exhibits a broad host range encompassing over 450 plant families. However, a characteristic sudden wilting symptom defines its infection in solanaceous crops, including tomato, eggplant, and chili pepper.

Symptoms in Solanaceous Vegetables

The initial visual symptom is drooping of green leaves at the plant's apical portion, often followed by a unilateral wilting. As the infection progresses, the wilting encompasses the entire plant, with wilted leaves retaining a green appearance. In severe cases, water-soaked necrotic lesions develop at the collar region of the basal stem and near branch shoots, ultimately leading to plant death. Additionally, a transverse section of infected stems typically reveals brown discoloration within the xylem vascular tissue, a hallmark of bacterial wilt disease.

R. solanacearum infection in potato manifests in two distinct phases

1. Wilt Phase: This phase is characterized by leaf chlorosis and drooping, followed by the development of dark brown streaks on the collar region. Subsequently, petiole epinasty (downward bending) accompanies wilting symptoms in standing plants.

2. Rotting Phase: This phase can occur in both field and storage conditions. Symptoms include ring-like brown discoloration on cut tubers. In some cases, tubers may exude creamy-white bacterial ooze from the eyes and upon cross-sectioning, providing a characteristic sign for *R. solanacearum* identification in potato.

Preliminary Diagnosis

Traditionally, detection of *R. solanacearum* infection has relied on the ooze-out test, where a freshly cut section of infected stem, root, or tuber is placed in clear water. The presence of a thread-like, milky-white, and slimy ooze emanating from the vascular system into the water confirms *R. solanacearum* infection. This rapid and straightforward test serves as a preliminary diagnostic tool for field and laboratory applications.

Differential Diagnosis

In field conditions, bacterial wilt caused by *R. solanacearum* can be challenging to distinguish from fungal wilts affecting solanaceous vegetables, particularly those caused by soil-borne pathogens like Fusarium wilt (*Fusarium oxysporum*), southern blight/sclerotial wilt (*Sclerotium rolfsii*), and verticillium wilt (*Verticillium dahlia* and *V. albo-atrum*). However, characteristic symptomatology of bacterial wilt, such as the ooze-out test and the green appearance of wilted leaves, can aid in differentiating it from fungal wilts.

Dissemination and Persistence of *Ralstonia solanacearum*

R. solanacearum exhibits a multifaceted strategy for long-distance and localized spread, posing a significant challenge for disease management. Asymptomatic transmission via infected plant material, particularly tubers and seeds, is well documented. Potato bacterial wilt exemplifies this, with latently infected seed potatoes facilitating local and international dissemination. Notably, potato strains from lower altitudes (27°C) can express latent infections at higher altitudes (29-35°C) in tropical/subtropical regions, causing wilt even in tomato (Charkowski et al., 2020). The bacterium persists on the surface, lenticels and internal vascular tissue of potato tubers (Genin and Denny, 2012). Seed transmission has been suspected for various solanaceous crops.

Locally, *R. solanacearum* spreads through contaminated soil, irrigation water from infected fields, farm equipment, and improper cultural practices that facilitate bacterial movement (Genin and Denny, 2012). Root wounding by root-knot nematodes (*Meloidogyne incognita*) has been shown to exacerbate bacterial wilt incidence in tomato and eggplant.

During overwintering, *R. solanacearum* adopts a saprophytic lifestyle, persisting in association with reservoir plants, infected plant debris and soil. A wide range of weed hosts, including *Solanum dulcamara* (bittersweet nightshade), *Solanum nigrum* (black nightshade) and *Urtica dioica* (stinging nettle), serve as potential inoculum sources. Released from infected plant materials, bacterial cells are protected by an extracellular polysaccharide matrix that aids in their survival within the soil. Studies report that *R. solanacearum* can persist in agricultural soil for up to one year and two years after crop removal, with wilt-causing capacity even after a four-year intercropping period with non-host plants. Notably, the bacterium can survive and even multiply in contaminated water, highlighting the potential for irrigation water and water channels to act as major dissemination routes (Alvarez et al., 2008). Retention of infected plant debris and seed potatoes within the field significantly increases inoculum pressure for subsequent seasons.

Integrated Disease Management

R. solanacearum, the causative agent of bacterial wilt disease, presents a significant challenge due to the following several factors:

- **Broad Host Range and Geographical Distribution:** The bacterium infects a wide variety of plant species and thrives in diverse geographical regions, making its control geographically complex.
- **Species Complexity:** *R. solanacearum* encompasses a taxonomically diverse group with varying pathogenicities, further complicating management strategies.

- **Antibiotic Resistance:** Certain strains exhibit resistance to antibiotics, limiting the effectiveness of chemical control methods.
- **Soilborne Persistence:** The ability to survive in soil for extended periods allows for long-term disease persistence.
- **Weed Association:** The presence of weed hosts within agricultural fields serves as a reservoir for the bacterium, promoting disease spread.

Despite these challenges, various control strategies have been explored.

- **Crop Rotation:** Crop rotation with non-host plant species is a commonly employed cultural control method. However, the effectiveness of this approach can be limited, as *R. solanacearum* possesses a broad host range and can survive in the soil for extended periods.
- **Phyto-sanitation:** In areas with endemic or newly introduced *R. solanacearum*, implementing strict phytosanitary measures is crucial. This includes utilizing disease-free planting materials, such as seeds (particularly for seed potatoes) and vegetative propagules. Additionally, controlling weed hosts through targeted herbicide applications can further reduce pathogen reservoirs within the field.
- **Intercropping:** The use of intercropping with specific plant species has shown variable efficacy in managing bacterial wilt disease. Intercropping with cereal crops like maize and wheat, as well as other vegetables such as onions, cabbage, beans and peas reduce the disease incidence.
- **Soil Solarization:** This technique, involving soil heating through solar radiation, effectively controls soilborne pathogens but may not be economically viable for large-scale applications.
- **Biocontrol agents:** The application of beneficial microbes has shown promise in suppressing bacterial wilt under field conditions. However, their efficacy often remains higher in controlled laboratory settings compared to real-world field environments.
- **Transgenic Approaches:** The use of genetically modified plants or avirulent strains of *R. solanacearum* holds potential but raises concerns regarding potential environmental risks to other organisms.
- **Resistant cultivars:** In India, several resistant cultivars have been adopted by growers across various solanaceous crops: tomato (Arka Rakshak, Sakthi, Anagha,

Manulakshmi), eggplant (Swetha, Surya, Haritha), chili (Ujjwala, Anugraha) and potato (CIP lines such as CIP382381.13, CIP381381.20, CIP382193.9, CIP378699.2, CIP387792.5).

- **Grafting for Enhanced Resistance:** Grafting susceptible cultivars onto resistant rootstocks like *Solanum torvum* has proven effective in controlling bacterial wilt incidence. Studies have demonstrated successful resistance induction in tomato plants grafted onto 'Dai Honmei' and 'RST-04-105-T' rootstocks.
- **Chemical Fumigation:** While offering temporary control, chemical fumigants pose a threat to non-target beneficial soil microbes and potentially contaminate the food chain.

Conclusion

Due to its extensive host range and strain variability, *R. solanacearum* poses a significant threat to vegetable crops globally. Managing this complex disease requires a multifaceted approach. Limited availability of resistant cultivars and a lack of specific, effective chemical controls necessitate alternative strategies. Biological control using native antagonistic microbes presents a promising option. Furthermore, implementing strict quarantine measures, particularly for seeds, potatoes, and other propagative materials, is crucial to prevent the introduction and spread of the disease into new regions.

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ORCHIDS IN KERALA

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Introduction

Certainly! Orchids are fascinating plants, and it's wonderful that you're interested in their cultivation. Certainly! Orchids are fascinating flowering plants that belong to the family **Orchidaceae**. Orchids come in over **25,000 species**, found in almost every corner of the world. They exhibit a wide variety of blossom forms, colors, and shapes.Orchids have been prized for their exquisite flowers and rarity throughout history. In the 1800s, there was an obsession with orchids among the upper classes known as **"Orchidelerium."** Their unique beauty and allure captured the imaginations of collectors and enthusiasts.While some orchids require specialized care, many species are surprisingly easy to grow indoors.

Let's delve into the details of orchid morphology, planting materials, varieties, and care:

1. **Morphology and Distribution**:
    - Orchids are a major group found in various vegetational types, from the western coastal region to mountains.
    - They thrive in forests, and each forest type has its unique composition of orchid flora.
    - High rainfall, cool climate, and bright sunshine create an ideal habitat for epiphytic orchids.
    - The profuse growth of moss on trees provides a suitable environment for small epiphytic orchids.

- In the Western Ghats, 267 species, 3 subspecies, and 2 varieties across 72 genera have been reported.
- Among these, 130 species, 2 subspecies, and 2 varieties are endemic to India, with 72 species being specific to the Western Ghats. Nineteen taxa are extremely rare and endangered.

2. **Selection Criteria for Planting Materials**:
    - Terminal cuttings with healthy aerial roots are ideal for planting.
    - Basal cuttings (30 cm length) with roots and leaves are also suitable, although they take longer to sprout.
    - Sympodial orchids can be propagated by separating pseudobulbs.
    - Keikis (sprouts at the top of pseudobulbs) can be separated and planted when fully grown.
3. **Popular Orchid Genera in Kerala**:
    - Monopodials: Arachnis, Aranthera, Vanda, Phalaenopsis
    - Inter-generic monopodials: Aranda, Mokara
    - Sympodials: Dendrobium, Cattleya, Oncidium

Oncidium

Phalaenopsis

4. **Dendrobium Varieties** (grouped by colour):
   - Purple and white: Sonia 17, Sonia 28, Sonia Bom Jo, Earsakul
   - Purple: Renappa, New Wanee, Sabine Red, Jurie Red
   - White: Emma White, Fairy White, Kasem White, Snow White
   - Pink: Sakura Pink, New Pink
   - Yellow: Sherifa Fatimah, Kasem Gold, Tongchai Gold

Dendrobium

5. **Plantation and Growing Media**:
   - Use broken bricks, gravel, tile bits, charcoal, coconut husk bits, and tree fern for epiphytic orchids.
   - Wash components thoroughly before filling pots.
   - Terrestrial orchids benefit from a mixture of humus, leaf mold, dried manure, chopped fern fiber, and sphagnum moss.
6. **Water Management**:
   - Water early in the day to allow orchids to dry out by nighttime.

- Frequency depends on climate: once a week in winter, twice a week in warm, dry weather.
- Container size also affects watering frequency.

7. **Nutrient Management**:
   - Apply low-concentration whole-plant sprays frequently.
   - Micronutrients improve quality and should be applied monthly.
   - Balance chemical fertilizers with organic manures (e.g., cow dung, cow urine, groundnut oil cake).
8. **Weed and Pest Management**:
   - Manual weeding or use of weedicides (like paraquat) controls weeds.
   - Mulching reduces weed population.
   - Insecticides control common pests (thrips, aphids, spider mites, etc.).
   - Snails and slugs can be hand-picked; systemic insecticides help control them.

Remember to adapt these guidelines to your specific orchid species and local conditions. Certainly! Proper plant protection is crucial for maintaining healthy anthurium plants. Let's address the diseases and pests you mentioned, along with harvesting and postharvest processing:

1. **Diseases**:
   - **Bacterial Blight**: Yellowing of plants is a key symptom. To control it, remove the diseased portion and spray streptocycline (200 mg/l).
   - **Anthracnose**: This fungal disease causes flower rot. Mancozeb (0.2%) spray can help control it and also address leaf spot disease.
   - **Root Rot**: Ensure proper aeration to prevent root rot.
   - **Damping Off**: This disease affects seedlings and young plants. Good sanitation practices and well-draining soil can help prevent it.
2. **Pest Management**:
   - Common pests include scales, mealy bugs, thrips, and mites.
   - Implement appropriate measures to control these pests.
3. **Harvesting**:
   - Harvest spikes when a few buds at the top remain unopened.
   - Cut the spikes with a small stalk.

- Dip the cut end in a fungicide solution.
- Cover with a wet cotton swab and tie using a rubber band.
- Pack them in appropriately sized cartons with proper ventilation.

4. **Postharvest Processing**:
   - Recut flower stems at an angle under warm water (38-44°C or 100-110°F).
   - Place them in a plastic container with 100-150 mm (4-6 in) of floral preservative solution.
   - Remove at least 25 mm (1 in) of stem and any foliage below the water line.
   - Typical solutions contain 1% sugar, a biocide (e.g., 200 ppm 8-HQC, 8-HQS, or Physan-20), and an acidifier (200-600 ppm citric acid or aluminum sulfate).

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RENEWABLE: AN EFFICIENT SOURCE OF POWERING RURAL WOMEN ENTREPRENEURIAL BEHAVIOUR

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Introduction

In the contemporary world, the empowerment of women and the transition to renewable energy are pivotal topics. While these subjects often appear in separate discussions, their intersection is generating significant interest, particularly in rural areas. Renewable energy, characterized by its sustainability and minimal environmental impact, is emerging as a powerful catalyst for entrepreneurial behavior among rural women. This article explores the symbiotic relationship between renewable energy and the entrepreneurial spirit of rural women, highlighting the transformative potential of this dynamic duo.

The Rural Landscape and Women's Entrepreneurship

Rural areas, often characterized by limited access to resources and infrastructure, present unique challenges and opportunities for entrepreneurship. Women in these regions frequently face additional barriers, including limited access to education, financial resources, and social support systems. Despite these challenges, rural women possess a wealth of untapped potential and resourcefulness that can be harnessed through strategic interventions.

Entrepreneurship among rural women is not just a pathway to economic empowerment but also a means to foster community development and social change. By creating business ventures, rural women can improve their economic status, gain independence, and contribute to the overall well-being of their communities.

The Role of Renewable Energy

Renewable energy, derived from natural and replenishable sources such as solar, wind, and biomass, offers a sustainable solution to the energy needs of rural areas. Unlike traditional energy sources, renewable energy systems can be deployed in remote locations without the need for extensive infrastructure. This accessibility makes renewable energy an ideal solution for empowering rural communities.

1. Solar Energy:

Solar energy is particularly well-suited for rural areas due to its scalability and adaptability. Solar panels can be installed on rooftops, community centers, and agricultural fields, providing a reliable source of electricity. For rural women entrepreneurs, access to solar energy means the ability to power their businesses, extend their working hours, and reduce operational costs.

2. Wind Energy:

Wind energy, though less common in rural areas compared to solar, can also play a significant role. Small-scale wind turbines can provide electricity for households and small businesses. Women entrepreneurs in regions with suitable wind conditions can leverage this technology to power their enterprises, particularly those involved in agriculture and small-scale manufacturing.

3. Biomass Energy:

Biomass energy, derived from organic materials such as agricultural residues and animal waste, is another viable option. In rural areas where agricultural activities are predominant, biomass energy systems can convert waste products into a valuable source of energy. Women entrepreneurs can utilize biomass energy for cooking, heating, and even small-scale industrial processes.

Empowering Rural Women Entrepreneurs

1. Enhancing Livelihoods:

Renewable energy provides rural women with the tools to enhance their livelihoods. For instance, solar-powered irrigation systems enable women farmers to cultivate crops year-round, increasing agricultural productivity and income. Similarly, solar-powered sewing machines and lighting allow women in tailoring and handicrafts to work efficiently and safely.

2. Reducing Energy Poverty:

Energy poverty, defined as the lack of access to modern energy services, disproportionately affects rural women. Renewable energy solutions help bridge this gap by providing affordable and reliable electricity. This access reduces the time and labor spent on traditional energy sources like firewood and kerosene, freeing up time for women to engage in entrepreneurial activities.

3. Improving Health and Well-being:

Traditional energy sources such as kerosene lamps and wood stoves contribute to indoor air pollution, posing significant health risks. Renewable energy solutions like solar lanterns and clean cook stoves mitigate these risks, improving the health and well-being of rural women and their families. Healthier women are more capable of pursuing and sustaining entrepreneurial ventures.

4**. Fostering Education and Skill Development**:

Access to renewable energy extends beyond economic benefits to educational and skill development opportunities. Electrified schools and training centers enable rural women to acquire the knowledge and skills needed to run successful businesses. Programs that integrate renewable energy training with entrepreneurial education empower women to harness these technologies effectively.

Challenges and Solutions

Despite the promising potential, there are challenges to integrating renewable energy into rural women's entrepreneurial endeavors:

1. Initial Investment Costs:

The upfront costs of renewable energy systems can be prohibitive for many rural women. Microfinance institutions, government subsidies, and public-private partnerships can help mitigate these costs and make renewable energy more accessible.

2. Technical Knowledge and Maintenance:

The effective use and maintenance of renewable energy systems require technical knowledge. Training programs and local support networks are essential to ensure that rural women can operate and maintain these systems efficiently.

3. Social and Cultural Barriers:

In some regions, social and cultural norms may restrict women's participation in entrepreneurial activities. Community awareness campaigns and advocacy efforts are necessary to challenge and change these norms, creating a more supportive environment for women entrepreneurs.

Conclusion

Renewable energy holds transformative potential for rural women entrepreneurs. By providing reliable, affordable, and sustainable energy solutions, renewable energy enables rural women to overcome many of the barriers they face in their entrepreneurial journeys. The synergy between renewable energy and women's entrepreneurship not only enhances individual livelihoods but also drives broader community development and social progress.

Investing in renewable energy and supporting rural women entrepreneurs are not just isolated goals but interconnected strategies that can lead to sustainable development. As we move towards a more inclusive and sustainable future, recognizing and fostering this intersection will be crucial. By empowering rural women through renewable energy, we can unlock a wealth of untapped potential, driving economic growth and social change in some of the world's most underserved communities.

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BIO FORTIFICATION: FUTURE PERSPECTIVES IN HUMAN NUTRITION

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Introduction

Bio fortification is an innovative agricultural strategy aimed at increasing the nutritional value of crops through conventional plant breeding techniques, agronomic practices, or modern biotechnological methods. As global populations rise and malnutrition persists, bio fortification offers a sustainable solution to address micronutrient deficiencies, particularly in developing countries where diets heavily rely on staple crops.

Bio fortification is different from fortification as it involves the selection of crops that have high nutrient content. The primary means of bio fortification include conventional plant breeding, genetic engineering, and agronomic practices. Each approach has unique advantages and applications, contributing to the goal of improving human nutrition.

The Need for Bio fortification

Malnutrition, especially deficiencies in essential micronutrients like iron, zinc, and vitamin A, poses significant public health challenges. According to the World Health Organization (WHO), over 2 billion people suffer from micronutrient deficiencies, often referred to as "hidden hunger" because they may not always be visible but have profound impacts on health and development. Traditional supplementation and fortification programs, while effective, have limitations such as distribution challenges and low compliance. Bio fortification directly targets the food supply, ensuring that the nutrients are naturally embedded in the food people consume daily.

Advances in Bio fortification

Conventional Breeding:

Traditional plant breeding techniques have been successfully used to enhance the nutritional content of crops. For example, Harvest Plus, a global bio fortification initiative, has developed and distributed bio fortified varieties of crops such as vitamin A-rich sweet potatoes and iron-fortified beans.

Conventional plant breeding is a long-established method that involves selecting and crossbreeding plants with desirable traits to produce offspring with enhanced nutritional qualities. This process can take several years but has been successfully used to develop bio fortified crops.

Key steps include:

Selection of Parent Plants: Identify and select plant varieties that naturally have higher levels of the desired nutrients.

Cross breeding: Cross these high-nutrient varieties with other high-yield, disease-resistant varieties.

Screening and Selection: Grow the offspring and select those that exhibit both high nutrient content and desirable agricultural traits.

Field Testing: Conduct extensive field trials to ensure that the bio fortified crops perform well under various environmental conditions.

Examples:

Vitamin A-rich sweet potatoes: Developed to address vitamin A deficiency.

Iron-fortified beans: Bred to reduce iron deficiency anemia.

Genetic Engineering:

Biotechnology offers precise tools for bio fortification, allowing for the introduction of specific genes responsible for nutrient synthesis. Golden Rice, genetically modified to produce beta-carotene (a precursor of vitamin A), is a prominent example. Despite regulatory and public acceptance challenges, such innovations hold significant potential.

Genetic engineering involves directly modifying the DNA of crops to introduce or enhance specific nutritional traits. This method allows for precise changes and can achieve results more quickly than conventional breeding. Key techniques include:

Gene Insertion: Introduce genes responsible for the production of specific nutrients, such as beta-carotene, into the crop's genome.

CRISPR/Cas9: Utilize advanced gene-editing technologies to enhance the plant's ability to produce or store essential nutrients.

RNA Interference (RNAi): Suppress genes that may inhibit nutrient accumulation.

Examples:

Golden Rice: Genetically modified to produce beta-carotene, addressing vitamin A deficiency.

Iron and zinc bio fortified rice: Engineered to increase iron and zinc content, combating multiple micronutrient deficiencies.

Agronomic Practices:

Agronomic bio fortification involves the application of micronutrient-rich fertilizers to the soil or crops. This method is less dependent on breeding cycles and can be rapidly implemented. For instance, zinc-enriched fertilizers have been used to increase the zinc content in wheat.

Agronomic bio fortification involves the application of nutrient-rich fertilizers or soil amendments to increase the micronutrient content of crops. This approach is quicker to implement compared to breeding and genetic engineering and can be used to enhance nutrient levels in crops already under cultivation. Key practices include:

Soil Fertilization: Apply fertilizers enriched with specific micronutrients (e.g., zinc, selenium) to the soil.

Foliar Feeding: Spray nutrient solutions directly onto the leaves of the crops, allowing for direct absorption.

Soil Management: Improve soil health through crop rotation, organic amendments, and conservation practices to enhance nutrient uptake by plants.

Examples:

Zinc-enriched wheat: Achieved by applying zinc fertilizers to the soil.

Selenium-fortified crops: Enhanced through the use of selenium-rich fertilizers.

Impact on Human Health

Bio-fortified crops can significantly improve nutritional intake without altering dietary habits. Studies have shown that consumption of bio-fortified crops leads to improved health outcomes. For example, vitamin A-rich orange-fleshed sweet potatoes have been linked to reduced incidence of vitamin A deficiency among children in Africa. Similarly, iron-bio-fortified beans have shown promise in combating iron deficiency anemia.

Future Perspectives

Enhanced Crop Varieties:

Continued research and development will likely produce more crop varieties with enhanced nutritional profiles. Combining multiple traits, such as high iron and zinc content in a single crop, could provide compounded benefits.

Integration with Food Systems:

Integrating bio fortified crops into local food systems and markets is crucial. This involves not only scientific innovation but also creating awareness and demand among consumers, ensuring that farmers adopt these crops and they become a regular part of diets.

Policy and Regulatory Support:

Governments and international organizations need to support bio fortification through favorable policies, funding, and regulatory frameworks. Streamlined approval processes for bio fortified crops, especially genetically modified ones, will facilitate their adoption.

Global Partnerships:

Collaboration among governments, non-governmental organizations, research institutions, and the private sector is essential for scaling up bio fortification efforts. Programs like Harvest Plus, supported by organizations such as the Bill & Melinda Gates Foundation, exemplify successful partnerships driving bio fortification forward.

Consumer Acceptance:

Educating consumers about the benefits of bio fortified foods is vital. Addressing misconceptions and demonstrating the tangible health benefits can drive consumer acceptance and demand.

Bio-fortification Advantages and Limitations

Advantages

- Sustainability: Bio-fortified crops provide a continuous source of nutrients without the need for recurrent interventions.
- Cost-effectiveness: Once developed, bio-fortified seeds can be distributed widely, reducing the need for ongoing supplementation programs.

- Accessibility: Bio-fortified crops reach rural and low-income populations who may not have access to diverse diets or supplements.

Limitations

- Acceptance and Adoption: Farmers and consumers may be hesitant to adopt new crop varieties without adequate education and incentives.
- Regulatory Hurdles: Genetically engineered crops face stringent regulatory approval processes in many countries.
- Environmental Variability: The effectiveness of agronomic bio-fortification can be influenced by soil types, weather conditions, and farming practices.

Conclusion

Bio-fortification represents a promising strategy to combat micronutrient deficiencies and improve global health outcomes. By enhancing the nutritional content of staple crops, bio fortification offers a sustainable, long-term solution to hidden hunger. As scientific advancements continue and global efforts align, the potential of bio fortification to transform human nutrition and health is immense. Bio fortification is a multifaceted approach to enhancing the nutritional quality of food crops, employing conventional breeding, genetic engineering, and agronomic practices. Each method contributes uniquely to the goal of addressing micronutrient deficiencies and improving public health. Continued research, policy support, and consumer education are crucial to realizing the full potential of bio fortification in achieving global nutrition security.

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DIVERSE MECHANISMS OF NEMATODE CONTROL BY FUNGAL SPECIES AND THEIR INFECTION STRUCTURES

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Introduction and distribution:-

Nematophagous fungi are a group of fungi that prey on nematodes, microscopic roundworms found in soil and water. They use various strategies to capture and consume nematodes, such as forming traps, producing spores that infect nematodes, or secreting toxins. These fungi play a crucial role in regulating nematode populations, contributing to soil health and offering potential for biological control in agriculture.

Nematophagous fungi play a crucial role in agriculture and ecosystem health. They naturally control plant-parasitic nematodes, reducing the need for harmful chemical nematicides and promoting sustainable farming practices. By regulating nematode populations, they help maintain soil ecosystem balance, which is essential for healthy plant growth.

Nematophagous fungi are widely distributed across various environments, including soils, decaying organic matter, and aquatic habitats. They are found in diverse ecosystems such as forests, grasslands, agricultural fields, and wetlands. Their presence is influenced by factors like soil type, moisture, organic content, and the presence of nematode populations. These fungi thrive in environments where nematodes are abundant, as they rely on them for nutrition. Their wide distribution makes them important players in natural pest control and soil health maintenance across different ecosystems.

Some common species of nematophagous fungi:

1. *Arthrobotrys oligospora*
2. *Hirsutella rhossiliensis*

3. *Dactylellina cionopaga*
4. *Drechmeria coniospora*
5. *Meristacrum aesteospermum*
6. *Monacrosporium ellipsosporum*
7. *Stylopage hadra*
8. *Stylopage grandis*
9. *Catenaria anguillulae*

Habitation:

Nematophagous fungi inhabit diverse environments where nematodes are present. Common habitats include soils of forests, grasslands, and agricultural fields, as well as decaying organic matter and aquatic environments like freshwater and marine sediments. They thrive in areas rich in organic material and moisture, which support high nematode populations. These fungi can adapt to various soil types and environmental conditions, making them widespread and ecologically significant in natural and managed ecosystems.

How nematophagus fungi is important in controlling field crop pest:

Nematophagous fungi play a critical role in controlling field crop pests, particularly plant-parasitic nematodes, through biological control mechanisms. Here's a more detailed explanation of their importance:

1. Natural Predation: Nematophagous fungi are specialized predators of nematodes. They have evolved various strategies to capture and kill nematodes, such as forming adhesive traps (e.g., adhesive networks, rings, knobs), producing adhesive substances, or using mechanical penetration to enter nematode bodies.

2. Infection and Parasitism: Some nematophagous fungi infect nematodes through spores that adhere to the nematode's cuticle, germinate, and penetrate the nematode's body. Inside the nematode, these fungi grow and consume their host, eventually killing it. Examples include fungi like *Arthrobotrys* and *Drechmeria* species.

3. Toxin Production: Certain nematophagous fungi produce toxins that can immobilize or kill nematodes upon contact. These toxins disrupt nematode cellular processes or cause physical damage, leading to their demise. *Pochonia chlamydosporia* is an example known for its nematode-toxic compounds.

4. Regulation of Nematode Populations: By effectively reducing nematode numbers, nematophagous fungi help maintain soil health and crop productivity. Plant-parasitic nematodes can cause significant damage to crops by feeding on roots, leading to stunted growth, reduced yield, and increased susceptibility to other stresses. Controlling nematode populations mitigates these detrimental effects.

5. Environmental Sustainability: The use of nematophagous fungi as biological control agents reduces reliance on synthetic chemical nematicides, which can have adverse effects on non-target organisms and environmental health. This approach aligns with principles of integrated pest management (IPM), promoting sustainable agricultural practices.

6. Economic Benefits: Effective control of nematodes by nematophagous fungi can lead to improved crop yields and quality, thereby enhancing economic returns for farmers. It also reduces the costs associated with chemical inputs and mitigates the risks of developing nematode resistance to chemical treatments.

7. Research and Development: Studying nematophagous fungi contributes to advancements in biological control methods and understanding their ecological roles. This research may lead to the development of new fungal strains or formulations optimized for specific nematode pests or environmental conditions.

About in-vivo culture of nematophagous fungi:

In-vivo culture of nematophagous fungi involves:

1. Isolate Selection: Choosing effective fungi for nematode control.
2. Inoculum Preparation: Growing fungi on suitable media to produce spores.
3. Nematode Selection: Using specific nematode hosts.
4. Inoculation: Applying fungal spores to nematodes.
5. Incubation: Maintaining optimal conditions for fungal growth and nematode infection.
6. Observation: Monitoring fungal penetration, colonization, and nematode death.
7. Analysis: Studying physiological and biochemical changes in infected nematodes.

Some common culture media for nematophagous fungi:

Common culture media used for cultivating nematophagous fungi include:

1. Potato Dextrose Agar (PDA): A general-purpose medium that supports the growth of many fungi, including nematophagous species.

2. Cornmeal Agar: Contains cornmeal extract and is supplemented with various nutrients, suitable for the cultivation of diverse fungi.

3. V8 Agar: Made from V8 vegetable juice and agar, providing a nutrient-rich medium often used for fungi that require additional nutrients.

4. Water Agar: A simple medium consisting of agar and water, used for initial isolation or observation of fungal growth.

5. Cereal-Based Media: Such as oatmeal agar or rice bran agar, which provide nutrients and support growth of nematophagous fungi.

6. Insect Extract Agar: Contains extracts from insects or nematodes themselves, providing specific nutrients that some nematophagous fungi require.

7. Sabouraud Dextrose Agar (SDA): A medium typically used for yeasts and molds, but can also support the growth of some nematophagous fungi.

Table: Taxonomy of nematophagous fungi and their infection modes.

Fungal group	Phyla	Fungi	Infection structures
Nematode-trapping fungi	Zygomycota	*Stylopage*	Adhesive hyphae
		Cystopage	Adhesive hyphae
	Ascomycota	*Arthobotrys*	Adhesive networks
		Dactylellina	Adhesive knobs and/or nonconstructing ring
		Drechslerella	Constructing rings
	Basidiomycota	*Gamsylella*	Adhesive branches or unstalked knobs
		Nematoctonus/ Hohenbuchelia	Adhesive "hour-glass" knobs
Endoparasitic fungi	Oomycota	*Myzocystiopsis*	Zoospores
	Chytridiomycota	*Haptoglossa*	“Gun cell”, injection
	Blastocladiomycota	*Catenaria*	Zoospores
	Ascomycota	*Harposporium/Podocrella*	Ingested conidia

		Drechmeria *Haptocillium/cordyceps* *Hirsutella*	Adhesive conidia
	Basidiomycota	*Nematoctonus/Hohenbuehelia*	Adhesive "hour-glass" knobs
Egg- and female-parasitic fungi	Oomycota	*Nematophthora*	Zoospores
	Ascomycota	*Pochonia/Metacordyceps* *Paecilomyces/Cordyceps* *Lecanicillium/Cordyceps*	Appressoria Appressoria Appressoria
Toxin-producing fungi	Basidiomycota	*Pleurotus*	Toxic droplets
		Coprinus	Toxin, “Spiny structures”

Trapping structure of nematophagous fungi:

Nematophagous fungi employ various trapping structures to capture nematodes, enhancing their predatory capabilities. These structures include:

1. Adhesive Networks: Thin, branching structures composed of sticky cells or mucilage that adhere to nematodes upon contact. Examples include *Arthrobotrys* species.

2. Adhesive Columns: Vertical, adhesive structures that trap nematodes climbing through the soil or other substrates. They are found in fungi like *Dactylellina* species.

3. Constricting Rings: Flexible rings that expand and contract around nematodes, squeezing and immobilizing them upon contact. *Drechmeria* fungi are known for this trapping mechanism.

4. Adhesive Knobs: Spherical or knob-like structures that adhere to nematodes passing nearby, facilitating fungal attachment and infection.

These trapping structures enable nematophagous fungi to effectively capture and immobilize nematodes, initiating the process of infection and nutrient acquisition essential for their growth and reproduction.

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NUTRI-SMART VILLAGES: AN INNOVATIVE AND MULTISPECTRAL APPROACH FOR ENSURING NUTRITIONAL SECURITY

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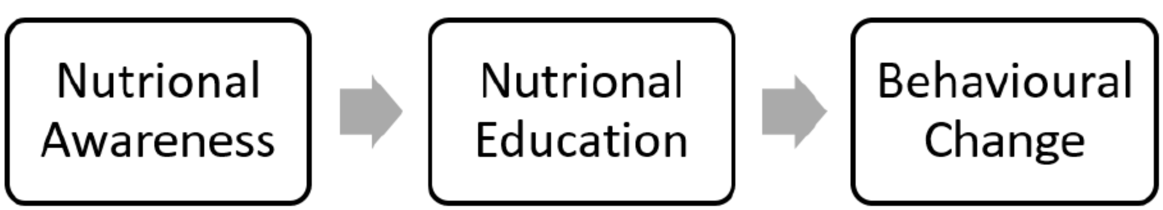
Introduction

India achieved food security with the onset of Green revolution but its struggling with nutritional security. Researches shows the cases of malnutrition and nutritional disorders are still prevalent among the large section of marginalized section of the country. Women and children are the major sufferer of the issue. To overcome this time to time many women and children centric programmes and schemes has been launched by the government. But at grassroot level there is still gap which is needed to be filled to achieve nutritional security. Policymakers are searching sustainable solutions to tackle this grappling situation.

As an integral part of Azadi Ka Amrit Mahotsav, to commemorate the 75th year of Independence of India a programme on "Nutrition Smart Village" was initiated to strengthen the Poshan Abhiyan. This new initiative aims to reach out to 75 villages across India through the network of All India Coordinated Research Project on Women in Agriculture (AICRP-WIA) which is in operation at 13 centres in 12 States. Establishing community based nutrition garden and crop diversification model are pillars to develop Nutri Smart Village. The convergence of traditional wisdom and modern scientific insights creates a knowledge-sharing ecosystem, driving context-specific solutions for improved nutrition. Nutri-Smart Villages present a holistic and innovative approach to ensure nutritional security in India's rural landscape.

Determinants of Nutrition Smart Village



Role of Extension Personnel in promoting Nutri Smart Villages

To achieve the goal of Nutritional Security and Healthy village , pivotal role of extension personnel come into the play.

1. **Organize Awareness Campaigns –** To sensitize people regarding nutritional value of food, importance of nutrition, balanced diet, nutria thali, regular and intensive campaigns should be organized at prominent place s of the villages to aware them.
2. **Demonstrations of establishing Nutri-thali and Nutrition gardens –** Seeing is believing. It builds credibility about the concept so extension personnel should demonstrate how to prepare an ideal nutria-thali, nutri- food and setting up of nutrition garden villages.
3. **Undertake Field Tour** to successful nutrition village, gardens will boost up villagers confidence in adopting the idea of Nutrition Smart Village for strengthening the Poshan Abhiyan.
4. **Establish Nutritional Camps –** Identify under nutrition/ mal nutrition affected child and women and through capacity building of their caregivers skill them to upgtade their nutritional status.
5. **Up-skilling through Capacity Building Programmes -** Give proper hygiene training and improve their WASH behaviour patterns through different capacity building programmes
6. **Replicate feasible Sustainable Integrated Farming System (SIFS) Models –** Identify agro ecological sustainable farming system model encompassing cereal- pulses-vegetables-aquatic-livestock poultry interventions to improve the dietary diversity among the people.
7. **Sensitization of Community about LANN –** Educate and sensitize community about the linkages between agriculture, natural resource and nutrition management and motivate them to adopt local indigenous food of health and nutritional importance which will also help in environment and biodiversity conservation.
8. **Strengthen Institutional linkages –** With the help of local community, agencies, SHGs, Local leaders build nutritional budgets and safeguard nutritional practices and interventions and arrange all necessary nutritional based interventions.

9. Awareness among the women farmers will also be created about their legal rights in all walks of life.

All these actions will ultimately help the villagers to reduce cost of production, consume safe food, adopt safer and right hygiene practices, generate income and empower the community through collaborative team efforts. These practices will help in attaining food and nutritional security of the nation by reducing the cases of malnutrition and ill health among the community.

Flow diagram of outcome of Nutri Smart Village

By converging modern agricultural practices, advanced technologies, community engagement, and nutrition education, Nutri-Smart Villages empower villages towards self-sufficiency and improved well-being. Community participation plays a vital role in the success of Nutri-Smart Villages. Empowering local communities through capacity-building workshops, training sessions, and women's self-help groups fosters a sense of ownership and sustainability.

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JELLY FISH: NATIONAL GEOGRAPHIC KIDS/ KING OF THE SEA

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Introduction

The jellylike creatures pulse along on ocean currents and are abundant in cold and warm ocean water, in deep water, and along coastlines. But despite their name, jellyfish aren't actually fish—they're invertebrates, or animals with no backbones, they are plankton that fall under phylum Cnidaria and the class Scychoza. Jellyfish are marine animals that lack most of the features we are seeing in an animal. They have no eyes, teeth, claws or fangs, but with their poisonous tentacles they dominate ocean ecosystems. Some jellyfish are clear, but others are vibrant colors of pink, yellow, blue and purple. They can be ***bioluminescent,*** too, which means they produce their own light. Jellyfish have no brain, heart, bones or eyes, they are made up of a smooth, bag-like body and tentacles armed with tiny, stinging cells.

Most jellyfish are equipped with stinging cells called nematocysts on their tentacles which they use both to capture their prey and also as a form of defence. When a jellyfish comes in contact with prey, the nematocysts are activated, which send poison filled stingers into the jellyfish's victim. A prey animal makes contact with the surface of the jellyfish, the capsule opens and the filaments are ejected and stick into the prey, injecting their poison. However, although nearly all jellyfish have stinging capabilities, only some are deadly to humans.

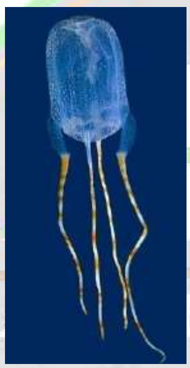
History of Jelly fish

Jellyfish have been around for **millions of years**, even before dinosaurs lived on the Earth. The name jellyfish, in use since 1796, has traditionally been applied to all similar animals including the comb jellies (ctenophores, another phylum). Other scientists prefer gelatinous zooplankton for all soft-bodied animals in the water column. The name alludes to the tentacled head of Medusa in Greek mythology. Jellyfish are inhabitants of the tropical seas and of the cold waters of the Arctic. They have been there for over 650 million years.

Types of Jelly fish

While many types of jellyfish are relatively harmless to humans, some can cause severe pain and are more likely to cause a systemic reaction.

1. **Box jellyfish:** Box jellyfish can cause intense pain. Life-threatening reactions although rare, are more common with this type. The more dangerous species of box jellyfish are in the warm waters of the Pacific and Indian oceans. The box jellyfish is a highly poisonous type named for its box-like shape with one tentacle protruding from each corner. These jellyfish live in the Indo-Pacific Ocean and the coasts of Northern Australia. Their poison is enough to send humans into cardiac arrest, causing them to drown in shock before reaching shore.



2. **Lion's Mane Jellyfish:** The lion's mane jellyfish are the largest jellyfish on Earth. It can grow upto 800 tantacles in a flowing net of yellow and orange drifting nearly 100 feet beaneath it. Unlike the box jellyfish, the lion's mane jellyfish likes it cold. It can be found in the cool waters of the Arctic, Northern Atlantic and Northern Pacific oceans. Although not as poisonous as the box jellyfish, a lion's mane sting will definitely leave a painful memory. These are the world's largest jellyfish, with a body diameter of more than 3 feet (1 meter). They're most common in cooler, northern regions of the Pacific and Atlantic oceans.

3. **Flower Hat Jellyfish:** Like the name sounds, these jellyfish are fabulously made up of a colorful pinstripe bell and multicolor tentacles extending outward. They're much smaller than the lion's mane jellyfish, at only six inches in diameter. However, large swarms of jellyfish off of the coast of Argentina and Brazil can make swimming in the summer difficult despite their modest size. These beautiful jellyfish can also be found off of the coast of Japan.

4. **Golden Jellyfish**: Not all jellyfish live in the sea. The golden jellyfish lives in a saltwater lake, in the island chain of Palau near Philippines. To survive, they spend most of their day migrating back and forth across the lake to the western shore. They are one of the few species of jellyfish that actively navigates their environment. Named for their golden domes and tentacles, these small jellyfish congregate in large numbers in lake.

5. **Black Sea Nettle:** Common in both warm and cool seawaters, they live along the northeast coast of the United States and are abundant in the Chesapeake Bay. The black sea nettle (Chrysaora achlyos), sometimes informally known as the “black jellyfish” due to its dark coloration, is a species of jellyfish that can be found in the waters of the Pacific Ocean. It is a giant jellyfish, with its bell measuring up to 1 m (3 ft) in size, and

its oral arms extending up to 6 m (20 ft) in length.The sea nettle is radially symmetrical, marine, and carnivorous.

6. **Breede River Jellyfish:** This species forms large swarms in the Breede River during summer. The numbers decrease during autumn and by early winter they have disappeared.

7. **White Spotted Jellyfish**: Also called the Australian Spotted Jellyfish, these are native to the Pacific Southwest waters. Fairly large they generally consume snail species but they have become a concern in some areas because of the huge amount of water they filter.

8. **Blue Jellyfish:** Also known as Bluefire jellyfish is a species of jellyfish in the family Cyaneidae. This species is found in the pelagic zone of the west coast of Scotland, the North Sea and the Irish Sea. It has a blue or yellow tone and grows to approximately 10 to 20 cm, but specimens can grow to 30 cm.

9. **Mediterranean or Fried Egg Jellyfish:** This is a really strange but beautiful creature, which looks like a fried or poached egg and lives in the Mediterranean, Adriatic and Aegean seas. It is also one of the few jellies that can locomote on its own, not just relying on current.

10. **Purple Striped Jellyfish:** The purple-striped jelly is a species of jellyfish that exists primarily off the coast of California in Monterey Bay. The bell (body) of the jellyfish is up to 70 cm (27.6 inches or 2.3 feet) in diameter, typically with a radial pattern of stripes. The tentacles vary with the age of the individual, consisting typically of eight marginal long dark arms, and four central frilly oral arms.

Morphology of Jelly Fish

Jellyfish are a pelagic animal that is to say that they live in the open seas, and although they can propel themselves with rhythmic motions of their umbrella, they move basically at the mercy of the currents of the sea.

The jellyfish's mouth is found in the centre of its body from this small opening it both eats and discards waste. Jellyfish have tiny stinging cells in their tentacles to stun or paralyze their prey before they eat them. Inside their bell-shaped body is an opening that is its mouth, they eat and discard waste from this opening. Tentacles hang down from the smooth baglike body and sting their prey, stings can be painful to humans and sometimes very dangerous, but jellyfish don't purposely attack humans and most stings occur when people accidentally touch a jellyfish, but if the sting is from a dangerous species, it can be deadly. Jellyfish digest their food very quickly, they wouldn't be able to float if they had to carry a large, undigested meal around, because their body is composed 98 per cent of water.

The body of a jellyfish is divided into three main parts:

a. The umbrella
b. The oral arms (around the mouth)
c. Stinging tentacles.

They are animals with radial symmetry and they have an internal cavity, in which the digestion is carried out, denominated the gastro-vascular cavity and which has a single aperture which carries out the functions of both the mouth and the anus.

They show two different types of morphology:

a. **Polyp form:** Which lives fixed to the substrate, with a tubular body and with tentacles and its mouth directed upwards,
b. **Jellyfish form:** Free-living and with the tentacles and the mouth downwards.

Jellyfish are composed of 98 per cent of water and have only 6 major body parts:

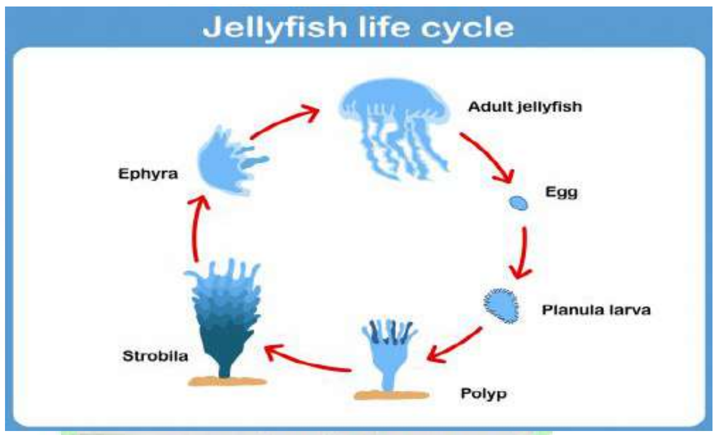
a. Epidermis
b. Gastrodermis
c. Mesoglea
d. Gastrovascular cavity Orifice
e. Tentacles

Jellyfish have 3 major stages of development:

a. Polyps - Baby jellyfish
b. Ephrae - Young jellyfish
c. Medusae - Adult jellyfish

Life cycle of Jelly Fish

The jellyfish have separate sexes there are male and female jellyfish. In order to reproduce, males and females release sperm and eggs into the water (sexual reproduction). After fertilisation, they develop larvae which give rise to new jellyfish or which settle on the sea bottom as polyps, from these polyps, by means of asexual reproduction, new free-living jellyfish may develop. The life cycle of free-swimming jellyfish typically consists of three stages. A sessile polyp(scyphistoma) stage asexually buds off young medusae from its upper end, with each such ephyra growing into an adult. The adults are either male or female, but in some species they change their sex as the age. In many species, normal fusion of egg and sperm results in an embryo that is brooded in the gut of the adult until it becomes a ciliated planula larva, but in some this development takes place in the sea. After the planula larva leaves its parent, it lives for a time in the plankton and eventually attaches to a rock or other solid surface, where it grows into a new scyphistoma.



Jelly fish stings

Jellyfish stings are relatively common problems for people swimming, wading or diving in seawaters. The long tentacles trailing from the jellyfish body can inject you with venom from thousands of microscopic barbed stingers. Jellyfish stings vary greatly in severity. Most often they result in immediate pain and red, irritated marks on the skin. Some jellyfish stings may cause more whole-body (systemic) illness. Most jellyfish stings get better with home treatment and severe reactions require emergency medical care.

Conditions that increase your risk of getting stung by jellyfish include:

- Swimming at times when jellyfish appear in large numbers (Jellyfish bloom)
- Swimming or diving in jellyfish areas without protective clothing
- Playing or sunbathing where jellyfish are washed up on the beach
- Swimming in a place known to have many jellyfish

The following tips can help you avoid jellyfish stings:

a) **Wear a protective suit:** When swimming or diving in areas where jellyfish stings are possible, wear a wet suit or other protective clothing. Consider protective footwear as stings can also occur while wading in shallow water.

b) **Get information about conditions:** Talk to lifeguards, local residents or officials with a local health department before swimming or diving in coastal waters, especially in areas where jellyfish are common.

c) **Avoid water during jellyfish season:** Stay out of the water when jellyfish numbers are high.

Common signs and symptoms of jellyfish stings include:

- Burning, prickling, stinging pain, Red, brown or purplish tracks on the skin — a "print" of the tentacles' contact with your skin, itching and swelling
- Stomach pain, nausea and vomiting, Headache, Muscle pain or spasms, Weakness, drowsiness, fainting and confusion
- Difficulty breathing, Heart problems
- Delayed hypersensitivity reaction, causing blisters, rash or other skin irritations one to two weeks after the sting
- **Irukandji syndrome:** which causes chest and stomach pain and high blood pressure

The severity of your reaction depends on:

- The type and size of the jellyfish
- Your age, size and health, with severe reactions more likely in children and people in poor health
- How long you were exposed to the stingers
- How much of your skin is affected

How to Treat a Jellyfish Sting

- If you are stung by a box jellyfish, seek medical help immediately. While you are waiting for medical help, flood the area with vinegar until medical help is available and keep as still as possible, and soak the area and tentacles for 10 minutes or more, before attempting to remove them. If the sting is on the arms or legs, you can place a pressure dressing around the sting, be careful that you do not stop blood flow, the fingers and toes should always stay pink. This will help to slow down the spread of the toxin.

- For other jellyfish stings, soak or rinse the area in vinegar (acetic acid) for 15-30 minutes to stop the nematocysts from releasing their toxins. If you do not have vinegar available, rinse in sea water,70 per cent isopropyl alcohol, or Safe Sea Jellyfish After Sting® pain relief gel. Do not use fresh water because fresh water will cause the nematocysts to continue to release their toxin. For the same reason, do not rub the area, apply ice or hot water.
- Remove tentacles with a stick or pair of tweezers.
- Apply shaving cream or a paste of baking soda to the area. Shave the area with a razor or credit card to remove any adherent nematocysts. Then reapply vinegar or alcohol. The shaving cream or paste prevents nematocysts that have not been activated from releasing their toxin during removal with the razor.
- Eye stings should be rinsed with a commercial saline solution like Artifical Tears; dab the skin around the eyes with a towel that has been soaked in vinegar. Do not place vinegar directly in the eyes.
- Mouth stings should be treated with 1/4 strength vinegar. Mix ¼ cup of vinegar with ¾ cup of water. Gargle and spit out the solution. Do not drink or swallow the solution.
- For pain, take acetaminophen (Tylenol) 325 mg 1-2 tablets every 4-6 hours for pain; or Ibuprofen (Motrin) or Aleve every 8 hours for pain.

What preventive measures should be taken against jellyfish?

- If there are a large number of jellyfish in coastal waters, the beach should be closed for at least 24 hours, taking precautions even if the jellyfish are abundant at some distance from the coastline.
- If the jellyfish are close to the beach, the best thing is to stay out of the water and keep one's distance from the breaking waves.
- Jellyfish should not be touched in the sand, even though they appear to be dead, the stinging cells remain active for a period of time; even walking along the water's edge can be dangerous as there may be remains of tentacles in the sand. It is necessary for a period of a day's sun to de-activate the stinging cells located in the fragments.

Health Benefits of Jellyfish

Since jellyfish is consumed in dried form, so it contains calcium binding proteins that are beneficial to maintain healthy cells, so it is remarkable age-fighting solution and also great for human brain.

1. **Perfect food for weight loss**

   Jellyfish is low in calories with only a little trace of carbohydrate, so this food is perfect choice for weight loss foods. Moreover, jellyfish is excellent source of protein to help you maintaining healthy muscle during diet while amino acids help maintaining the continuity of cell regenerations.

2. **Great for memory**

   The main benefits of jellyfish is this kind of seafood is good for memory due to the calcium binding protein contained in this remarkable sea creature. Normally, this type of protein is produced by brain itself but the amount will be progressively reduced as you get older but you could get it just by consuming jellyfish.

3. **Reduces the risk of several brain diseases**

   Calcium binding protein content found in jellyfish is also good to reduce the risk of several brain diseases which is aging related but also some fatal conditions such as Alzheimer and dementia.

4. **Keep yourself younger**

   Jellyfish is one of the immortal creatures due to its ability to fix itself. Well, eating jellyfish is not going to make you immortal but at least eating jellyfish could help you slowing down the aging process. The reason is due to the collagen content found in jellyfish.

5. **Excellent source of collagen**

   Normally, human body is producing its own collagen through metabolism process of vitamin c benefits. However, just by consuming jellyfish, you could enjoy collagen rightly from your dinner plate.

6. **Good for skin health**

   One of the main benefits of collagen is good for skin health. Collagen is keeping the elasticity of skin even when you are getting older. Collagen is supporting the skin cell regenerations to keep it firm and young in much longer time.

7. **Used as cosmetic ingredients**

Jellyfish has been used as one of the main cosmetic ingredients due to its collagen content. Jellyfish is a remarkable creature due to its ability to transform all old cells into younger cells.

8. Good for heart

As jellyfish is low in calories and carbohydrate but packed with protein and amino acids, so jellyfish is among those foods that are good for heart. It is so unlike other seafood but even if you have heart problem, jellyfish is safe choice of dinner.

9. Manages cholesterol level

Jellyfish is one of the foods that lower cholesterol level and the Chinese have been using jellyfish to help them managing cholesterol level as part of their traditional medicines and home remedies.

10. Reduces the risk of high blood pressure

One more amazing thing about jellyfish is its ability to reduce the symptoms of high blood pressure. In other words, it could help reducing all the health risk related to high blood pressure such as stroke and heart attack.

11. Maintains blood vessel

The ability of jellyfish in maintaining the blood pressure level is due to its ability prevent hardening of the arteries in order to maintain the health of blood vessel.

Availability: Jellyfish is usually sold already dried – it then just needs to be soaked overnight, rinsed, dried some more, and then shredded to add to salads or mixed with vegetables.

Cautions about Jellyfish food

- Jellyfish is very delicious food but it could be really hazardous.
- Jellyfish is supposed to be consumed in dried form because within hours jellyfish will be easily decayed and decayed jellyfish is very toxics.
- Dried jellyfish required salt to keep from decaying. Salt contains sodium, though there are a lot of health benefits of sodium but still in excessive amount could be really dangerous. So, it is better to soak it in the water for quite a long time before consuming it to help removing the excessive amount of the salt besides it will make the taste of dried jellyfish crunchier and tastier.

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MECHANICAL WEED MANAGEMENT REPLACES CHEMICAL WEED MANAGEMENT ECONOMICALLY IN MAIZE?

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Abstract

To optimize the pre-emergence herbicide dose of atrazine 0.5 kg/ha, 0.75 kg/ha and 1.0 kg/ha in experiment I and along with recommended dose of pre-emergence herbicide of atrazine @ 0.25 kg/ha and optimize the time and method of post emergence weed management in maize *viz.*, hand weeding, early post emergence herbicide application, post emergence herbicide application and mechanical weeding in various time in experiment II. After 2 years of study, the best performed treatments from experiment I and II were combined and tested in 3rd year. The result of the experiment revealed that a significant higher grain yield (9,251 kg/ha) was recorded in the application of atrazine @ 1.0 kg/ha as pre-emergence and followed by spraying of tembotrione @ 120 g a.i./ha at 15 DAS than control and recommended practice. The highest net returns of Rs.1,17,864/- per hectare and BCR of 3.04 in application of atrazine @ 1.0 kg/ha followed by tembotrione @ 120 g a.i./ha at 15 DAS. Total weed population was significantly lesser in atrazine 1.0 kg/ha (PE) fb mechanical weeding at 25 DAS) at 15 DAS. The total weed dry weight was also significantly lesser (5.7 g/m^2 and 5.0 g/m^2) in T_9 (atrazine 1.0 kg/ha (PE) fb tembotrione @ 120 g a.i./ha at 15 DAS) at 15 DAS and at 25 DAS. Whereas at 50 DAS, the significant lesser total weed dry weight (5.2 g/m^2) was found in atrazine application @ 1.0 kg/ha (PE) fb One hand weeding at 30-35 DAS.

Key words: Herbicide optimization, Maize, Grain yield, pre-emergence, post emergence, weed control efficiency

Introduction

Maize *(Zea mays L.)* is the second most important cereal crop in the world in terms of total food production. It is grown for fodder as well as for grain. The grains of maize are use in a variety of ways by the human beings. Recently, with the release of improved cultivars and hybrids, the grain yield has been increased but still the maize crop faced many problems. Weeds are one of the most important factors in maize production. They causes important yield losses worldwide with an average of 12.8 % despite weed control applications and 29.2 % in the case of no weed control (Oerke and Steiner, 1996). Therefore weed control is an important management practice for maize production that should be carried out to ensure optimum grain yield.

The review on herbicides controlling broad leaved, grasses and sedges said that the higher dose of (1.0 kg/ha) Atrazine recorded higher 100 grain weight (33.8 g) and grain yield (Kamble Anand Shankar *et al.*, 2015). These studies are also evidenced in the sequential application of Atrazine 0.75 kg/ha fb 2, 4-D 1.00 kg/ha or mechanical weeding alone or application of Atrazine 1.00 kg/ha alone at both the doses recorded the higher grain yield. Sequential application of Atrazine 0.75 kg/ha fb 2,4D 1.00 kg/ha is on par with weed free treatment (Shantveerayya Hawaldar and Agasimani, 2012). The broad leaved weeds like *Trianthema portulacastrum* (*Saranai in Tamil language*) will grow faster than the maize crop in the early stage and grass like *Dactyloctenum aegypticum* (Crow foot grass) will farm mat like structure are shown less effect for post emergence herbicides at 25 DAS.

Assessment methodology

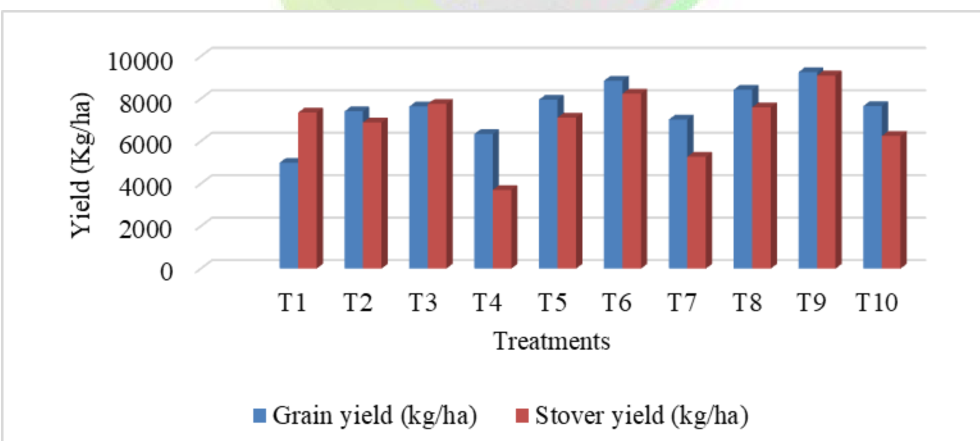
This experiment was conducted in two phases in a same time as experiment I and experiment II. Experiment I comprised of pre-emergence herbicide atrazine in various doses *viz.*, 0.25 kg a.i./ha, 0.50 kg a.i./ha, 0.75 kg a.i./ha and 1.0 kg a.i./ha and hand weeding twice at 20 days after sowing and 40 days after sowing. All these herbicide doses and manual weeding was compared with unweeded check. Simultaneously, experiment II comprised of early post emergence herbicide 2,4-D @ 1.0 kg a.i./ha, tembotrione @ 120 g a.i./ha and halosulfuron ethyl @ 60 g a.i./ha at 15 days after sowing and 25 days after sowing. Another post weed management practice of mechanical weeding and existing recommended weed management practice of atrazine @ 0.25 kg a.i./ha followed by one hand weeding at 35 days after sowing. All these weed management methods were compared with unweeded check. The hybrid chosen was TNAU Maize hybrid Co 6. Statistical design was Randomized Block Design with four replications in

Experiment I and three replications in Experiment II. The plot size formed in I year was 4.2 m X 3.0 m with the spacing of 60 cm X 25 cm, in year II, the plot size of 3.6 m X 3.0 m and the spacing of 60 cm X 25 cm. The study was consolidated after two years data and better performed treatments were combined and formed a new set of treatments. The variety chosen was TNAU Maize hybrid Co 6 in statistical design of RBD with three replications. The plot size made to 5.0 m X 4.0 m and taken up the sowing with the spacing of 60 cm X 25 cm.

Impact of weed management practices on yield and economics

Effect of pre and post emergence herbicides on hybrid maize with various doses and methods had a positive impact on grain yield and stover yield. A significant higher grain yield (9,251 kg/ha) was recorded in the application of atrazine @ 1.0 kg/ha as pre emergence and followed by spraying of tembeotrion @ 120 g a.i./ha at 15 DAS (T_9). This was followed by T_6 (atrazine 0.75 kg/ha (PE) fb tembotrione @ 120 g a.i./ha at 15 DAS) and T_8 (atrazine 1.0 kg/ha (PE) fb One hand weeding at 30-35 DAS (Rec.) i.e. 8,847 kg/ha and 8,428 kg/ha respectively. It was clearly shown that the unweeded check resulted poor and significantly lesser grain yield. This result was supported with the findings of increased grain yield in maize under spraying of atrazine as pre-emergence herbicide by (Larbi *et al*, 2013) which was substantiating the findings of Rout and Satapathy (1996). A similar result was also obtained by Sandhya Rani *et al*, (2022).

Fig. 1. Optimization of pre emergence and time of post emergence weed management methods on yield in hybrid maize



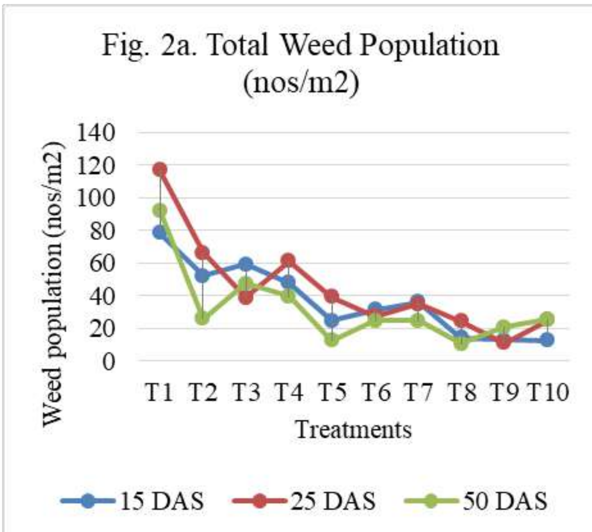
As the highest yield attributes, kernel and stover yield of maize was recorded with hand weeding twice at 15 and 30 DAS, which was however, comparable with application of atrazine 1.0 kg ha-1 as PE *fb* topramezone 30 g ha-1 as PoE. This might be due to reduced competition between the crop and weeds for the existing resources throughout the crop growing period enabling the crop for maximum utilization of nutrients, moisture, light and space, which enhanced the vegetative and reproductive potential of the crop that reflected in the form of higher kernel and stover yield of maize as also noted by Parameswari *et al.,* (2017).

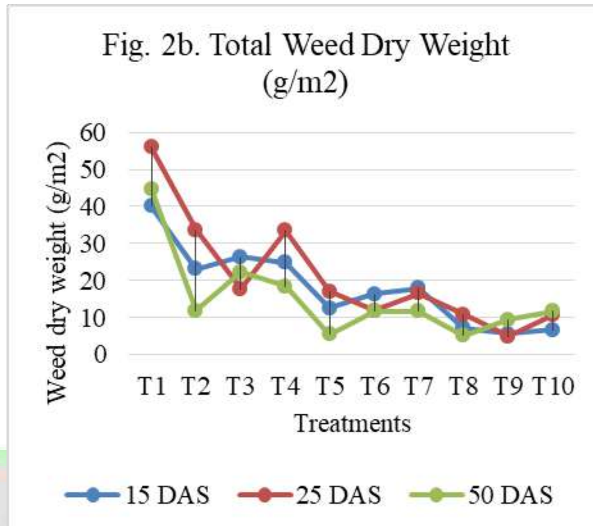
The highest benefit cost ratio was calculated (Rs.1,17,864/- per hectare) in application of atrazine @ 1.0 kg/ha followed by tembotrione @ 120 g a.i./ha at 15 DAS (T_9), which was followed by T_6 (atrazine 0.75 kg/ha (PE) fb tembotrione @ 120 g a.i./ha at 15 DAS) and T_8 (atrazine 1.0 kg/ha (PE) fb One hand weeding at 30-35 DAS (Rec.)) treatments (Rs. 1,10,113/- and Rs. 1,01,204/- respectively). The benefit cost ratio was also in the same trend as that of net returns. The highest BCR was registered in T_9, followed by T_6 and T_8 treatments (3.04 followed by 2.91 and 2.73 respectively).

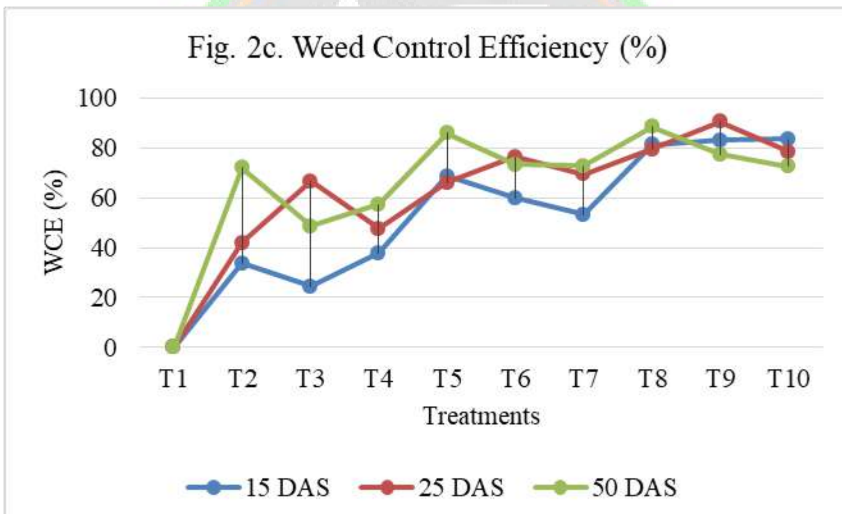
Impact on weed control

The total weed population and total weed dry weight in a square meter observed area was pooled and calculated. A significant difference was found in weed population and total weed dry weight. Significantly lesser total weed population was recorded in T_{10} (atrazine 1.0 kg/ha (PE) fb mechanical weeding at 25 DAS) at 15 DAS, T_9 (atrazine 1.0 kg/ha (PE) fb tembotrione @ 120 g a.i./ha at 15 DAS) at 25 DAS and T_8 (atrazine 1.0 kg/ha (PE) fb One hand weeding at 30-35 DAS) at 50 DAS. (12.7 nos./m^2 at 15 DAS, 11.0 nos./m^2 at 25 DAS and 10.7 nos./m^2 at 50 DAS). The total weed population was significantly higher in unweeded check (T_1) (78.3 nos./m^2 at 15 DAS, 116.7 nos./m^2 at 25 DAS and 92.3 nos./m^2 at 50 DAS).

The total weed dry weight was significantly lesser (5.7 g/m^2 and 5.0 g/m^2) in T_9 (atrazine 1.0 kg/ha (PE) fb tembotrione @ 120 g a.i./ha at 15 DAS) at 15 DAS and at 25 DAS. Whereas at 50 DAS, the significant lesser total weed dry weight (5.2 g/m^2) was found in T_8 (atrazine 1.0 kg/ha (PE) fb One hand weeding at 30-35 DAS). As in the case of total weed population, the total weed dry weight was also higher in unweeded check (T_1) (40.1 g/m^2, 56.0 g/m^2 and 44.8 g/m^2). Pre followed by post emergence herbicide application of herbicides might have resulted in effective control of weeds during the initial and later stages of crop growth and was equally effective to that of hand weeding twice as accordance with the earlier reports of Puscal *et al.,* (2018). Similar results of reduced density and dry weight of weeds with sequential application of herbicides were reported by Dharam *et al.,* (2018) and Sandeep *et al.,* (2018). The total weeds count and biomass was significantly higher with weedy check (T10), than rest of all the weed management practices performed.







Conclusion

Study on optimizing the pre emergence herbicide and time of post emergence weed management practice in irrigated maize was conducted at Southern Agro-climatic zone of Tamilnadu (Maize Research Station, Vagarai) during the year 2017 to 2019 and it was concluded that significant higher grain yield was recorded in the application of atrazine @ 1.0 kg/ha as pre-emergence and followed by spraying of tembotrione @ 120 g a.i./ha at 15 DAS which was followed by application of atrazine 0.75 kg/ha (PE) fb tembotrione @ 120 g a.i./ha at 15 DAS. The highest benefit cost ratio was calculated in application of atrazine @ 1.0 kg/ha followed by tembotrione @ 120 g a.i./ha at 15 DAS, which was followed by application of atrazine 0.75

kg/ha (PE) fb tembotrione @ 120 g a.i./ha at 15 DAS). The highest BCR was registered in application of atrazine 1.0 kg/ha (PE) fb tembotrione @ 120 g a.i./ha at 15 DAS, followed by atrazine 0.75 kg/ha (PE) fb tembotrione @ 120 g a.i./ha at 15 DAS. The WCE was significantly higher in atrazine 1.0 kg/ha (PE) fb mechanical weeding at 25 DAS in 15 DAS and at 25 DAS, it was higher in atrazine 1.0 kg/ha (PE) fb tembotrione @ 120 g a.i./ha at 15 DAS and at 50 DAS, the WCE was significantly higher in atrazine 0.75 kg/ha (PE) fb one hand weeding at 30-35 DAS.

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CARBON SEQUESTRATION

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Introduction

Carbon dioxide makes up just 0.035 per cent of the atmosphere, but is the most abundant of the greenhouse gases which include methane, nitrous oxide, ozone, and CFCs. All of the greenhouse gases play a role in protecting the earth from rapid loss of heat during the nighttime hours, but abnormally high concentrations of these gases are thought to cause overall warming of the global climate.

Human activities, especially the burning of fossil fuels such as coal, oil, and gas, have caused a substantial increase in the concentration of carbon dioxide (CO_2) in the atmosphere. This increase in atmospheric CO_2—from about 280 to more than 380 parts per million (ppm) over the last 250 years—is causing measurable global warming. Potential adverse impacts include sea-level rise; increased frequency and intensity of wildfires, floods, droughts, and tropical storms; changes in the amount, timing, and distribution of rain, snow, and runoff; and disturbance of coastal marine and other ecosystems. Rising atmospheric CO_2 is also increasing the absorption of CO_2 by seawater, causing the ocean to become more acidic, with potentially disruptive effects on marine plankton and coral reefs. Technically and economically feasible strategies are needed to mitigate the consequences of increased atmospheric CO_2.

Global carbon cycle

The global carbon cycle describes the Earth's four carbon reservoirs and the exchanges (or flows) of carbon between these reservoirs. These flows are accomplished by various chemical, physical, geological and biological processes. The four reservoirs are the atmosphere, terrestrial biosphere (including freshwater systems) oceans and sediments (including fossil fuels). Figure 1 illustrates the global carbon cycle.

The flow of carbon is measured in billions of metric tons (gigatons). Annually, plants “give” about 60 billion metric tons of CO_2 to the atmosphere through respiration and “take” 61 billion metric tons of CO_2 that is turned into new plant biomass through photosynthesis. These carbon sinks are immense. The atmosphere contains about 750 gigatons of CO_2, the ground contains about 2,190 gigatons of CO_2 and the oceans contain about 40,000 gigatons of CO_2.

CARBON SEQUESTRATION:

Carbon sequestration is the process of capture and long-term storage of atmospheric carbon dioxide. A natural or artificial process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form. Carbon sequestration describes long-term storage of carbon dioxide or other forms of carbon to either mitigate or defer global warming and avoid dangerous climate change. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels.

Carbon sequestration specifically refer to:"The process of removing carbon from the atmosphere and depositing it in a reservoir." When carried out deliberately, this may also be referred to as carbon dioxide removal, which is a form of geoengineering. Carbon capture and storage, where carbon dioxide is removed from flue gases (e.g., at power stations) before being stored in underground reservoirs. Natural biogeochemical cycling of carbon between the atmosphere and reservoirs, such as by chemical weathering of rocks.

Carbon dioxide is naturally captured from the atmosphere through biological, chemical, or physical processes. Some anthropogenic sequestration techniques exploit these natural processes, while some use entirely artificial processes. Artificial processes have been devised to produce similar effects, including large-scale, artificial capture and sequestration of industrially produced. Carbon dioxide using subsurface saline aquifers, reservoirs, ocean water, aging oil fields, or other carbon sinks.

Direct soil carbon sequestration occurs by inorganic chemical reactions that convert CO_2 into soil inorganic carbon compounds such as calcium and magnesium carbonates. Direct plant carbon sequestration occurs as plants photosynthesize atmospheric CO_2 into plant biomass. Subsequently, some of this plant biomass is indirectly sequestered as soil organic carbon (SOC) during decomposition processes. The amount of carbon sequestered at a site reflects the long-term balance between carbon uptake and release mechanisms. Many agronomic, forestry, and conservation practices, including best management practices, lead to a beneficial net gain in carbon fixation in soil.

The term "**carbon sequestration**" is used to describe both natural and deliberate processes by which CO_2 is either removed from the atmosphere or diverted from emission sources and stored in the **ocean**, **terrestrial environments** (vegetation, soils, and sediments), and **geologic formations**. Before human-caused CO_2 emissions began, the natural processes that make up the global "carbon cycle" (fig 1) maintained a near balance between the uptake of CO_2 and its release back to the atmosphere. However, existing CO_2 uptake mechanisms (sometimes called CO_2 or carbon "sinks") are insufficient to offset the accelerating pace of emissions related to human activities. Annual carbon emissions from burning fossil fuels in the United States are about 1.6 gigatons (billion metric tons), whereas annual uptake amounts are only about 0.5 gigatons, resulting in a net release of about 1.1 gigatons per year.

Oceanic carbon sequestration:

Oceans absorb, release and store large amounts of CO2 from the atmosphere. There are two approaches for oceanic carbon sequestration which take advantage of the oceans' natural processes. One approach is to enhance the productivity of ocean biological systems (e.g., algae) through fertilization. Another approach is to inject CO2 into the deep ocean.

The world's oceans are the primary long-term sink for human-caused CO_2 emissions, currently accounting for a global net uptake of about 2 gigatons of carbon annually. This uptake is not a result of deliberate sequestration, but occurs naturally through chemical reactions between seawater and CO_2 in the atmosphere. While absorbing atmospheric CO_2, these reactions cause the oceans to become more acidic. Many marine organisms and ecosystems depend on the formation of carbonate skeletons and sediments that are vulnerable to dissolution in acidic waters. Laboratory and field measurements indicate that CO_2-induced acidification may eventually cause the rate of dissolution of carbonate to exceed its rate of formation in these ecosystems. The impacts of ocean acidification and deliberate ocean fertilization on coastal and marine food webs and other resources are poorly understood. Scientists are studying the effects of oceanic carbon sequestration on these important environments.

Terrestrial carbon sequestration

Terrestrial sequestration is a form of indirect sequestration whereby ecosystems (e.g., forests, agricultural lands, and wetlands) are maintained, enhanced or manipulated to increase their ability to store carbon.Terrestrial sequestration (sometimes termed "biological sequestration") is typically accomplished through forest and soil conservation practices that enhance the storage of carbon (such as restoring and establishing new forests, wetlands, and grasslands) or reduce CO_2 emissions (such as reducing agricultural tillage and suppressing wildfires).

Existing terrestrial carbon storage is susceptible to disturbances such as fire, disease, and changes in climate and land use. Boreal forests and northern peatlands, which store nearly half the total terrestrial carbon in North America, are already experiencing substantial warming, resulting in large-scale thawing of permafrost and dramatic changes in aquatic and forest ecosystems. USGS scientists have estimated that at least 10 gigatons of soil carbon in Alaska is stored in organic soils that are extremely vulnerable to fire and decomposition under warming conditions. The capacity of terrestrial ecosystems to sequester additional carbon is uncertain.

Decisions about terrestrial carbon sequestration require careful consideration of priorities and tradeoffs among multiple resources. For example, converting farmlands to forests or wetlands may increase carbon sequestration, enhance wildlife habitat and water quality, and increase flood storage and recreational potential– but the loss of farmlands will decrease crop production. Converting existing conservation lands to intensive cultivation, while perhaps producing valuable crops (for example, for biofuels), may diminish wildlife habitat, reduce water quality and supply, and increase CO_2 emissions. Scientists are working to determine the effects of climate and land-use change on potential carbon sequestration and ecosystem benefits, and to provide information about these effects for use in resource planning.

Geologic carbon sequestration

Geologic sequestration begins with capturing CO_2 from the exhaust of fossil-fuel power plants and other major sources. The captured CO_2 is piped 1 to 4 kilometers below the land surface and injected into porous rock formations. Compared to the rates of terrestrial carbon uptake shown in figure 2, geo-logic sequestration is currently used to store only small amounts of carbon per year. Much larger rates of sequestration are envisioned to take advantage of the potential permanence and capacity of geologic storage.

The permanence of geologic seques-tration depends on the effectiveness of several CO_2 trapping mechanisms. After CO_2 is injected underground, it will rise buoyantly until it is trapped beneath an impermeable barrier, or seal. In principle, this physical trapping mechanism, which is identical to the natural geologic trap-ping of oil and gas, can retain CO_2 for thousands to millions of years. Some of the injected CO_2 will eventually dis-solve in ground water, and some may be trapped in the form of carbonate minerals formed by chemical reactions with the surrounding rock. All of these processes are susceptible to change over time following CO_2 injection.

Scientists are studying the permanence of these trapping mechanisms and developing methods to determine the potential for geologically sequestered CO_2 to leak back to the atmosphere. The capacity for geologic carbon sequestration is constrained by the volume and distribution of potential storage sites. The potential storage capacity of deep porous rock formations that contain saline ground water is much larger (estimated by the U.S. Department of Energy to be about 900 to 3,400 gigatons of carbon) and more widely distributed, but less is known about the effectiveness of trapping mechanisms at these sites. Unmineable coal beds have also been proposed for potential CO_2 storage, but more information is needed about the storage characteristics and impacts of CO_2 injection in these formations. Scientists are developing methods to refine estimates of the national capacity for geologic carbon sequestration. To fully assess the potential for geologic carbon sequestration, economic costs and environmental risks must be taken into account. Infrastructure costs will depend on the locations of suitable storage sites. Environmental risks may include seismic disturbances, deformation of the land surface, contamination of potable water supplies, and adverse effects on ecosystems and human health. Scientists are pioneering the use of new geophysical and geochemical methods that can be used to anticipate the potential costs and environmental effects of geologic carbon sequestration.

Importance of carbon sequestration

Before the Industrial Revolution, the concentration of greenhouse gases (GHGs) in the atmosphere remained relatively constant. Except for slow changes on a geological time scale, the absorption and release of carbon was kept in balance. During that time, changes in biomass and soil organic carbon1 were the main sources of fluctuation in atmospheric levels of carbon.

By clearing forests and burning fossil fuels more rapidly than the carbon can be sequestered, industrialization may have altered this equilibrium. Currently, human activity is directly or indirectly responsible for the release of six to seven billion metric tons of carbon annually. Since before the Industrial Revolution, CO_2 concentrations in the atmosphere have increased from 280 parts per million (ppm) to nearly 380 ppm in 2005. CO_2 emissions from energy use are projected to increase between 40 to 110 percent between 2000 and 2030.

Increases in atmospheric CO_2 concentration may be generating increases in average global temperature and other climate change impacts. Although some of the effects of increased CO_2 levels on the global climate are uncertain, most scientists agree that doubling atmospheric CO_2 concentrations may cause serious environmental consequences. Rising global temperatures could raise sea levels, change precipitation patterns and affect both weather and climate conditions.

In light of these potential impacts, strategies to help reverse these emission trends are increasing in importance. Many state, national and international governments are taking steps to more effectively manage and slow the growth of their carbon emissions. For many of these governments, terrestrial sequestration is part of a portfolio of approaches to inventory and reduce GHG emissions. Their experience is demonstrating that establishing new forests can offer cost-effective management options for offsetting carbon emissions, particularly in the near future.

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BUZZING BENEFITS: HOW INSECTS DRIVE POLLINATION AND BOOST CROP YIELDS

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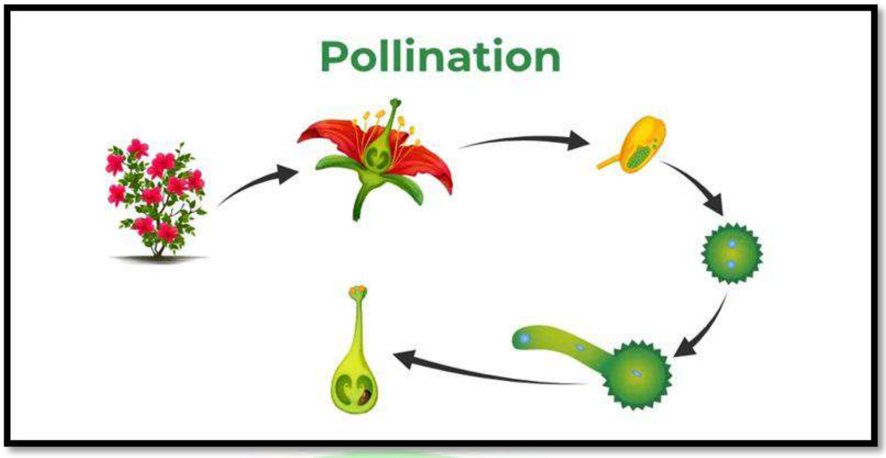
Abstract

Pollination involves both abiotic and biotic elements. Insect pollinators, or entomophily, are the primary biotic force in pollination. Insects have a 15% to 30% role in the production of food worldwide. Insect pollinators are linked to crops in the ecosystem and have a positive correlation between their visits and yield. They improve the quality and quantity of crops. Pollination connects agricultural production systems with wild habitats, which provide food and shelter to a large number of wild species. It is essential to both food production and human lifestyles. An ecosystem would collapse in the absence of this service, the numerous interrelated species that live there, and the processes that keep it running. As a result, this article discusses the function of insects in pollination, which eventually raises crop quality and yield.

Introduction

Pollination facilitates the union of male and female gametes, which leads to fertilisation. It aids in the growth of seeds and food. Pollination facilitates the transfer of traits and qualities from both parents to the progeny. It is a crucial step in the reproduction of plants. When pollen from one flower scrapes or falls upon another, it adheres to the stigma, which is the female portion of the flower, from the anthers, the male portion of the plant. Afterwards, the fertilised bloom produces fruit and seeds. Crop production and quality are impacted by pollination. Certain crops, including mangoes and field beans, require insect pollination to produce higher yields than when they do it alone. When insects pollinate a number of plants, including passion fruit, cowpea, sesame, litchi, mustard, and cashew, the yield is significantly boosted.

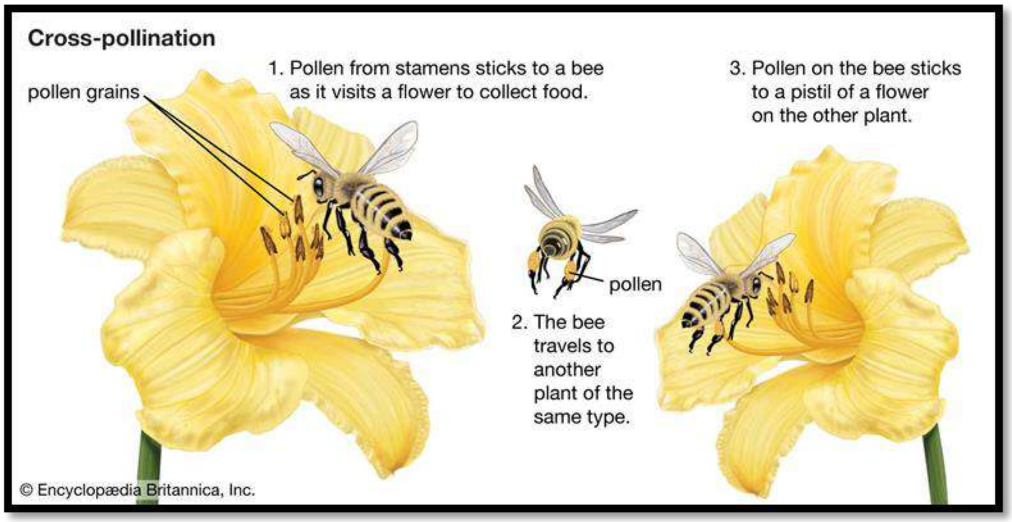


The biotic agent, animal, or vector that transfers pollen from a flower's anthers to its stigma is known as a pollinator. For the cultivation of healthy crops used to produce food, fibre, edible oils, medications, and other goods, insects and other animal pollinators are essential. They play a crucial role in ecosystems, agriculture, and our food chain. They aid in the reproduction of thousands of blooming plants, including certain crops, fruits, and flowers. Additionally beneficial effects of pollinator habitat on farms include reduced soil erosion and increased biodiversity.

Bees are the most efficient pollinators in the world because of their adaptations as well as the regularity with which they visit flowers. Other insect pollinators, such wasps, flies, beetles, moths, and butterflies, are just as important to the pollination of plants even though they are not as effective as bees.

Role of Insects in Pollination and crop production

Fruits, vegetables, ornamentals, cotton, tobacco, sunflower, and many more crops are all pollinated by insects. Pollination by insects promotes consistent seed set, higher crop yields, and improved quality. To produce healthy crops for food, fibre, edible oils, pharmaceuticals, and other items, insects and other animal pollinators are essential. Globally, an estimated 1,300 different plant species are cultivated for food, drink, medicine, spices, sauces, and even textiles. Roughly 75% of these are pollinated by wildlife. Pollinators are directly responsible for more than one in every three bites of food or drinks we consume.



According to Klein *et al*. (2007), pollinators like bees, birds, and bats actually contribute to 35 percent of global agricultural production, boosting the yields of 87 of the major food crops and numerous medications produced from plants. Insect pollination is essential for the production of fruits, vegetables, and nuts, which cover around 6 million acres. Roughly 15% of human diet consists of these plants (Gregor, 1976). In addition to providing a substantial income for producers, pollinators also assist those who live in an agricultural community that is fruitful. Hence, fruit output increased by 50% by bee pollination over wind-pollinated fruit (Krishnan *et al*., 2012).

In order to increase fruit yield in Aonla orchards, pollinators (honey bees) and pollenizers must be used (Allemullah & Ram 1990). Only the hymenopterous fig wasp, *Blastophaga psenes* (L.), which overwinters in the caprifig fruit, can pollinate Smyrna and second crop San Pedro figs. The oldest method of artificially induced insect pollination, known as caprification, involves the employment of this wasp.

Bael blooms are 95% animal pollinated and only around 5% self-pollinated. According to Haldhar *et al*. (2010), this fruit crop is primarily pollinated by a variety of insect pollinators, including honey bees (*Apis dorsata*, *A. mellifera*), hover flies, yellow wasps, carpenter bees, weevils, black ants, and butterflies. Insect pollination is a necessary extra input for cucumber crops in order to increase productivity (Shah *et al*., 2015).

In coriander, ajwain, and fennel, Ramanujam *et al*. (1964) recorded natural cross pollination rates of 55.86%, 70.05 to 77.83%, and 82.20 to 91.4%, respectively. Insects and wind both cross-pollinate papaya plants. Honey bees, wasps, midges, thrips, syrphid flies and butterflies are among the insects that pollinate papaya (Crane, 2013). The pollinators create crops with a high yield and quality. Approximately 75% of crops have higher yields thanks to pollinating insects.

Conclusion

The substantial potential of insects as pollinators for a variety of agricultural crops is concluded in this essay. Hence, the world's agricultural sector is at risk due to the dwindling bee population. It is imperative that bees and other pollinators' health be improved. Many of the foods we eat and the beautiful natural environments we love would not survive without pollinators. It is beneficial for our economy and ecology to act immediately to save pollinators and use less harmful pesticides. If we don't find some solutions, a large number of bees may eventually disappear. Enhancing and promoting pollinator value to society is a practical approach to ensure pollinator conservation.

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IMPORTANT TIPS TO KEEP RATS AWAY FROM HOUSE

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Introduction

Rodents inhabit almost every terrestrial environment, from Arctic tundra heights of about 5700 meters to extreme deserts. In India out of the 13 rodents species which needs attention, house rat (*Rattus rattus*), and house mouse (*Mus musculus*) are the major commensal pests which casue significant damages in the residences and storehouses. Rodents cause significant crop and commodity damage through feeding, spoilage, contamination, and hoarding. They are also reservoirs for many infectious diseases. In India, they damage major crops both in fields and storage. In homes, they chew plastic cables and contaminate food with feces, urine, and fur.

Changing agricultural practices and natural calamities have increased rodent invasions and crop damage. Protecting food grains from pests is essential to feed India's population of over one billion. Implementing Integrated Rodent Management and strategic planning can effectively control rodent pests in residential areas. These strategies will help minimize the risk of rodent infestations and protect stored grains from damage and contamination. Regular monitoring and adapting control measures based on the level of rodent activity are essential for long-term success in rodent control. Controlling rodents in households involves a combination of preventive measures, monitoring, and direct control methods. Here are some effective strategies to keep rodents out of your home:

1. Preventive Measures:

- **Seal Entry Points:** Inspect your home for gaps, cracks, and holes in walls, floors, and foundations.

- ✓ Seal any openings larger than 1/4 inch with materials like steel wool, metal mesh, concrete and cement or treat them with rodenticide.
- ✓ Put metal guard or wire mesh guard (24 gauge) around drainage canals, sewers, gutter or any drains.
- ✓ Also, put cone metal guards on the wires (electricity, dish, telephone etc.) at the end connecting to the building and sealed that opening with cement from where these cables enter into the building.

- Ensure doors and windows close tightly. Use door sweeps and weather stripping to seal gaps under doors and around windows. Put galvanized wire meshes (24 gauge) to windows and ventilators and fix them tightly.
- Store food such as cereals, pulses etc. in airtight containers made of glass or metal. Keep pet food in sealed containers as well.
- Remove clutter from around your home, including piles of paper, cardboard, and other materials that can provide nesting sites for rodents.
- Use garbage cans with tight-fitting lids. Dispose of trash regularly and keep outdoor garbage areas clean.

2. Sanitation:

- Keep your home clean, especially kitchen and dining areas. Clean up food spills and crumbs promptly regularly. Also, remove the weeds or any other dense vegetation around the residential area by hoeing or spray of weedicides.
- Avoid leaving pet food out overnight in the bowls to avoid the accidental feeding of rodents. Store pet food in sealed containers.
- Dispose of food waste in sealed garbage bags and take out the trash daily.

3. Monitoring:

- **Regular Inspections:** Check for signs of rodent activity, such as droppings, gnaw marks, and tracks. Inspect areas like basements, attics, and garages where rodents may enter. Repair any points that have been re-opened by rats.
- **Bait Stations and Traps:** Use bait stations and traps to monitor rodent activity in and around the houses. Place them in areas where you’ve seen signs of rodents, such as along walls and near entry points.

4. Control Methods:

- Use snap traps, glue traps, and live traps to catch rodents. Place traps in areas with signs of activity. Use wooden/wonder traps at right angles to the wall, with the baited end of the trap closest to the wall of room visited frequently by rats as evidenced by their droppings, chewed entry holes or where we hear night time activity. Check and reset traps regularly.
- Use rodenticides such as Zinc phosphide or Bromadialone @ 10-20g in protected bait containers on the runways of rats in the evening or put them in the burrows to prevent accidental exposure to pets and children. Follow all safety guidelines and regulations.
- Consider using ultrasonic devices that emit high-frequency sounds to deter rodents. Note that their effectiveness can vary and should be used as a supplementary measure.

5. Integrated Pest Management (IPM):

- Implement an IPM plan that combines sanitation, exclusion, monitoring, and direct control methods for the effective control of the rats in the residences.
- Educate household members about rodent control measures and the importance of maintaining a rodent-free environment to avoid the diseases caused by the rats.

6. Professional Assistance:

- If there is severe rodent problem in the house which cannot be controlled by the owners themselves, then consider hiring professional pest control services at the earliest to avoid the damage from the rodents. Professionals can provide more effective and targeted treatments.

7. Environmental Management:

- Maintain the area around your home. Trim vegetation, keep grass short, and remove debris and wood piles that can provide shelter for rodents.
- Ensure proper drainage around your home to avoid creating water sources that can attract rodents.

8. Regular Maintenance:

- Regularly inspect and maintain your home’s structure. Repair any damage that could allow rodents to enter.
- Ensure that utility lines entering your home are properly sealed. Rodents can use these as entry points.

By combining these strategies, you can effectively control and prevent rodent infestations in your household. Regular monitoring and prompt action at the first signs of rodent activity are crucial for keeping your home rodent-free.

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THE ECONOMIC IMPACT OF FARMER PRODUCER ORGANIZATIONS IN INDIAN RURAL ECONOMY

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Introduction

Agriculture is the backbone of India's economy, with over 58% of the rural population relying on it for their livelihood (Economic Survey, 2020-21). However, small and marginal farmers, who constitute around 86% of the farming community, face numerous challenges such as limited access to markets, credit, and technology (NABARD, 2018). To address these issues, the concept of Farmer Producer Organizations (FPOs) has been promoted as a viable solution. FPOs are collectives of farmers that aim to enhance their socio-economic status by providing better market access, input procurement, and financial services.

This article explores the economic impact of FPOs on the rural economy of India, tracing their origin, examining their necessity in the current scenario, comparing them with international initiatives, and discussing their role and overall impact.

History of FPOs

The concept of FPOs in India can be traced back to the cooperative movement that began in the early 20th century. However, the modern framework for FPOs was laid out by the Ministry of Agriculture and Farmers Welfare in 2002, with the establishment of the Small Farmers' Agribusiness Consortium (SFAC). The SFAC was tasked with promoting and nurturing FPOs to address the issues faced by smallholder farmers. The Companies Act of 1956 was amended to include the provision for Farmer Producer Companies (FPCs), which are a type of FPO registered under this Act. This legal recognition provided a structured approach to forming and managing farmer collectives, ensuring better governance and accountability.

Need for FPOs in Indian Agricultural sector

In the contemporary agricultural landscape of India, FPOs are more crucial than ever. Small and marginal farmers continue to face significant challenges, including:

1. **Fragmented Land Holdings**: The average size of landholdings in India is decreasing and leading to inefficiencies in farming practices and reduced economies of scale (Agricultural Census, 2015-16).
2. **Market Access**: Farmers often have limited access to markets, resulting in their dependency on middlemen who exploit them by offering low prices for their produce (Dev, 2017).
3. **Access to Credit**: Traditional banking systems are reluctant to lend to small farmers due to perceived high risks, leaving them reliant on informal and often usurious moneylenders (RBI, 2019).
4. **Technological Adoption**: There is a significant gap in the adoption of modern agricultural practices and technologies among small farmers due to lack of awareness and resources (FAO, 2014).

FPOs can address these challenges by pooling resources, improving bargaining power, facilitating access to credit, and promoting the adoption of advanced agricultural practices.

Role of FPOs in Rural Economy

FPOs play a multifaceted role in enhancing the rural economy such as:

1. Market Access and Better Price Realization

FPOs help farmers access larger markets and negotiate better prices for their produce by aggregating their output. According to Singh et al. (2018), FPOs have significantly improved price realization for their members by reducing the dependency on middlemen and establishing direct market linkages with retailers and processors.

2. Access to Credit and Financial Services

FPOs facilitate access to credit for their members by acting as a collective entity that can secure loans from banks and financial institutions. The collective guarantee provided by FPOs reduces the perceived risk for lenders, leading to better credit terms for farmers (Dev, 2017).

3. Input Procurement and Cost Reduction

FPOs negotiate bulk purchases of inputs such as seeds, fertilizers, and pesticides, ensuring timely and cost-effective access for their members. This collective procurement reduces the overall cost of inputs, enhancing the profitability of farming operations (Agarwal, 2018).

4. Capacity Building and Technology Adoption

FPOs play a crucial role in educating farmers about modern agricultural practices and technologies. They organize training programs, workshops, and exposure visits to promote the adoption of advanced farming techniques, which can significantly improve productivity (FAO, 2014).

5. Value Addition and Agro-Processing

FPOs encourage value addition by setting up processing units for agricultural produce. This not only enhances the income of farmers but also generates employment opportunities in rural areas. For instance, the Sahyadri Farmers Producer Company has established processing units for fruits and vegetables, enabling farmers to sell processed products at higher prices (NABARD, 2019).

Comparison of FPOs with International Initiatives:

FPOs in India can be compared with similar initiatives in other countries to understand their effectiveness and areas for improvement. The scale of operations, level of government support, and access to infrastructure in India are still evolving.

1. United States: Farmer Cooperatives

In the United States, farmer cooperatives have a long history and play a significant role in the agricultural sector. These cooperatives provide a wide range of services including marketing, supply of inputs, and financial services. They have been successful in enhancing the income and bargaining power of farmers by providing a platform for collective action. In the United States, 1,671 agricultural cooperatives were registered in 2022. Out of all of them, Minnesota had the most agricultural cooperatives in the state in 2022 (182 cooperatives), followed by Texas (161) and North Dakota (129).

2. European Union: Producer Organizations (POs)

The European Union promotes Producer Organizations (POs) under the Common Agricultural Policy (CAP). These organizations help farmers improve their market position, reduce production costs, and enhance product quality (European Commission, 2019). The success of POs in Europe can be attributed to strong policy support, financial incentives, and a well-developed infrastructure. There were 3,505 POs and APOs recognised by national authorities in 25 different EU Member States in 2017. Out of them, the FV sector employs more than half of the recognised POs and APOs (1,851).

3. Africa: Smallholder Farmer Organizations

In Africa, nearly 33 million smallholder farmer organizations are crucial for improving agricultural productivity and market access. These organizations, supported by various international agencies, focus on capacity building, access to credit, and value addition (IFAD, 2015). The success of these organizations highlights the importance of external support and capacity-building initiatives.

Challenges faced by the FPOs:

The role of FPOs in the rural economy of India is undeniably significant. They have the potential to transform the agricultural landscape by addressing the systemic issues faced by small and marginal farmers. However, the success of FPOs is contingent upon several factors:

1. Infrastructure and Logistics

Adequate infrastructure and logistics support are critical for the success of FPOs. Poor road connectivity, lack of storage facilities, and inadequate processing units can hinder the operations of FPOs and limit their impact (Singh et al., 2018). Investment in rural infrastructure is essential to enhance the efficiency and reach of FPOs.

2. Policy Support and Financial Incentives

Supportive policies and financial incentives from the government are crucial for the growth and sustainability of FPOs. Subsidies, grants, and credit guarantees can encourage the formation and development of FPOs. Additionally, policies that promote the integration of FPOs into the value chain can enhance their impact (Dev, 2017).

3. Capacity Building and Training

The success of FPOs also depends on the capacity and skills of their members. Training programs and capacity-building initiatives are essential to equip farmers with the knowledge and skills required to manage and operate FPOs effectively. This includes training in areas such as financial management, marketing, and technological adoption (FAO, 2014).

4. Collaboration and Partnerships

Collaboration and partnerships with various stakeholders, including government agencies, financial institutions, and private sector players, can enhance the effectiveness of FPOs. These partnerships can provide access to resources, markets, and expertise, enabling FPOs to scale up their operations and impact (Agarwal, 2018).

Conclusion

Farmer Producer Organizations hold immense potential to transform the rural economy of India by addressing the challenges faced by small and marginal farmers. By improving market access, facilitating access to credit, reducing input costs, and promoting value addition, FPOs can significantly enhance the socio-economic conditions of farmers. The comparison with international initiatives highlights the importance of strong policy support, infrastructure development, and capacity-building initiatives for the success of FPOs.

To fully realize the potential of FPOs, there is a need for a supportive ecosystem that includes adequate infrastructure, favorable policies, financial incentives, and capacity-building programs. By addressing these challenges and leveraging the strengths of FPOs, India can achieve sustainable agricultural development and improve the livelihoods of millions of small and marginal farmers.

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IMPROVED PRODUCTION TECHNOLOGIES (IPTS) TO ENHANCE THE PRODUCTIVITY OF BLACK GRAM

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Introduction

Black gram is one of the important crops among the pulses crop. Black gram (*Vigna mungo* L) is a short duration crop belongs to Leguminacae family. Black gram is rich in protein (25-26%) and grown as intercrop, catch crop and also as solo crop. It is also called as urd bean. In India the area under black gram cultivation is 3.30 million ha producing 1.60 million tonnes, with the mean productivity of 490 kg ha^{-1} and contributes 11% of total production in the country (Pushkar Choudhary *et al.*, 2017). It also acts as cover crop and its deep root system protects the soil from erosion. The crop also improves soil fertility by symbiotic fixation of atmospheric nitrogen in root nodules. Black gram area accounts for about 19 per cent of India's total pulse acreage which contributes 23 per cent of

total pulse production. India currently represents the largest producer of black gram accounting for more than 70% of the global production. India is followed by Myanmar and Pakistan. In India during kharif 2021-22, area covered under black gram is 37.52 lakh ha as against 38.18 lakh ha in last year. Tamil Nadu leads first in productivity with an average yield of 775 kg ha^{-1} (Peruru Sasidhar *et al*.,2022).

Improved pulse production is a way to increase the farm income and profitability of farmers along with sustaining soil health for enhancing the productivity in long run. Generally, the grain yield ranged from 500 to 700 kg ha^{-1} depending upon the management practices followed during the crop growth period (Umamageswari *et al*., 2019).

Study area

In order to increase the awareness among the farmers on improved production technologies in black gram cultivation, field demonstrations were conducted at the farmers' field under Tamil Nadu – Irrigated Agriculture Modernization Project (TNIAMP) in Pachaiyar Sub Basin of Tirunelveli District. The objective of the study is an area expansion and productivity enhancement of pulses under crop diversification in gap areas. The demonstration on black gram with improved production technologies was conducted in 40 hectares and 50 beneficiaries holdings under irrigated condition in Nanguneri block of Nanguneri Taluk, Tirunelveli district, Tamil Nadu during 2021-22 (Dec-Jan). The latest production technologies in comparison with the farmers' practices were demonstrated in the selected farmer's holdings. The package technology included improved varieties and technologies for crop establishment, weed, nutrient, pest and disease management are as follows

Package of Improved production technologies adopted in demonstration plot

Particulars	Improved production technologies
Variety	Blackgram VBN 6
Time of sowing	December – January
Seed rate	30 kg ha^{-1}
Seed treatment	Seed treatment with polymer (3 ml kg^{-1} of seeds), imidacloprid (1.5 ml kg^{-1} of seeds), *P. fluorescens*(10 g kg^{-1} of seeds), rhizobium (30 g kg^{-1} of seeds) and phosphobacteria (30 g kg^{-1} of seeds)
Method of sowing	Dibling the seeds with a spacing of 30 x 10 cm

Herbicide application	Application of pendimethalin 3.3 l ha^{-1} pre-emergence herbicide on DAS followed by imazethapyr 10% SL @ 500 ml ha^{-1} and quizalofop ethyl 5% EC @ 1 l ha^{-1} when weeds are at 2- 3 leaf stage
Foliar spray	Pulse wonder @ 5 kg ha-1 at flowering
Plant protection measures	Monitoring of pests and diseases throughout the crop period and spraying of thiomethoxam @ 100 g ha^{-1} against sucking pests, chlorantraniliprole @ 150 ml ha^{-1} against pod borers, carbendazim @ 250 g ha^{-1} against powdery mildew and soil application of *P. fluorescens*@ 2.5 kg ha^{-1} against root rot disease

Performance on productivity

The demonstrations were conducted as per recommendation in package along with full farmers' participation. Before the TNIAMP intervention, the farmers were adopting conventional method in which the recommended crop geometry was not maintained and also have not practiced proper management practices which resulted in reduction of plant population and correspondingly yield. As part of the intervention, the farmers were advised to follow the improved cultivation practices. Besides, the farmers adopted local variety before the intervention. The farmers were also advised to follow biofertilizer and bio-inoculants application, DAP spray, pulse wonder booster in order to have better crop establishment and maximize the productivity. The black gram variety Vamban 6 was used as a test variety due to its higher potential yield, marketing value and resistant to yellow mosaic virus.

Rhizobium is widely distributed in soils of tropics and has the ability to fix atmospheric nitrogen in symbiotic association. Inoculation of Rhizobium culture in legumes increased the crop yield from 20-80% and leaving beneficial effect on the subsequent crop yield. It is a biofertilizer which increases symbiotic nitrogen fixation and ultimately it increases the yield. Increased grain legume production depends on effective symbiotic dinitrogen fixation through successful legume inoculation (Geetanjali *et al*., 2020). Several workers have reported that seed inoculation with Rhizobium has significantly increased the growth and yield of legume crops (Pathak *et al*., 2001). Application of bio-inoculants like Pseudomonas fluorescence and *Trichoderma viride* improved the growth parameters of black gram. Trichoderma, a saprophytic fungus is known to be one of the best candidate of biocontrol agents. Trichoderma species are effective biocontrol agents for several soil borne fungal plant pathogens including *M. phaseolina* and some species are also known for their abilities to enhance systemic resistance to plant disease as well as overall plant growth as reported by Athira, 2017.

The average yield data was assessed and recorded the yield of 832 kg ha^{-1} under pulse area expansion intervention (improved production technologies). The lowest average grain yield of 645 kg ha^{-1} was recorded in farmers practice. The percentage in improved practices yield increase over farmers practice was 29 percent.

Better income

Before the intervention, the farmers were able to get only low yield than the potential yield due to management practices resulting in high cost of cultivation and poor yield cum economic returns from the investment made. After the intervention, the farmers practiced the recommended technologies and package of practices in an integrated manner which resulted in expected yield and economic returns. The economic analysis reveals that, before the intervention the average net return was only Rs. 23284/- per hectare from farmers practice whereas it rose to Rs.32367/- in improved practice, respectively, resulting raise in benefit cost ratio from 1.59 to 2.18. In terms of monetary advantage, 28.0% higher net return was realized. The variation seen in improved practices and farmers plot could be considered as a gap between adoptions of recommended package of practices.

Conclusion

It is inferred that, the increase in awareness level on varieties, seed quality, seed rate, seed treatment, time of sowing, use of herbicides, foliar spraying of nutrients and adoption of pest and disease management played a vital role in increasing the grain yield when compared to the farmers' practices which contributed to higher yields and income. The very important aspects which contributed to increased yield are improved varieties, seed treatment with biofertilizers and bio-inoculants, maintenance of optimum plant population through adoption of correct seed rate, optimum sowing time and use of herbicides for effective management of grasses and broad leaved weeds. Hence, it can be concluded that increase in awareness level on improved production technologies contributed to higher yields and income in black gram under irrigated condition in Pachaiyar sub basin of Tamil Nadu.

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CONSERVATION TILLAGE- AN ECO-FRIENDLY TECHNIQUE FOR SUSTAINABLE CROP PRODUCTION

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Introducion

Conservation tillage systems are cropping production systems that leave at least 30% of crop residues on the soil after planting. There are several types of these systems. For instance, mulch-till systems redistribute at least 30% of crop residues over the entire soil surface. This is a full-width tillage system, usually involving one to three tillage passes over the field, disturbing the soil surface. It is performed prior to and/or during planting (Conservation Technology Information Center [CTIC], 2002). Ridge-till systems leave crop residues undisturbed except for the ridges (up to 1/3 of the crop row width) into which seeds are planted (CTIC, 2011). No till systems, often considered the most effective, leave 100% of crop residues on the soil surface and the soil is undisturbed from harvest to planting, resulting in the highest percentage of surface being covered by crop residues, this minimizes soil loss and water runoff.

Effect of Conservation Tillage on the Environment:

- **Reduces soil erosion:** This is an obvious benefit of conservation tillage. In fact, a 90% erosion reduction can be expected when using a no-till instead of intensive tillage system.
- **Increases organic matter:** Each tillage trip oxidizes some organic matter. Research shows continuous notill can increase organic matter in the top 2 inches of soil about 0.1% each year.
- **Improves water quality:** When combined with crop nutrient management, weed and pest management (IPM) and conservation buffers, conservation tillage plays an important

role in improving both runoff to streams, rivers and lakes as well as water that finds its way into aquifers.

- **Wildlife:** Conservation tillage improves habitat. The crop's residue provides food and shelter. And, if combined with other needed habitat (grassy cover and woody areas), wildlife may increase significantly.
- **Energy Use:** Conservation tillage, especially no-tillage, along with N fertilizer management, offers farmer one of their greatest opportunities to conserve energy in crop production.

Effect of Conservation tillage on soil

Soil is a fundamental natural resource on which civilization depends. Agricultural production is directly related to quality of soil. In view of the rapidly expanding global population and its pressure on the finite amount of land available for agricultural production; maintaining soil quality is essential not only for agricultural sustainability, but also for environmental protection. Maintenance of soil quality would reduce the problems of land degradation, decreasing soil fertility and rapidly declining production levels that occur in many parts of the world which lack the basic principles of good farming practices.

Soil Physical Properties:

A. Bulk Density and Compaction: The surface 0-5 cm of the no-tillage soil had slightly lower bulk density than the surface of the moldboard-plow system.

B. Soil Aggregation: Soil aggregation involves the binding together of several soil particles into secondary units. Plant emergence, water infiltration, and soil erosion are directly influenced by aggregate stability. Aggregation was highest in the 0-5 cm layer of notillage treated soil.

C. Soil Water Conservation: Tillage can significantly affect infiltration and evaporation in all soils and affects available water holding capacity and effective rooting depth in some soils.

Soil Chemical Properties:

A. Soil pH:

Numerous studies conducted in temperate climate zones showed that no-tillage resulted in acidification of surface layer when continued for several years. The accelerated acidification related to no-tillage has been attributed in part to decomposition of the concentrated layer of organic residues at the surface with subsequent leaching of resultant organic acids into mineral soil.

B. Distribution of Nutrients in the Soil:

Mineralization of organic N, P, and S can be a major source of plant available nutrients near the surface of no-tilled soils. Exchangeable K was not significantly affected by N rates; however, it was greater in the 0-5 cm depth of no-tilled than conventional tilled soils. Without mechanical mixing, K continuously accumulated near the surface of no-tillage plots, whereas conventional tillage resulted in mixing of K in the surface 20 -25 cm depth depending on the depth of plowing.

C. Soil Organic Matter:

Doran found that the organic C and Kjeldahl N contents of surface soil (0- 7.5 cm) with no-till averaged 1.25 and 1.20 (25 and 20%) times higher, respectively for no-till than for conventionally tilled soil. Soil organic matter was increased because of straw recycling, which can increase soil porosity. Many soil-surface modifications would influence the components in the WUE equation viz. manipulation of the soil surface by tillage and surface residue management or mulching, can increase soil water retention capacity, improve the ability of roots to extract more water from the soil profile, or decrease leaching losses.

Soil Biological Property:

An important aspect of tillage with respect to soil porosity is its effect on soil fauna activity, especially earthworms. Because earthworm activity and intensive tillage are highly incompatible, there are few earthworms in most cultivated soils. Lal found five times greater earthworm activity in no-tillage areas than in plowed soil in the tropics. Among the aerobic organism, the fungi and aerobic bacteria increased most with no-till as compared with conventional tillage.

Weed Control:

Tillage encourages weed germination and emergence. Any tillage system that leaves substantial mulch at the surface provides shading that may suppress weeds because the environment is unfavorable for germination of some weeds.

Economics:

Lower labor, animal or equipment requirement is a major advantage of conservation tillage because it allows elimination of several operations, depending on the conservation tillage systems used. Maximum reduction in operations occurs with no-tillage system, but this system generally involves the use of herbicides to control weeds

Merits:

- Yields are as good, if not better, than reduced or intensive tillage systems when attention is paid to management details.
- Optimizes soil moisture. Improved infiltration and increased organic matter are especially important on droughty soils and may help the crop through a persistent dry period. Tillage reduces available moisture by about 1/2” per trip.
- Saves time. On a 1000 acre farm an additional 100 hours are needed for every pass (example based on 18’ disk, 160 Hp FWD). Many growers take advantage of the time savings by exploring other “opportunities.”
- Reduces fuel consumption. In fact, no-till can reduce fuel use by 3.5 gallons/acre compared to intensive tillage.

Conservation tillage system

Any system that leaves about a third of the soil covered after planting is known as Conservation tillage system. This includes no-till/ strip-till, ridge-till and mulch-till. The total area under no-tillage/zero tillage in India is about 3.43 m ha.

No-till/strip-till

No-till means leaving the residue from last year’s crop undisturbed until planting. Strip-till means no more than a third of the row width is disturbed with a coulter, residue manager or specialized shank that creates a strip. If shanks are used, nutrients may be injected at the same time.

Ridge-till

In this 4-6” high ridges are formed at cultivation. Planters using specialized attachments scrape off the top two inches of the ridge before placing the seed in the ground.

Mulch-till

This full-width tillage system usually includes only one or two tillage passes. Yet, after Planting, at least a third of the surface remains covered with residue.

Reduced-till and intensive-till

Full-width tillage systems like these are not considered as conservation tillage. After planting, field residue covers less than a third of the soil.

Conservation tillage system management

Managing a conservation tillage system is an important part of the overall farm management strategy. It includes planning crop rotation; analyzing soil conditions; keeping tabs on soil temperature and moisture; adjusting nutrient and weed management approaches and selecting the equipment and attachments to match your farming system.

1) Crop rotation

The previous crop will, in many ways, dictate the amount of tillage (if any) that can be done and still leave around a third of the soil's surface covered with crop residue. Corn, wheat and sorghum produce high levels of residue after harvest. Thus, you can either plant directly into these residues (no-till/strip-till) or use one or two low-disturbance tillage passes (mulch-till) and still leave approximately a third of the soil covered. Soybeans and cotton produce much less crop residue. Thus just one tillable pass may not leave enough cover after planting.

2) Soil condition

While compaction, drainage and low fertility levels are important to correct in any tillage system, they are especially important to correct *prior* to the adoption of a conservation tillage system. Improved soil structure and higher organic matter levels may reduce the necessity to repeat these corrective measures.

3) Equipment selection and adjustment

To assure good seed-to-soil contact when planting, equipment must be selected and adjusted to match your system, soils, yields and size. For instance, your combine needs to have a chaff spreader so the crop's residue is evenly spread across the full width of the combine. If your equipment is extremely old, you'll need to modify and strengthen it to handle high residue and more strenuous field conditions. In some regions residue managers, coulters and other planter attachments may be needed. Special equipment–like strip-till equipment–may be needed for sensitive crops (corn and cotton) in climates where moisture keeps soil cool at planting time. Row width will also need to be analyzed.

4) Weed control

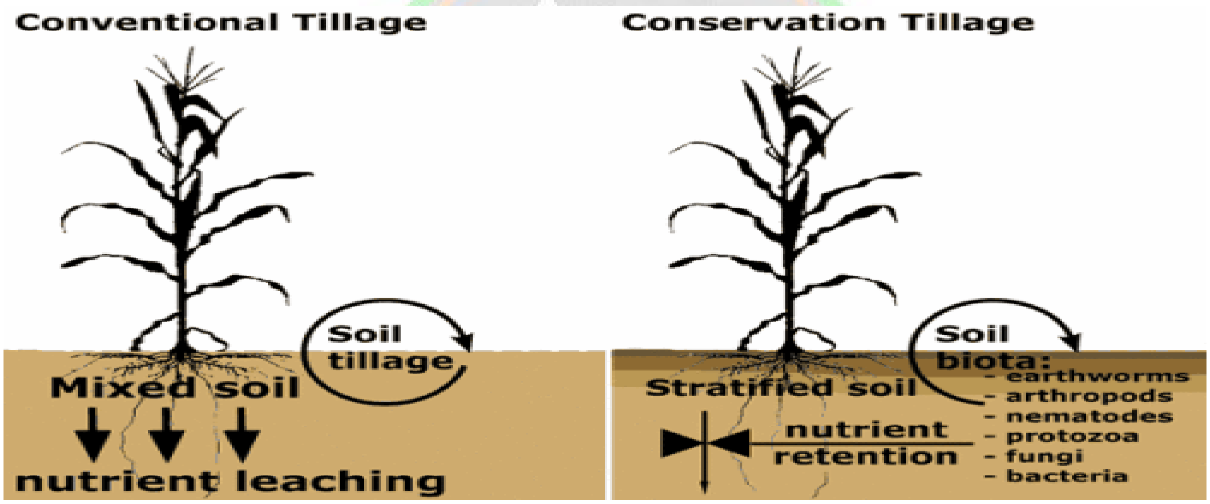
Weed control strategies may need to be modified. While weed pressure often seems to increase the first few years, over time weed pressure may decrease. A different array of weeds may prefer different tillage systems. For instance, weed species commonly found In intensive tillage systems often differ from those commonly found in a no-till system.

5) Nutrient management

Approach to nutrient management will also change to optimize production in a conservation tillage system. For instance, crops that require nitrogen to be added to the soil usually do best if the nutrient management program includes a starter fertilizer applied with the planter.

6) Bottom line

If the factors are properly managed –crop rotation, soil conditions, equipment selection and adjustments, plant nutrients and weed control–conservation tillage will help improve your bottom line. It's also a critical step in maintaining–and even improving–soil productivity. Best of all, conservation tillage helps keep topsoil, nutrients (particularly phosphorus) and crop protection products on your fields and out of creeks, streams and lakes. In fact, scientific evidence indicates approximately80% of environmental issues that result from cropland can be corrected by integrating conservation tillage, conservation buffers, nutrient management and weed and pest management (IPM) systems into your farm management approach.



Benefits of conservation tillage

1. Reduces labor, saves time
2. Saves fuel and improves farm profitability
3. Reduces machinery wear
4. Improves soil tilth
5. Increases organic matter and soil biological diversity
6. Traps soil moisture to improve water availability and water use efficiency
7. Reduces soil erosion
8. Improves water quality
9. Improves wildlife habitat

10. Improves water and air quality

11. Sequesters carbon in soil

Constraints for adopting conservation tillage practices

- Lack of information on conservation tillage
- No farms around practicing conservation tillage could serve as Demonstration/example.
- Extensionists know very little or nothing about the system
- Costs implied by changing the tillage systems
- Lack of access to inputs and credits (for purchase of conservation tillage implements)
- Risk avoidance (fear of failure or wrong application of new technique in the absence of guidance phase)
- Opportunity costs of crop residues

LIMITATIONS:

- Poses a challenge both for the scientific community and the farmers to overcome the past mindset and explore the opportunities
- Managing conservation agriculture systems will be highly demanding in terms of knowledge base, Conservation agriculture as an upcoming paradigm for raising crops will require an innovation system
- Conservation tillage systems are much more complex than the conventional systems
- CA practices need a longer term and broader perspective which goes beyond yield increases only

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DRONES FARMING CULTIVATION IS FUTURE AGRICULTURE INDIA

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Introduction

India is primarily an agrarian economy. Agriculture remains the chief source of income for the majority of the rural households. India's economy is also heavily dependent on the agricultural produce that constitutes a major portion of its exports as well. However, despite mounting importance of agriculture, the sector is still far behind in technological advancements. Crop failure due to adverse weather conditions and uncontrolled pests issues have been the key contributors to this scenario. Moreover, Indian farmers are even now dependent on monsoon rains for irrigation and use age-old methods for other farming practices. Hence, the quality and quantity of agricultural produce is sometimes compromised in spite of the relentless efforts of farmers.

Drones are uncrewed aerial vehicles (also known as UAVs), which are used for surveillance in various industries. Till now, they were primarily used by companies working in industrial sectors such as mining and construction, army, and hobbyists.But now, drone technology is increasingly available for use in various sectors of agriculture as well. Though the technology is still nascent in India, many companies are trying so that it is easily available to Indian farmers and ready to be used to increase efficiency in agricultural production.

Kisan Drones

Adoption of Unmanned Aerial Vehicles (UAV) or drones offers enormous potential to revolutionise Indian agriculture by helping farmers address the challenges of water scarcity, pests, and diseases. The growing use of drones in agriculture are primarily driven by the increasing adoption of precision farming techniques and the growing demand for organic and sustainable farming. The use of drones in agriculture can help to:

- Increase crop yields
- Improve crop quality
- Reduce the use of pesticides and fertilizers
- Reduce labour costs
- Improve farm management

Drones can be used for a variety of agricultural activities, including:

• Spraying pesticides and fertilizers on crops which will reduce the use of labour and improve the accuracy of spraying.

• Collecting data on soil health which can be used to improve fertilizer and irrigation practices.

• Monitoring crops for pests, diseases, and water stress enabling the farmers to take timely action to protect their crops.

• Collecting data on individual fields which enables precision farming or customized farming plans for each field.

Government Initiatives

The Union Finance Minister in her budget speech for 2022-23 said that the use of 'Kisan Drones' will be promoted for crop assessment, digitization of land records, spraying of insecticides, and nutrients. Subsequently, the Prime Minister Narendra Modi on February 19, 2022, launched Kisan Drones at 100 places across the country.Speaking at the occasion, the Prime Minister said that until a few years back, a drone was considered to be a technology related to the Army, or a device used to combat enemies, thus limiting our thought to that particular use. With the inauguration of Kisan drone facilities in Manesar, India was marking a new chapter in the direction of modern farming system of the 21st century.

Recognizing the huge potential of drones in agriculture, the Government has introduced various policies to promote their use in farming, including:

- **The National Agricultural Drone Mission (NADM):**With an aim of promoting use of drones in agriculture, the government provides subsidies for the purchase of drones and training for farmers on how to use them.
- **The Drone Kisan Scheme:**The Government provides loans to farmers for the purchase of drones besides providing training for farmers on how to use drones.
- **The Agricultural Drones and Robotics (ADR) Policy:** It provides a framework for the regulation of agricultural drones with an aim to promote the safe and responsible use of drones.

Funds for Kisan Drones

(i) Financial assistance @ 100% of the cost of drone up to a maximum of Rs. 10 lakhs per drone is provided for purchase of drones for their demonstration by institutes under Indian Council of Agricultural Research, Farm Machinery Training & Testing Institutes, KrishiVigyanKendras (KVKs), State Agriculture Universities (SAUs), State and other Central Government Agricultural Institutions/Departments and Public Sector Undertakings (PSUs) of Government of India engaged in agricultural activities.

(ii) The Farmers Producers Organizations (FPOs) are provided grants up to 75% of the cost of agriculture drone for its demonstrations on the farmers' fields.

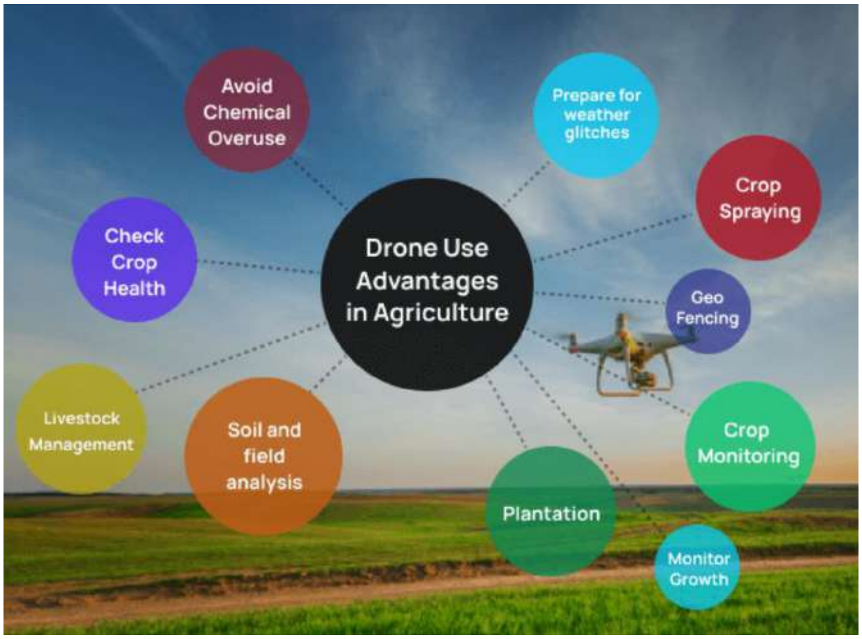
(iii)A contingency expenditure of Rs. 6,000 per hectare is provided to the implementing agencies that do not want to purchase drones but will hire drones for demonstrations from Custom Hiring Centres (CHCs), Hi-tech Hubs, Drone Manufacturers and Start-Ups.

(iv) In order to make available drone services to farmers on rental basis, financial assistance @

40% up to a maximum of Rs. 4 lakhs are provided for purchase of drones by CHCs under Cooperative Society of Farmers, FPOs and Rural entrepreneurs.

(v) Agriculture graduates establishing CHCs are eligible to receive financial assistance @ 50% of the cost of drone up to a maximum of Rs. 5 lakhs per drone.

(vi) For purchase of drones on individual ownership basis, the Small and Marginal, Scheduled Caste/Scheduled Tribe, Women and North Eastern State farmers are provided financial assistance @ 50% of the cost up to a maximum of Rs. 5 lakhs and other farmers @ 40% up to a maximum of Rs. 4 lakhs.



Benefits of agri-drones

- **Security**

The drones are operated by trained drone pilots. So, there are no chances of their misuse.

- **High efficiency**

Drones do not have any operational delays and can work double the speed of human labor.

- **Water-saving**

In comparison to traditional spraying methods, agricultural drones use ultra-low volume (ULV) spraying technology, thus saving more water.

- **Low cost and easy to maintain**

Agri drones are sturdy, low in cost, and require minimum maintenance. Some of the key features include a detachable container, low-cost frame, precise spraying of pesticides.

Limitations of agri drones

- **Connectivity issue**

Often, online coverage is unavailable in rural areas. Under such circumstances, a farmer needs to invest in internet connectivity, which can turn into a recurring expense.

- **Weather dependent**

Drones do not have any operational delays and can work double the speed of human labor.

- **Weather dependent**

Drones are heavily dependent on good weather conditions. Under rainy or windy weather conditions, it is not advisable to fly drones.

- **Knowledge and Skill**

Using new technology is a welcoming change but using it daily requires the right skillset and adequate knowledge. An average farmer may struggle to understand drone functions. Either he must acquire the knowledge or remain dependent on an experienced person.

Conclusion

Drones have already vastly altered the agricultural industry and will continue to grow in the coming years. While drone use is becoming more useful to small farmers, there is still a ways to go before they become part of every farmer's equipment roster, particularly in developing nations. However, the industry needs mature reforms, keeping in mind the growing population, the needs of the farmers, operational policies, and the shrinking farmlands. Moreover, trained pilots are needed to take forward the still untapped drone market. Our farmers and drone operators are the harbingers of change. Overall, it would be interesting to see how things go ahead, and how useful the applications of drones turn out to be in the long run

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ROLE OF TREES TO COMBAT AIR POLLUTION

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Introduction

At global level, clean air is crucial for maintaining balanced relationship between the environment and public health; nevertheless, the worsening of air quality brought on by the release of pollutants into the environment from a variety of sources is becoming a problem for both the climate and human health. When there is a significant amount of one or more toxins in the air, it is deemed to be polluted. Gaseous pollutants such as sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen oxides (NO_X), ozone (O_3), lead (Pb), and particulate matter ($PM_{2.5}$ and PM_{10}) are examples of anthropogenic or natural pollutants found in the atmosphere. These are referred to as the criteria air pollutants.

The population in low-income countries has reportedly been significantly impacted by a wide range of possibly fatal health issues that are caused by both ambient and indoor air. Additionally, according to the World Health Organisation, air pollution is "the silent killer" and is responsible for an estimated 7 million fatalities annually. In 2016, it was estimated that over 95% of people on Earth were breathing toxic air. Long-term exposure to contaminated air caused 6.1 million deaths worldwide, with India and China estimated to be jointly responsible for nearly 50% of deaths linked to $PM_{2.5}$.

Numerous human health conditions, including pulmonary, cardiac, vascular, and neurological illnesses, chronic respiratory symptoms, and illnesses affecting the elderly around the world, may be brought on by air pollution, according to epidemiological studies. Furthermore, exposure to air pollution from various sources is blamed for a steady rise in heart, respiratory, lung, and death diseases worldwide. One of the air pollutants, atmospheric particulate matter ($PM_{2.5}$), is projected to result in 3.3 million premature deaths annually, mostly in Asia, and has a number of detrimental impacts on human health.

Air pollution

As a result, bio-monitoring research in the field of air pollution science is crucial for restoring urban ecosystems since once pollutants are released into the atmosphere, they disperse and negatively impact the environment. Therefore, more studies have reported on and acknowledged the importance that plants play in reducing air pollution. The sole ecomanagement strategy (means to decrease the negative effects of human activity on the environment) for lowering and absorbing pollutants from the atmosphere has been suggested for air pollution.

There is an urgent need for environmentally sound repair methods because air pollution is a major problem on a global scale. As a result, phyto-remediation has gained popularity as a method for cleaning up air pollution. This method is eco-friendly since it is secure, protects the environment through energy efficiency and cheaper pollutant reduction, has no negative environmental effects, and employs a renewable energy source. The measurement of some biological factors of each species aids in calculating tolerance levels based on how plants react to air pollution. By assessing specific biochemical and socioeconomic traits, which may be found from the two indices known as the air pollution tolerance index (APTI) and anticipated performance index (API), respectively, the right plant species can be found.

Air pollution tolerance index (APTI)

The ability of plants to withstand air pollution is described by the air pollution tolerance index (APTI). It is one of the crucial factors that might be taken into account while choosing the species of plants for traffic barriers. The ability to classify plants according to their levels of sensitivity or tolerance to air pollution is a crucial tool. Four biochemical factors have been used to describe plant APTI: total chlorophyll, relative water content (RWC), ascorbic acid, and pH of leaf extract. A single parameter's change as a result of pollution may not accurately represent the situation. In order to arrive at an empirical number indicating the APTI of plants, four biochemical characteristics are taken into account.One of the frequent consequences of air pollution that inhibits photosynthesis is the progressive removal of chlorophyll and the yellowing of leaves. An essential electron donor in photosynthesis is ascorbic acid. pH is a key factor in photosynthetic activity. These metabolic factors are interdependent and most affected by air pollution. Low APTI plant species can be utilised as bio-indicators in low pollution areas based on APTI values, whereas high APTI plant species can be used to reduce air pollution in highly contaminated areas.

Urban greening

Urban greening can improve social, economic, and environmental conditions as well as provide colour to an otherwise drab metropolitan landscape. Thus, there is a connection between green infrastructure and human health. There always exists the nexus between air quality, human health and green infrastructure. Many researchers concluded that, although there is limited scientific evidence connecting these benefits to the reduction of air pollution by urban vegetation, urban vegetation can facilitate a wide range of health benefits. In order to define the underlying policy, design, and engineering guidelines guiding its implementation, significant effort is required.

The need for creating guidelines for urban greening design in order to maximise the benefits of greening and to measure the socioeconomic and health benefits of green infrastructure were always emphasised by the scientific community. To assess their environmental advantages and for basic street tree management, it is crucial to comprehend and quantify the structure of the street tree resources within an urban setting.

Height, thickness, coverage, porosity/density, and species traits that support better air quality were included in the design requirements. Urban planners and developers must understand how to protect existing roadside vegetation or create vegetative barriers to minimise the effects of air pollution close to transportation facilities, which is why these design criteria are crucial. For instance, the distance between trees has an impact on airflow over a wider area.

In general, studies have shown that vegetation with a minimum 5 m thickness, and most often with a thickness of 10 m or more, results in lower near-road pollution concentrations. Studies have focused on the economic and environmental benefits of trees. Huge, healthy trees with trunk diameters more than 30 inches yearly remove almost 70 times as much air pollution as tiny, healthy trees with trunk diameters smaller than 10 inches.

Economic benefits

- ✓ Increased property values – it is estimated that homes on tree-lined streets are valued 30% higher than those without trees.
- ✓ Research suggests that green cities have lower health costs due to healthier residents.

- ✓ Reducing energy costs by shading buildings and reducing the need for air conditioning in summer.
- ✓ The shade that trees give helps council assets and infrastructure, such as roads and footpaths, last longer.

Environmental benefits

- ✓ Temperatures in cities are lowered by trees, particularly in the summer. They provide shade for pavements and roadways, and their leaves both reflect and absorb sunlight, reducing the amount of heat that houses and other structures absorb during the day.
- ✓ Large tree canopies and extensive root systems aid in the management of stormwater flows and heavy metal concentrations.
- ✓ Air pollution and greenhouse gas emissions are significantly decreased by trees.

Trees absorb carbon dioxide, nitrous oxides, sulphur dioxide, carbon monoxide, and ozone from the atmosphere through the process of photosynthesis

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NAVIGATING THE WORK-FROM-HOME REVOLUTION IN INDIA: ADVANTAGES, CHALLENGES, AND HOLISTIC HEALTH SOLUTIONS

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Introduction

In the wake of the COVID-19 pandemic, India, like many other countries, witnessed a seismic shift in its work culture. The traditional office setting gave way to the rise of the work-from-home (WFH) system. What started as a necessity to ensure safety soon became a long-term solution, bringing with it a host of advantages and unforeseen challenges.

The Emergence of Work from Home in India

Before the pandemic, remote work in India was primarily limited to certain industries like IT and software development. However, as lockdowns were imposed and businesses had to adapt swiftly, remote work became the new norm across various sectors.

Organizations quickly realized the benefits of WFH. Reduced overhead costs, increased productivity due to fewer distractions, and access to a wider talent pool were among the key advantages. Moreover, employees enjoyed the flexibility of working from the comfort of their homes, eliminating time-consuming commutes and achieving a better work-life balance.

Unforeseen Challenges and Health Implications

Despite its benefits, the WFH model brought forth a unique set of challenges, particularly concerning employee well-being. Prolonged hours in front of screens, blurred boundaries between work and personal life, and isolation from colleagues led to a surge in mental and physical health issues.One of the most significant concerns was the sedentary lifestyle induced by WFH. Many employees found themselves tied to their desks for hours on end, leading to a decline in physical activity levels. This lack of movement resulted in various health issues, including back pain, neck strain, obesity, and decreased immunity.

Sitting is a new smoking

Long working hours led to 745,000 deaths from stroke and heart disease in 2016, a 29 per cent increase since 2000, according to estimates by the World Health Organization (WHO) and the International Labour Organization (ILO) published in Environment International. In their first global study on the health impacts of long working hours, WHO and ILO found that, in 2016, 398,000 people died from stroke and 347,000 from heart disease because they worked at least 55 hours a week. Between 2000 and 2016, deaths from heart disease due to long working hours increased by 42 per cent, and deaths from stroke by 19 per cent.

Men were particularly affected, with 72 per cent of deaths occurring among males. The problem was most severe in the Western Pacific and South-East Asia regions, and among middle-aged or older workers. Most deaths were recorded in people aged 60-79, who had worked long hours between the ages of 45 and 74. Long working hours are now responsible for about one-third of all work-related diseases, making it the biggest occupational risk factor. Working 55 or more hours per week increases the risk of stroke by 35 per cent and the risk of dying from heart disease by 17 per cent, compared to working 35-40 hours a week.

The number of people working long hours is increasing and currently stands at 9 per cent of the global population, putting more people at risk of work-related disability and early death. The COVID-19 pandemic has worsened this trend by changing the way people work, often blurring the boundaries between home and work, and leading to longer working hours. WHO Director-General Dr. Tedros Adhanom Ghebreyesus emphasized the need for governments, employers, and workers to set limits to protect workers' health. Dr. Maria Neira, Director of the Department of Environment, Climate Change and Health at WHO, added that it's crucial for everyone to recognize the serious health risks of long working hours and take action to prevent premature death.

Solutions for Health and Well-being

To combat the adverse effects of prolonged WFH, it's crucial for both employers and employees to prioritize health and wellness. Here are some effective solutions:

1. Regular Exercise Routine:

Encouraging employees to incorporate regular exercise into their daily schedules can work wonders for their physical and mental well-being. Simple activities like stretching exercises, yoga, or brisk walks can help alleviate stiffness and improve overall fitness levels.

2. Ergonomic Workstations:

Providing ergonomic furniture and equipment, such as adjustable chairs and standing desks, can promote better posture and reduce the risk of musculoskeletal problems. Ergonomic assessments and adjustments can also be offered to ensure employees have an optimal workspace setup.

3. Scheduled Breaks:

Ergonomics boosts productivity by reducing discomfort and fatigue, preventing injuries, and enhancing efficiency. Ergonomically designed workspaces improve employee comfort, minimize strain, and lower the risk of musculoskeletal disorders, leading to fewer sick days and higher job satisfaction. This improved well-being and efficiency enable employees to maintain focus and perform tasks more effectively, resulting in a more productive and motivated workforce.

Encouraging employees to take regular breaks throughout the day is essential for combating the sedentary nature of WFH. Short breaks for stretching, walking, or engaging in recreational activities can help refresh the mind and body, example an employee can keep their water bottle bit away from the table so that they get to get up and walk least to reach the bottle. Employers can implement policies or tools to remind employees to take breaks and disconnect from work during non-working hours. More the employees are provided good working environment more the productivity.

4. Mental Health Support:

Offering access to mental health resources, such as counseling services or mindfulness sessions, can help employees manage stress, anxiety, and feelings of isolation. Creating a supportive work culture where employees feel comfortable discussing mental health concerns is vital. Employers can also provide training to managers on recognizing signs of mental health issues and offering appropriate support.

5. Flexible Work Hours

Implementing flexible work hours allows employees to balance their professional and personal responsibilities effectively. This flexibility empowers individuals to prioritize self-care and maintain a healthy work-life balance. By accommodating varying schedules and time zones, organizations can foster inclusivity and support employee well-being.

Embracing a Holistic Approach

As India continues to embrace the WFH culture, it's essential to adopt a holistic approach that prioritizes employee health and well-being. By implementing proactive measures and fostering a supportive work environment, organizations can ensure that the WFH model remains sustainable and beneficial for all stakeholders involved.

Remember, a healthy workforce is the foundation of a thriving and resilient business ecosystem. By investing in the well-being of employees, organizations can cultivate a positive workplace culture and drive long-term success in the era of remote work.

Conclusion

In conclusion, the transition to remote work in India, accelerated by the COVID-19 pandemic, has been transformative, bringing both advantages and challenges to the forefront. While remote work offers benefits such as increased flexibility and reduced costs, it also presents unique health and well-being concerns for employees.Addressing these challenges requires a multifaceted approach that prioritizes physical and mental health. Employers must invest in resources and initiatives that support employee well-being, from promoting regular exercise and ergonomic workstations to offering mental health support and flexible work hours.By embracing a holistic approach to remote work, organizations can foster a positive and resilient work culture that prioritizes the health and happiness of employees. In doing so, they not only safeguard individual well-being but also lay the foundation for sustained success in the evolving landscape of remote work in India.

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GENOME EDITING: A KEY PLAYER IN CROP IMPROVEMENT

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Abstract

Agriculture has long been crucial to human survival and development, but it now faces immense pressure from a growing global population and climate change. Traditional breeding methods are often too slow and imprecise to meet these challenges. Genome editing, a revolutionary technology, offers precise modifications to plant DNA, enhancing traits such as disease resistance, pest resilience, abiotic stress tolerance, and nutritional profiles. Techniques like CRISPR-Cas9, TALENs, and prime editing provide unparalleled control and efficiency in crop improvement. These advancements promise significant contributions to sustainable agricultural practices by reducing chemical inputs and improving crop resilience. However, the technology faces challenges, including regulatory hurdles, ethical concerns, and potential off-target effects. This article explores the role of genome editing in crop improvement, examining its methodologies, applications, advantages, and disadvantages. Genome editing stands as a key player in advancing crop science, poised to ensure food security and sustainability for future generations.

Keywords: Genome Editing, CRISPR-Cas9, Stress resistance, DNA, Crop Improvement

Introduction

Agriculture has always been a cornerstone of human civilization, providing the essential resources needed for survival and development. The agricultural sector is under immense pressure of feeding a rapidly growing global population and adapting to the unpredictable impacts of climate change. Traditional breeding methods, while instrumental in historical crop development, often lack the speed and precision required to keep up with these evolving demands. In this context, genome editing has emerged as a revolutionary technology that allows for precise modifications to an organism's DNA, offers a promising solution. By allowing scientists to make precise, targeted changes to the DNA of plants, genome editing offers a level of control and efficiency previously unattainable in crop science. By enabling precise, targeted modifications to an organism's DNA, genome editing offers unparalleled opportunities to enhance crop traits, from disease and pest resistance to improved nutritional profiles and stress tolerance.

Genome editing encompasses a suite of advanced techniques, most notably CRISPR-Cas9, TALENs, and prime editing, each providing unique advantages in manipulating plant genomes. These methods enable the enhancement of desirable traits such as disease resistance, pest resilience, abiotic stress tolerance, and improved nutritional profiles. The implications of genome editing extend beyond yield improvement and pest management. It promises to contribute significantly to the sustainability of agricultural practices by reducing the need for chemical inputs and enhancing the resilience of crops to environmental stresses. However, the adoption of genome editing is not without challenges. Regulatory hurdles, ethical concerns, and the risk of off-target effects are significant considerations that need to be addressed to fully realize the benefits of this technology. This article delves into the multifaceted role of genome editing in crop improvement, exploring the methodologies, applications, advantages, disadvantages and challenges. By harnessing the power of genome editing, we stand on the brink of a new era in crop science, poised to meet the demands of the 21st century with innovations that could ensure food security and sustainability for future generations.

Methods of Genome Editing

Genome editing is an advanced technique that makes precise modifications to DNA, impacting only a few nucleotides out of the billions that make up the genome sequences in living organisms.Here are the primary methods with examples of their applications:

1. **CRISPR-Cas9 (Clustered Regularly Interspaced Short Palindromic Repeats-Associated Protein 9):** CRISPR-Cas9 has revolutionized genome editing due to its simplicity, efficiency, and versatility. The system consists of two main components: the Cas9 enzyme, which cuts the DNA, and a guide RNA (gRNA) that directs Cas9 to a specific sequence in the genome. Once the DNA is cut, the cell's natural repair

mechanisms either disable the gene (knockout) or allow for the insertion of new genetic material (knock-in).

2. **TALENs (Transcription Activator-Like Effector Nucleases):** TALENs are engineered proteins that bind to specific DNA sequences and introduce double-strand breaks, enabling targeted genetic modifications. TALENs are composed of a customizable DNA-binding domain and a DNA-cleaving nuclease domain.
3. **ZFNs (Zinc Finger Nucleases):** ZFNs are synthetic proteins that combine a zinc finger DNA-binding domain with a DNA-cleaving nuclease domain. These proteins can be engineered to target specific DNA sequences, where they create double-strand breaks, facilitating precise genetic modifications.
4. **Base Editors:** Base editors enable the direct conversion of one DNA base into another (e.g., C to T or A to G) without introducing double-strand breaks. This method provides a more refined approach to genetic modification, reducing the risk of unintended mutations.
5. **Prime Editing:** Prime editing is a recent advancement that combines aspects of CRISPR and reverse transcriptase enzymes to write new genetic information into a target site directly. This technique offers even greater precision and versatility in genome editing.

Applications of Genome Editing in Crop Improvement with Successful Examples

Genome editing has a wide range of applications in agriculture, addressing various challenges and enhancing crop traits in multiple ways:

1. **Disease Resistance:** Genome editing can enhance crop resistance to diseases by knocking out susceptibility genes or introducing disease-resistant alleles.

Disease-Resistant in Rice: Scientists developed a variety of rice resistant to bacterial blight by using CRISPR-Cas9 to knock out the OsSWEET14 gene, which the bacteria exploit to cause disease .

Powdery Mildew-Resistance Wheat: Wheat varieties resistant to powdery mildew have been created by disrupting the MLO gene using CRISPR-Cas9, demonstrating significant resistance to the fungal pathogen .

2. **Pest Resistance:** By editing genes associated with pest resistance, crops can become more resilient to insect attacks, reducing the reliance on chemical pesticides.

Eg: Researchers used CRISPR-Cas9 to create maize resistant to fall armyworm by knocking out the gene responsible for the production of volatile organic compounds that attract the pest.

3. Abiotic Stress Tolerance: Crops often face environmental stresses such as drought, salinity, and extreme temperatures. Genome editing can enhance the ability of crops to withstand these Stresses by modifying genes involved in stress response pathways.

Eg: Editing the ARGOS8 gene in maize using CRISPR-Cas9 has resulted in enhanced drought tolerance and increased yield under water-limited conditions.

4. **Nutritional Enhancement:** Genome editing can improve the nutritional profile of crops by increasing the content of essential vitamins and minerals

   Beta-Carotene Enriched Rice: CRISPR-Cas9 has been employed to biofortify rice with higher levels of beta-carotene, a precursor of vitamin A, which is essential for addressing vitamin A deficiency in developing countries.

5. **Yield Improvement:** By optimizing growth and development pathways, genome editing can significantly increase crop yields.

   Example: Editing the promoter of the GOS2 gene in rice has led to increased grain size and yield.

6. **Shelf Life and Quality:** Genome editing can enhance the shelf life and quality of crops by altering genes related to ripening and spoilage.

Example: sing CRISPR-Cas9 to target the RIN gene, researchers have developed tomatoes with extended shelf life and improved quality, reducing post-harvest losses .

Advantages of Genome Editing in Crop Improvement

Genome editing offers several advantages over traditional breeding methods and other genetic modification techniques:

- ✓ **Precision and Efficiency:** Genome editing allows for precise modifications at specific genomic locations, minimizing off-target effects. This high level of precision ensures that only the desired traits are altered without affecting other parts of the genome.
- ✓ **Speed:** Traditional breeding methods can take years or even decades to achieve desired traits. Genome editing significantly shortens this timeline, allowing for rapid development of improved crop varieties.
- ✓ **Cost-Effectiveness:** Compared to traditional breeding and transgenic approaches, genome editing can be more cost-effective. The ability to quickly and accurately introduce desired

traits reduces the resources needed for crop development.

- **Reduced Use of Chemical Inputs:** Crops engineered for disease and pest resistance through genome editing require fewer chemical inputs, such as pesticides and herbicides. This not only reduces production costs but also has positive environmental impacts.
- **Potential for Sustainable Agriculture:** Genome editing can contribute to more sustainable agricultural practices by developing crops that are more resilient to environmental stresses, require fewer resources, and have enhanced nutritional profiles. This aligns with the goals of sustainable agriculture to meet current needs without compromising future generations' ability to meet their own needs.

Challenges of Genome Editing in Crop Improvement

Despite its numerous advantages, genome editing also presents several challenges and disadvantages:

- **Regulatory Hurdles:** The regulatory landscape for genome-edited crops varies significantly across countries. While some countries have adopted relatively lenient regulations, others treat genome-edited crops similarly to genetically modified organisms (GMOs), which can be a lengthy and expensive process. **Example:** Many countries currently classifies genome-edited crops under the same regulations as GMOs, requiring extensive safety assessments and approvals before commercialization .
- **Ethical and Societal Concerns:** The use of genome editing in agriculture raises ethical and societal concerns, particularly regarding the long-term impacts on ecosystems and biodiversity. There is also public apprehension about consuming genetically edited crops, which can affect market acceptance. **Example:** Public opposition to genetically modified organisms (GMOs) in regions like Europe and India can also extend to genome-edited crops, affecting their adoption and marketability.
- **Off-Target Effects:** Although genome editing tools are designed for precision, there is still a risk of off-target effects, where unintended genetic changes occur. These off-target mutations can have unforeseen consequences on plant health and development.
- **Example:** Studies have shown that even CRISPR-Cas9 can sometimes introduce unintended mutations, which could potentially affect the plant's phenotype and fitness

Conclusions: By exploring these aspects, we aim to highlight how genome editing stands as a key player in driving the future of sustainable and resilient agriculture, ensuring food security for generations to come.

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