ISSN: 3048 - 989X

INNOVATIVE AGRICULTURE

A MONTHLY MAGAZINE FOR AGRICULTURE AND ALLIED SCIENCES

www.innovativeagriculture.in

JANUARY 2025

INNOVATIVE AGRICULTURE

A MONTHLY MAGAZINE

ISSN No.: 3048 – 989X

Frequency: Monthly
Month: January
Volume: 01, Issue 03

CONTENT

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Mass Production and Utilization of Biological Control Agents in Sustainable Agriculture

Bhagshali Patle[1] and Piyush Kumar[2]

[1]Ph.D. Research Scholar and [2]M.Sc. (Ag.) Student
Department of Plant Pathology and Nematology, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur 848 125, Bihar, India

"Biological control agents play a crucial role in sustainable agricultural practices by offering environmentally friendly alternatives to chemical pesticides. This article explores the mass production and utilization of various biological control agents, including *Trichogramma spp*., predatory spiders, *Bracon spp*., reduviid bugs and anthocorid bugs. These agents are integral to pest management in crops such as rice, sugarcane, cotton and vegetables, enhancing productivity while minimizing environmental impact. Techniques for mass production and field application of these agents are outlined, showcasing their effectiveness in controlling pest populations and fostering ecological balance. The adoption of these biological control agents in farming practices is a key strategy for promoting sustainable agriculture."

Introduction

Sustainable agriculture aims to meet current food production needs without compromising the ability of future generations to meet their own needs. A critical aspect of sustainable farming is integrated pest management (IPM), which combines biological, cultural, and chemical control methods to reduce reliance on chemical pesticides. Among the biological control strategies, the use of natural enemies such as parasitoids and predators has gained widespread attention for its ability to effectively manage pest populations while preserving environmental health. This article examines the mass production and utilization of several biological control agents, including *Trichogramma spp*., predatory spiders, *Bracon spp*., reduviid bugs and anthocorid bugs, which have proven effective in various crop systems. These biological agents provide a valuable, eco-friendly alternative to chemical pesticides, offering numerous benefits for pest control, crop productivity and ecological balance.

1. Mass Production of *Trichogramma spp*.

Trichogramma spp., minute egg parasitoids, are used extensively for controlling lepidopteran pests. These parasitoids target and parasitize the eggs of pest species, preventing larvae from emerging and causing crop damage. *Trichogramma spp*. have shown remarkable effectiveness in various crops, including rice, sugarcane and vegetables (Viswanathan, 2012).

Materials and Methodology

- **Trichocard Preparation:** The mass production of *Trichogramma spp*. begins with the preparation of Trichocards. Eggs of *Corcyra cephalonica*, treated under UV light to induce parasitization, are used as the substrate. After approximately four days, parasitized eggs turn black and are ready for release.

- **Field Release:** Trichocards are cut into smaller pieces and distributed in fields. If not immediately used, the cards can be refrigerated at 10°C for up to 21 days (Kathirvelu & Mahadevan, 1967).

Applications in Crop Protection

- Rice: *Trichogramma spp.* control pests such as the yellow stem borer (*Scirpophaga incertulas*) and leaf folder (*Cnaphalocrocis medinalis*).
- Sugarcane: Management of *Chilo sacchariphagus* and *Chilo infuscatellus*.
- Vegetables: Control of diamondback moths and fruit borers.

2. On-Farm Production of Predatory Spiders

Predatory spiders are highly effective biological control agents, particularly in controlling herbivorous pests. These spiders, such as orb spiders, wolf spiders, and jumping spiders, are obligate predators and help maintain the ecological balance in crops such as rice and apple orchards.

Conservation and Augmentation Techniques

- Providing hedges and mulches for shelter.
- Covering spider egg sacs with hay near standing crops.
- Releasing spiderlings produced in controlled environments.

Production Procedure

Predatory spiders are produced by rearing them in containers lined with branches or leaves. Maintain humidity with water-soaked cotton and introduce prey, such as *Corcyra* larvae or fruit flies. Female spiders lay egg sacs, which hatch in 21-28 days. Spiderlings are then released into the field for pest control.

Key Spider Species

- Orb spider
- Wolf spider
- Jumping spider

3. On-Farm Mass Production of *Bracon spp.*

Bracon spp., including *Bracon hebetor* and *Bracon brevicornis*, are gregarious ecto-larval parasitoids of several lepidopteran pests. These parasitoids parasitize pest larvae, laying eggs on their surface, which helps in controlling pest populations.

Mass Multiplication Procedure

1. **Rearing on *Corcyra cephalonica*:** Use wide-mouthed jars with a honey solution for adult feeding. Place 10-15 fourth or fifth instar larvae of *C. cephalonica* above muslin cloth.
2. **Parasitization:** Release 30-50 adults into the jar for 48 hours, then transfer parasitized larvae to separate Petri dishes for pupation.

Life Cycle Parameters

- Egg period: 1-2 days
- Larval period: 2-4 days
- Pupal period: 3-7 days
- Adult lifespan: 20-63 days

4. Mass Production of Reduviid Bugs

Reduviid bugs (*Isyndus heros*, *Rhynocoris marginatus*, *R. fuscipes*, etc.) are highly effective predators of insect pests such as *Helicoverpa armigera* and *Spodoptera litura*. These bugs are used for managing pests in crops like pulses, cotton, maize and groundnuts (Kumar *et al*., 2020).

Production Procedure

For mass production of reduviid bugs, start by using clean containers and placing a 2 cm layer of sand at the bottom. Add a cotton swab dipped in a 10–50% honey solution to the container for nourishment. Place corrugated paper inside the container to provide a surface for oviposition, and introduce 2–3 *Corcyra cephalonica* larvae. Release 2–3 pairs of adult reduviid bugs (in a 1:1 male-to-female ratio) into the container and cover it with muslin cloth to prevent escape. The honey swabs and larvae should be replaced every two days to ensure a constant food supply. After egg masses are laid on the corrugated paper, collect them and transfer them to Petri dishes for hatching. Once hatched, feed the nymphs with 1st–3rd instar *Corcyra* larvae and maintain the nymphs in containers with sand and corrugated paper to encourage healthy growth. After 40–45 days, the nymphs will mature into adults. These adults can either be released into the field to control pests or used for further breeding.

Field Application: Reduviids effectively control pests by consuming various sizes of caterpillars throughout their life cycle (Pandey & Yadav, 2018).

5. Mass Production of Anthocorid Bugs

Anthocorid bugs (*Cardiastethus pygmaeus*, *Xylocoris flavipes*, *Blaptostethus pallescens*) are generalist predators effective against pests such as thrips, aphids and spider mites. These bugs are used in crops like cotton, sunflower and coconut (Sharma *et al*., 2021).

Production Procedure

To mass produce anthocorid bugs, start by using a one-liter glass or plastic beaker, lining it with tissue paper. UV-irradiated *Corcyra* eggs are provided as a food source for the bugs. Adult anthocorid bugs are then released into the beaker and a water-soaked cotton swab is placed inside to provide hydration. The beaker is covered with muslin cloth and secured with a rubber band to ensure the bugs remain contained. After 24 hours, adults lay their eggs on cotton strands or beans, which are then collected. The collected eggs are transferred to a separate container for hatching. As the nymphs hatch, they are fed *Corcyra* eggs and maintained in hygienic conditions to promote healthy growth. Within 15–18 days, the nymphs mature into adults. These adult anthocorids can be used for further breeding or released into the field to suppress pest populations.

Field Application*:* For crops like cotton, sunflower and coconut, release 50,000 bugs at 100 spots or 5–10 nymphs per plant for effective pest suppression.

Conclusion

The mass production and field application of biological control agents such as *Trichogramma spp*., predatory spiders, *Bracon spp*., reduviid bugs and anthocorid bugs significantly contribute to sustainable pest management. These agents effectively reduce the need for chemical pesticides, promote biodiversity and enhance crop yields. By implementing these biological control methods, farmers can achieve long-term ecological balance, reduce production costs and ensure environmental sustainability. The continued development of mass production techniques and the adoption of these agents will play a vital role in transforming agriculture towards more sustainable and eco-friendly practices, benefiting both farmers and the environment.

References

Awasthi, N., Sharma, R., & Dubey, A. (2020). Predatory efficacy of reduviid bugs in managing pests in cotton. *Indian Journal of Entomology*, *82*(3), 365-371.

Kathirvelu, K., & Mahadevan, A. (1967). Studies on the efficacy of egg parasitoids in sugarcane pest management. *Journal of Biological Control*, *45*(3), 567–578.

Kumar, S., Patel, S., & Sharma, R. (2020). Biological control of pest species using reduviid bugs in pulses. *Crop Protection, 98*, 180-186.

National Institute of Plant Health Management (NIPHM). (n.d.). Biological control methods for pest management.

Pandey, R., & Yadav, K. (2018). Reduviid bugs as biological control agents in Indian agriculture. *Journal of Biocontrol Science, 13*(4), 215-221.

Sharma, N., Singh, S., & Bansal, M. (2021). Anthocorid bugs: Effective control agents for aphid management in crops. *Pest Management in Horticultural Ecosystems, 19*(2), 240-246.

Soni, P., Gupta, S., & Kumar, P. (2019). Mass production and field application of beneficial insects in sustainable agriculture. *Journal of Agricultural Science, 67*(6), 467-473.

Verma, M., Prasad, B., & Patil, D. (2017). Mass rearing and release of anthocorid bugs for integrated pest management. *Indian Journal of Plant Protection, 45*(1), 78-84.

Viswanathan, R. (2012). Advances in sugarcane pest management: A review on *Trichogramma spp.* applications. *International Journal of Plant Protection, 34*(4), 234–242.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Role of Aquatic Plants in Wastewater Treatment

K. Suganya[1], P. Kalaiselvi[2], V. Davamani[1], E. Parameswari[1], S. Paul Sebastian[3]

[1]Dept. of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore
[2]Krishi Vigyan Kendra, Santhiyur, Salem
[3]Agri College and Research Institute, Kudumiyanmalai

"Large scale use of surface and groundwater in various sectors like industries, agriculture and domestic purposes leads to release/ discharge of more amount of untreated wastewater into the nearby ecosystems and thereby creates lot of environmental issues. Conventional methods of wastewater treatment seem to be very expensive. Aquatic plants are known for their unique mechanisms in wastewater treatment. There many different types in aquatic plants which includes, free floating, floating leaved, submerged, and emergent plants. This eco-friendly approach of using aquatic plants for treating wastewater and their insights need to be explored."

Keywords: Wastewater, aquatic plants, BOD, COD

Introduction

Aside from food and shelter, clean water is an essential component of human existence. The two main sources of clean water are surface and subsurface water. However, many water sources are now contaminated due to the fast population increase and growing industrialization. This is because anthropogenic activities continuously release both organic and inorganic waste items into natural water sources.

Both solid and liquid wastes discharged into natural water bodies can seriously endanger human health and natural habitat by negatively affecting aquatic ecosystems. Wastewater must therefore be sufficiently treated before being released into the environment. In the present scenario, traditional wastewater treatment techniques aren't always successful in eliminating all water pollutants. As a result, cleaned water still contains trace amounts of harmful pollutants. Because the pollutants are hazardous and can disrupt numerous plant cellular processes, these residues may pose a threat to habitats.

One subfield of bioremediation that uses plants to treat wastewater is called phyto-remediation. It makes use of plant roots' capacity to take up nutrients from wastewater. Certain plant species that are chosen for phyto-remediation might accumulate a variety of contaminants. Compared to traditional treatment methods, the phyto-remediation process is more economical and efficient.

Aquatic Plants

Plants that have adapted to live in freshwater or saltwater conditions are known as aquatic plants. To differentiate them from algae and other microphytes, they are sometimes known as hydrophytes or macrophytes. An emergent, submergent, or floating plant that grows in or next to water is called a macrophyte. In lakes and rivers, macrophytes generate oxygen, serve as food for some fish and species, and offer cover for fish and aquatic invertebrates.

Aquatic plants serve as primary producers and play a necessary role for the food web for many organisms. They have the capacity to trap the pollutant and slow down their nature as well alter the soil chemistry to maintain the soil quality. Plant tissues of some of these aquatic plants have the ability to absorb pollutants in the wastewater.

Role of Aquatic Plants

S.No	Plants	Role	References
1	*Arundo donax*	Reduction of Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorus (TP).	Zhang *et al*. (2021)
2	*Glyceria maxima, Phragmites australis, Typha latifolia and Phalaris arundinacea*	Removal of macro and micronutrients	Agnieszka Parzyc *et al*. (2016)
3.	*Canna indica, Xanthomonas sagitifolium, Typha angustifiolia*	Reduction of biological oxygen demand (BOD), COD, Heavy metals	Suganya *et al* (2022)
4	*Colocasia esculenta and Canna indica*	landscape improvement, and purification	Gokul Kannan *et al*. (2019)

References

Agnieszka Parzych, Zbigniew Sobisz, Małgorzata Cymer, 2016. Preliminary research of heavy metals content in aquatic plants taken from surface water (Northern Poland), Desalination and Water Treatment, V olume 57, Issue 3, 2016, Pages 1451-1461, ISSN 1944-3986,

Gokul Kannan, T., M Maheswari, P Balasubramaniam, P Dhevagi. 2019. Role of radial oxygen loss (ROL) and rhizosphere microflora of reed plants in treating wastepaper based paper and board mill effluent. Int J Chem Stud;7(4):1077-1083.

Suganya, K., Joneboina Easwar Kumar, R. Jayashree, and S. Paul Sebastian. 2022. "Influence of Aquatic Plants and Flow Rate on Physico-Chemical Characteristics of Sewage Effluent Treated through Constructed Wetland Technology". International Journal of Environment and Climate Change 12 (10):882-91.

Zhang D, Jiang Q, Liang D, Huang S and Liao J. 2021. The Potential Application of Giant Reed (Arundo donax) in Ecological Remediation. Front. Environ. Sci. 9:652367.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

NANOTECHNOLOGY IN EFFLUENT TREATMENT

K. Suganya[1], P. Kalaiselvi[2], V. Davamani[1], E. Parameswari[1], S. Paul Sebastian[3]

[1]Dept. of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore
[2]Krishi Vigyan Kendra, Santhiyur, Salem
[3]Agri College and Research Institute, Kudumiyanmalai

"Anthropogenic activities deteriorate the quality of environment day by day and pose serious threat to the living organisms and the ecosystem. All the components of the environment viz., air, water, and soil gets polluted invariably. These pollutants need to be handled and disposed off with utmost care. Nanotechnology is an emerging field of science and the researchers throughout the world are working for the cutting edge approaches with this tool to remediate the environmental pollution. In this paper, an attempt was made to discuss many nano-technological interventions in wastewater treatment, as the per capita generation of wastewater is increasing throughout the world."

Keywords: Nanoparticles, Nanoclays, Nanosorbents, Nanocatalyst

Introduction

Nanotechnology is a branch of science which introduces new approaches and solutions for many emerging environmental issues and problems. Having high surface area is a distinctive characteristic of nano-particles and they have an immense prospective for their usage in waste water treatment efficiently in many ways viz., removing disease causing microbes, toxic metal ions, organic and inorganic solutes from water. Various categories of nanomaterials like metal-containing nanoparticles, carbonaceous nanomaterials, zeolites and dendrimers are found to be effective for water treatment.

Nano-technological Tools

Recent advances on different nano-technological tools includes the following

1. Nanocatalysts

Increasing the catalytic activity at the surface due to its higher surface area makes the nano-catalyst to serve an important role in water treatment process. Widely used nano-catalysts for degrading the persistent environmental contaminants viz., Azo-dyes, polychlorinated biphenyls (PCBs), organochlorine pesticides and halogenated herbicides are; bimetallic nano-particles, zero-valent metal nano-particles and semiconductor materials. (Xin et al., 2011). These particles augment the reaction and degradation of contaminants. These nanocatalyst has the property of ferromagnetism which help them to be sepearated very easily and thus it can be recycled back and reused.

2. Nanosorbents

Some of the nano-adsorbents used for various applications are given below:

Nanosorbent	Specialization/Treatment	Reference
Carbon-based nanosorbents	Nickel ions (Ni^{2+}) are removed from wastewater	(Lee et al., 2012)
Nanoclays	Used for treating the Dyes, Hydrocarbons and phosphorus	(Adane Adugna Ayalew, 2022)
Magnetic nanosorbents	Very important material for organic contaminants removal	(Subbaiah Muthu Prabhu et al., 2023)

Modified from Prachi *et. al.* (2013)

3. Bioactive nanoparticles

Due to the resistance developed by the pathogens and other microbes in water treatment process, the concept of bioactive nano-particles has been recently emerged which has given the alternative of new chlorine-free biocides. Current and emerging nanotechnology approaches for the detection of microbial pathogens will aid microbial and pathogen detection as well as diagnostics. The bacterium Bacillus cereus which have a very high antibacterial property could be used for synthesize of Silver nanoparticles (AgNPs).

4. Polymer-Based Nano-adsorbents

Covalent organic polymers, polysaccharides, nano-magnetic polymers, cyclodextrin are commonly used polymer based nano-adosrbents. These adsorbents offer high surface area for wastewater treatment process. These adsorbents have the following advantages in treatment process: good stability, improved process-ability, low cost and rapid decontamination.

5. Zeolites

Zeolites are one among the naturally found silicate minerals and can also be prepared artificially as bio-zeolite, magnetically modified zeolite etc. Due to its selective and compatible nature, these zeolite NPs are used widely for various environmental applications.

Conclusion

There are several nano technological tools that are found to be efficient in waste water treatment in the laboratory scale. But the practical application of them in the field conditions is yet be explored. Also the cost factor is to be adjusted in a way so that even small scale industries could afford to choose nano tools for their effluent treatment. These tools can be excellent treatment options if we could establish proper knowledge on them.

References

Adane Adugna Ayalew. A critical review on clay-based nanocomposite particles for application of wastewater treatment. Water Sci Technol 15 May 2022; 85 (10): 3002–3022.

Lee, H., Lytton-Jean, A., Chen, Y. et al. Molecularly self-assembled nucleic acid nanoparticles for targeted in vivo siRNA delivery. Nature Nanotech 7, 389–393 (2012).

Prachi, Pranjali Gautam, Deepa Madathil, A.N. rijesh Nair. 2013. Nanotechnology in Waste Water Treatment: A Review. International Journal of Chem Tech Research Vol.5, No.5, pp 2303-2308, July-Sept 2013

Subbaiah Muthu Prabhu, Niraj R. Rane, Xiaofang Li, Sachin V. Otari, Savita D. Girawale, Ashwini R. Palake, Kisan M. Kodam, Young-Kwong Park, Yoon-Hee Ha, Krishna Kumar Yadav, Moonis Ali Khan, Byong-Hun Jeon, Magnetic nanostructured adsorbents for water treatment: Structure-property relationships, chemistry of interactions, and lab-to-industry integration, Chemical Engineering Journal,Volume 468,2023,143474,ISSN 1385-8947.

Xin Zhaoa,b, Lu Lva,b, Bingcai Pana,b, Weiming Zhanga,b, Shujuan Zhanga, Quanxing Zhanga,b.,(2011), Polymer-supported nanocomposites for environmental application: A review, Chemical Engineering Journal, 170 (2–3), pp 381–394. Nanotechnology in waste water treatment: A review.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Insect Pest Infestation in Coconut Gardens of Tirupathur District

P. Thilagam[1] and S. Srividhya[2]

[1]Agricultural Research Station, Virinjipuram
[2]Horticultural College and Research Institute, Paiyur

Introduction

Coconut crop is being cultivated in an area of 10626 ha with average productivity of 2979 lakh nuts /ha. In Tirupathur District, coconut cultivation is carried out in six blocks viz., Tirupathur, Kandili, Jolarpet, Natrampalli, Madhanur and Alangayam blocks. Coconut crop is attacked by numerous insects viz., Rhinoceros beetle, Oryctes rhinoceros, red palm weevil, Rhynchophorus ferrugineus, black headed caterpillar, Opisinia arenosella and whitefly complex throughout the year causing considerable yield losses and the incidence is more during hot summer months. Based on the severity of coconut insect pests, survey was carried out in Jolarpet block of Tirupathur district during the month of July 2024.

Body

Insect complexity with hidden nature of damage and tall nature of coconut makes more complex with management options. Inspite of recent technological innovations also, the major loss in coconut is faced by the farmers because of poor nutrition and management. Moreover, many of the small and marginal farmers are not able to meet out the cost of pesticide and inorganic fertilizers and the spray due to increased cost of plant protection chemicals and the height of the crop remains a constraint in imposing the chemical treatments. Biological control is an alternative approach to the chemical insecticides and it may be a safe, effective and ecofriendly method for coconut insect pest management.

Large scale adoption of biocontrol is still in an infancy stage due to non-availability of biocontrol agents Hence, the livelihood of coconut farmers could be increased with promotion of knowledge on adoption of existing timely management tools. It is therefore imperative to adopt crop pest calendar approach for higher production of coconut and possible only with sensitization and adoption of ecosmart technologies to coconut growers in major coconut growing areas of Tirupathur District.

Hence, survey was made in Jolarpet block of Tirupathur district (Table 1) to assess the incidence of major insect pests viz., rhinoceros beetle, whitefly complex, black headed caterpillar and red palm weevil in 5 fields comprising of three villages covering 28 acres of coconut cultivation. The incidence of rhinoceros beetle and whitefly complex incidence varied from 5.0-10.0 per cent, black headed caterpillar incidence varied from 35.0 – 90.0 per cent. Based on the incidence of insect pests, the following control measures were sensitized and demonstrations were made for the benefit of the coconut growers.

ISSN : 3048 - 989X

Insect pest	Recommendation
Black Headed Caterpillar	Removal and destruction of affected leaflets Installation of one light trap per acre between 7.00-11.00 p.m Release of Braconids @ 21 pockets per acre at 21 days interval Sowing of sunnhemp around the field and pulses to encourage the activity of natural parasitoids
Whitefly Complex	Installation of yellow sticky trap @ 8 Nos per acre Insecticidal application has to be avoided so as to increase *Encarsia* activity Release of *Encarsia* @ 10 leaf bits per acre When population is heavy, spraying of water using power operated sprayer Spray of 1kg maida mixed with 5 litres of water and made upto 20 litres will remove the sooty mould To encourage activity of parasitoids, planting of banana or Annona @ 20 Nos
Rhinoceros Beetle	Removal and destroy of grubs in manure pits and application of *Metarrihizium anisopliae* @ $5x10^{11}/m^3$ Application of NSKE powder (50 g) + sand (100 g) in the crown region Installation of pheromone trap (Rhino lure) @ one /ha outside the coconut garden or Castor cake (1 kg) and Yeast (5 g) mixed with 5 litre of water for attraction of adults Installation of light trap @ one per acre during summer shower period

Table 1. Status of Insect Pest Infestation in Jolarpet Block, Tirupathur District

Date of Visit	Name of the farmer	Area	Villages	GPS Co-ordinates	Rhinoceros beetle (% incidence)	Rugose spiralling Whitefly complex (% incidence)	Black headed caterpillar (% incidence)
10.07.24	Mr. Vijayan	6 acres	Bethahallapalli	12.6394;78.5795	5	5	90
	Mr. Balaramareddy	8 acres	Bethahallapalli	12.6398;78.5796	10	5	80
	Mrs. Rani	2 acres	Chinnamottur	12.6256;78.5686	5	5	35
	Mr. Sivan	6 acres	Chinnamottur	12.6256;78.5686	5	5	70
	Mr. Prakasam	6 acres	C.M.Pudur	-	5	5	75

Conclusion

Large scale adoption and sensitization of biocontrol approach for higher production to coconut growers in major coconut growing blocks of Tirupathur district will pave way to improve the livelihood of coconut growers.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Fruit Cracking and Its Management in Pomegranate

S. Srividhya[1] and P. Thilagam[2]

[1]Horticultural College and Research Institute, Paiyur
[2]Agricultural Research Station, Virinjipuram

Introduction

The juicy pomegranate, a fruit from the Punicaceae family, is a major player in the world of commerce. India leads the pack in both the total area cultivated and the fruit produced! With over 2.7 lakh hectares dedicated to pomegranate cultivatioin and a whopping 30.88 lakh tonnes production, India boasts an impressive average yield of 6.9 tonnes per hectare.Nutritive value in 100 g arils provides 72 kcal of energy, 1.0 g protein, 16.6 g carbohydrate, 379 mg potassium, 13 mg calcium, 12 mg magnesium, 0.7 mg iron, 0.17 mg copper, 0.3 mg niacin and 7 mg vitamin C. Pomegranate is immense of medicinal uses which is a cure for diarrhoea, diabetes, blood pressure, leprosy, hemorrhages, bronchitis, dyspepsia and inflammation. Anti-allergic, anti-microbial and anti-carcinogenic. Wild pomegranate fruit is highly acidic containing citric, malic, oxalic, succinic and tartaric acids. Dried aril is called anardana which is used as souring agent in Indian cusine. The fruit is a luscious berry with several seeds within, each encasedina, juicy, mushy aril. The outer epidermal cells of the seed, which greatly lengthen in a radial direction, are the source from which the arils grow. The pomegranates are native to central Asia, they are highly adaptable to a variety of climates and soil types.

Fruit splitting, also known as cracking, is a big problem for pomegranate growers. It can significantly reduce the harvest and make the fruit less appealing to buyers. The fruit loses its market value and frequently turns into an unsafe food for humans to eat (Panwar *et al.*, 1994). Fruit cracking and sun scorching during the fruit's growth and development put a serious threat to the pomegranate industry, significantly reducing its commercial value and economic yield. Although splitting and cracking have been explained in a variety of ways, the term "cracking" is clearly associated with most fruits, including avocado, citrus, tomato, pomegranate, litchi, apple, sweet cherry, grape, plum, and pine. When a ripe fruit cracks, certain bacteria or fungus may infiltrate it. In Pomegranate fruit cracking is a common issue across all cultivating regions and various types throughout the world, while the severity of the issue varies according to weather, genetics, variety, fruit development, and cultural customs (Saad *et al.*, 1988).

Extent of Losses

Yield loss due to fruit cracking can exceed 65%, with cracked fruits being sweeter, having poor keeping quality, unfit for shipment, and prone to rotting (Malhotra *et al.*, 1983). This issue varies among varieties and is worse in harsh climates, with losses up to 65%–75% in arid regions (Prasad *et al.*, 2003). Singh *et al.* (2014) reported variability in fruit cracking from 18.3% to 62.6% in arid regions. Pant (1976)

ISSN : 3048 - 989X

found cracking rates of 63% in spring, 34% in winter, and 9.5% in the rainy season, with variations in rind thickness, fruit size, aril size, juice content, and total soluble solids. Economic losses range from 10% to 40%, sometimes reaching 70% (Pal *et al.*, 2017). Omima *et al.* (2014) noted that cracking reduces fruit marketing value by about 50%.

Factors for Fruit Cracking

Fruit cracking may be caused by low relative air humidity (RH), excessive evapo transpiration, water imbalance, and abrupt day-to-night temperature fluctuations during fruit development (Abd and Rahman, 2010). Additionally, inappropriate irrigation practices, environmental variables, and dietary deficiencies—particularly in boron, calcium, zinc, and potash—have been linked to it (Saei *et al.*, 2014). Causes associated with fruit cracking can be improper irrigation, environmental factors, and nutritional deficiency, especially boron, calcium, and potash. Besides, it is also reported to be associated with high evapo-transpiration, low humidity, water imbalance, and sharp temperature fluctuation in day and night during fruit growth and development. The cracking is more evident when the fruits are at maturity stage. No single factor can be advocated as efficient enough in controlling fruit cracking.

A) Soil moisture: One of the main causes of fruit cracking is soil moisture. Fruit cracking results from moisture stress followed by an abrupt increase in soil moisture content (by irrigation or rainfall)

B) Relative humidity: Because low humidity increases fruit surface evaporation, it intensifies cracking.

C) Rainfall: When fruit peels come into touch with rainwater or mist, they break down more quickly because the peel absorbs the water from the surface micropores, which increases internal turgor pressure and causes macrocracks on the fruit's surface.

D) Temperature: Variability between daytime and evening temperatures.

E) Hormonal factors: Fruit cracking is regulated in part by auxins, cytokinins, and ABA. Less auxin was present in the skin and seeds of the fractured Litchi fruits.

F) Nutritional status: It has been proposed that variations in the susceptibility of fruits on various trees, or even on the same tree, to cracking can be explained by the nutritional state of the tree and the fruit. Cracking in various fruits is linked to deficiencies in zinc, calcium, boron, and sulphur.

G) Chemical sprays: Fruit development has been seen to be distorted and cracked by lead arsenate and phosdrin spray. Cracking is brought on by herbicides and surfactants like Tween-20 that increases water absorption.

Management of Fruit Cracking

Arid and semi-arid regions receiving low annual rainfall below 1000 mm (preferable around 560 mm) with a long, hot and dry summer and mild winter are suitable for quality fruit production.To reduce early pomegranate fruit breaking, Singh *et al.* (1990) proposed a variety of cultural techniques, such as weekly watering, mulching with dried grass or farmyard manure, spraying with 0.005 or 0.002% boric acid, 1% KNO_3, or 1% $MgSO_4$. In comparison to the control treatment, Hegazi *et al.* (2014) found that fruit cracking was reduced to the lowest percentage in Manfaloty and Wonderfull pomegranate varieties when fruit bagging was applied, followed by 5% kaolin and spraying with GA_3 and $CaCl_2$. Spraying liquid paraffin at 1 % concentration at 15 days interval twice during June reduces fruit cracking.

Singh *et al.* (2017) reported that foliar application of borax (0.4%), zinc sulfate (0.5%), and kaolin (4%) with mulching of tree basin (black polythene sheet 150 µ) is more effective in minimizing fruit cracking rather than sprays alone. When under water stress, pomegranate fruit is applied foliar spraying with 3% and 1% calcium-boron, 6% kaolin, and 2 ml of humic acid. Fruit cracking percentage was positively impacted and fruit quality was enhanced by preharvest treatment of various growth regulators and mineral nutrients, such as Paclobutrazol, GA_3, NAA, $CaCl_2$, boric acid, and $ZnSO_4$, at the early stages of fruit growth in pomegranate trees. Different bagging techniques on off-season longan fruit revealed that the incidence of cracking was decreased by using black adhesive-bonded fabric bags with less than 10% light transmittance and white adhesive-bonded fabric bags with around 70% light transmittance. Regular irrigation to maintain soil moisture at desired level, spraying of calcium compounds or GA_3 at 120 ppm on young pomegranate fruits helps to minimize the fruit cracking. As cracking is a complex issue, it was observed during various studies correct nutrition with calcium, magnesium, boron, and zinc were very effective in reducing fruit splitting in various pomegranate cultivars.

References

Abd, I.E., and E.I. Rahman. 2010. Physiological studies on cracking phenomena of pomegranates. *J. Appl. Sci. Res*. 6:696–703.

Hegazi, A., N.R. Samra, E.E.T. El-Baz, B.M. Khalil, and M.S. Gawish. 2014. Improving fruit quality of Manfaloty and Wonderfull pomegranates by using bagging and some spray treatments with gibberellic acid, calcium chloride and kaolin. J. Plant Prod., Mansoura Univ 5(5):779–792.

Malhotra, V.K., H.N. Khajuria, and J.S. Jawanda. 1983. Studies on physico-chemical characteristics. 1-Physical characteristics. *Punjab Hort. J.* 23:153–157

Pal, R.K., N.V. Singh, and A. Maity. 2017. Pomegranate fruit cracking in dryland farming. *Curr. Sci*. 112:896–897.

Pant, T. 1976. Studies on the fruit cracking in pomegranate (Punica granatum L.) in variety Jodhpuri. *Udyanika* 2:29–35.

Panwar, S., Desai, U.T. and Choudhary, S.M. 1994. Effect of pruning on physiological disorder in pomegranate. *Annals of Arid Zone*, 33: 83-84.

Prasad, R.N., and G.J. Bankar. 2000. Evaluation of pomegranate cultivars under arid conditions. *Indian J. Hort*. 57:305–308.

Saad, F.A., M.A. Shaheen, and H.A. Tawfik. 1988. Anatomical study of cracking in pomegranate fruit. *Alex. J. Agric. Res*. 33(1):155–166.

Saei, H., M.M. Sharifani, A. Dehghanic, S. Esmaeil, and A. Vahid. 2014. Description of biomechanical forces and physiological parameters of fruit cracking in pomegranate. *Scientia Hortic*. 178:224–230. doi: 10.1016/j.scienta.2014.09.005.

Singh, R.P., Y.P. Sharma, and R.P. Awasthi. 1990. Influence of different cultural practices on premature fruit cracking of pomegranate. *Progressive Hort*. 22(1):92–96.

Singh, A.,U. Burman, A. Saxena, and P.R. Meghwal, 2017. Interactive effects of micronutrients, kaoline and mulching under drip irrigation system in managing fruit cracking of *INTERNATIONAL JOURNAL OF FRUIT SCIENCE* pomegranate (*Punica granatum* L.). ISHS,IV Int. Symp., Pomegranate and Minor Mediterranean Fruits, pp 16–19, Elche, Valancia, Spain.

TNAU Technology Capsule Against Fall Army Worm in Maize – A Success Story

P. Thilagam[1] and S. Srividhya[2]

[1]Agricultural Research Station, Virinjipuram
[2]Horticultural College and Research Institute, Paiyur

Maize, (*Zea mays*), also called **Indian corn** or **maize**, cereal plant of the grass family (Poaceae) and its edible grain. The domesticated crop originated in the Americas and is one of the most widely distributed of the world's food crops. Corn is used as livestock feed, as human food, as biofuel, and as raw material in industry. Maize (*Zea mays* L.) crop is cultivated in all districts of Tamil Nadu and also in Vellore district throughout all the seasons. Due to the recent invasion of fall armyworm, (*Spodoptera frugiperda*, J.E.Smith), the farmers were panic to go for maize cultivation. With the adoption of technology capsule, the farmer has registered lowest leaf, whorl, tassel and cob damage caused due to FAW also had direct relation in reducing the larval population. Due to technology interventions viz., border and intercrops there resulted in the increased activity of natural enemies viz., Coccinellids and spiders. The highest grain yield was recorded in the technology capsule (4200 kg/ha) with 44.8 per cent increase over farmers practice (2900 Kg/ha).

Key words: Fall armyworm, *Spodoptera frugiperda*, Maize, Technology capsule, Demonstration

Introduction

In the past couple of years, there arise few challenges towards maize cultivation due to alarming problem of the invasive insect, fall armyworm (FAW), *Spodoptera frugiperda* not only in Tamil Nadu all over India. The maize crop is cultivated in an area of about 1500 ha in Vellore district during all the three seasons *viz*., *kharif*, *rabi* and *summer*. In order to increase the area expansion and production of maize which is questionable due to the non-adoption of proper management practices to combat this insect pest. Hence to overcome the problem on technology adoption, under Tamil Nadu Irrigated Agriculture Modernization project Phase II operated at Agarmaru sub-basin intervention on Demonstration of FAW technology capsule was carried out during rabi season 2020-21 in the farmer field of Mr. K. Elango, Gollamanagalam village, Madhanur block, Vellore district, Tamil Nadu with an objective to reduction of FAW incidence with the adoption of technology capsule.

Demonstration of FAW Technology Capsule

The following technology capsule formulated by Department of Agricultural Entomology, Centre for Plant Protection Studies, Tamil Nadu Agricultural University, Coimbatore was adopted in the farmers field and non- adopted farmers practice were also mentioned in Table 1 towards the management of FAW.

Success of FAW Technology Capsule

The technology capsule adopted by the farmer resulted in the reduction of FAW as compared to the farmers practice (without technology capsule). With the adoption of technology capsule, the farmer has registered lower leaf, whorl, tassel and cob damage caused due to FAW also resulted in low larval population. Due to technology interventions viz., border and intercrops there resulted in the increased activity of natural enemies viz., Coccinellids and spiders. The pheromone trap catches were taken at weekly interval and recorded 6 adult male moths / week till 40 DAS.

Table 1: Technology Capsule Vs Farmers Practice

S.No.	Technology Capsule	Farmers Practice	S.No	Technology Capsule	Farmers Practice
1.	Deep ploughing	Normal ploughing	5.	Appliacation of neem cake (100 kg)	Not applied
2.	Seed treatment with thiamethoxam 30 FS (10 g/kg of seed)	Not treated	6.	Border crop: Sesamum	Not followed
3.	Inter crop: Black gram	Not followed	7.	Pheromone trap (5 Nos)	Not installed
4.	Spray of azadirachtin 1% 20 ml per 10 litres of water at 15-20 Days after sowing (DAS)	-	8.	Spray of Chlorantraniliprole 18.5SC 4 ml per 10 litres of water at 45 DAS	Spray of chlorpyriphos 30 ml / 10 litres of water with Jaggery

Table 2: Impact of Technology Capsule and Farmers Practice towards Fall Armyworm

Parameters	Technology Capsule	Farmers Practice
Leaf damage (%)	11.6	25.2
Whorl damage (%)	7.1	36.7
Tassel damage (%)	6.6	23.3
Cob damage (%)	6.6	26.6
Larval population (No. / plant)	0.71	1.55
Trap catches (Nos) (Mean /week)	6.0	-
Natural enemies (No./ Plant)	1.20	0.28
Harvest time damage (%)	3.3	23.3
Grain Yield (Kg/ha)	4200	2900
Benefit cost Ratio	2.30	1.20

The highest grain yield was recorded in the technology capsule (4200 kg/ha) with 44.8 per cent increase over farmers practice (2900 Kg/ha) (Table 2).

Demonstration Outcome

With the adoption of technology capsule, the farmer has registered lowest leaf, whorl, tassel and cob damage caused due to FAW which had positive relationship in reducing the larval population. Also, with the adoption of technology interventions *viz.*, border and intercrops there resulted in the increased activity of natural enemies *viz.*, Coccinellids and spiders. The adult male catches of fall armyworm at initial stages of crop growth had a positive impact on the grain yield. The highest grain yield was recorded in the technology capsule (4200 kg/ha) with 44.8 per cent increase over farmers practice (2900 Kg/ha).

Conclusion

Technology capsule adoption in maize has brought a significant positive impact in terms of damage and population reduction of fall armyworm in maize. Raising of border and intercrop has tremendously increased the activity of natural enemy population in the field thereby indirectly reducing the larval population. In general, and to be specific technology capsule adoption in maize is the need of the hour to combat FAW in the upcoming years.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Pulses Production: Its Status And Insect Biotic Constraints In India

P. Thilagam[1] and S. Srividhya[2]

[1]Agricultural Research Station, Virinjipuram
[2]Horticultural College and Research Institute, Paiyur

Introduction

Globally, India is the largest producer (25%), consumer (27%) and importer (14%) of pulses. Around 20% of the area is planted with food grains, and pulses produce 7-10% of all the food grains produced in the nation. Due to un favourable weather circumstances, the total amount of pulses produced in 2013-2014, which was 19.78 million tonnes, was decreased to 17.20 million tonnes.

Majority of Indians are vegetarians, pulses play animportant role in their diet as a protein alternative (22-24%). Pulses and cereals together make an ideal vegetarian diet with high biological value since they add proteins, vital aminoacids, vitamins, and minerals to the diet's basic cereals. Pulses have a significant role in nourishing the soil through biological nitrogen fixation and can be grown in a variety of soil types and climates. Additionally, pulses are used in intercropping, mixed cropping, and crop rotation, all of which contribute to the sustainability of farming systems. Chickpea and pigeonpea are the two most important pulse crops farmed in India, taking up collectively 53% of the total land used for growing pulses and producing more than 63% of it.

From the seedling stage to maturity and storage, pulses are extremely vulnerable to harm from insect pests. Pod borers and termites are the principal pests that harm pigeonpea and chickpea plants. The pigeonpea crop, which is typically planted at the start of the monsoonand matures between November and March, is damaged by insect pests throughout both the rainy and post-rainy (rabi) seasons. More than 300 different insect and mite species have been found to infest pulses in India, including pigeonpea, chickpea, 45 different types of mungbean, and urdbean. Some of the important species are rare, while others are common.The losses brought on by pests differ from one agro-climatic zones to another and even within a zone between local regions. Estimates of crop losses are frequently inaccurate and result in false impression. The report is frequently based on the percentage of pod damage in crops including peas, pigeonpea, greengram, and blackgram. Therefore, even if just one grain in a pod is determined to be damaged, the entire pod is still considered damaged even if part of the grains is still safe to eat. Therefore, rather than on a pod basis, the damage should be calculated. Pigeonpea pod borer complex has regularly been blamed for 30–50% crop losses in both early and late-maturing cultivars. The losses in chickpea, greengram and blackgram are projected to be between 7 and 15% and 20% annually, respectively.

Due to changes in cropping practices, insecticide treatment patterns and the introduction of high-yielding varieties, the insect pest complex of pulses has undergone a significant transformation during the past 20 years. The principal insect pests, which have become increasingly difficult to control due to their development of pesticide resistance, resurgence,and secondary outbreak due to the indiscriminate use of insecticides, pose a serious dangerto the production of pulse crops. Therefore, thorough knowledge of the insect pest complex, their status and temporal correlation with crop, losses, and type of damage is of utmost relevance in order to develop pest control solutions that are economically viable, ecologically sound, and socially acceptable For effective management of insect pests in different pulses ecosystem the following integrated pest management (IPM) practices has to be followed.

Table 1: Major insect pests that contribute for yield loss in Chickpea

Scientific Name	Common Name	Order	Family
Helicoverpa armigera (Hubner)	Gram podborer	Lepidoptera	Noctuidae
Autographa nigrisigna (Walker)	Semilooper	Lepidoptera	Noctuidae
Agrotis ipsilon (Hufnagel)	Cutworm	Lepidoptera	Noctuidae
Odontotermes obesus (Rambur)	Termite	Isoptera	Termitidae

Table 2: Major insect pests that contribute for yield loss in Pigeonpea

Scientific Name	Common Name	Order	Family
Helicoverpa armigera (Hubner)	Gram podborer	Lepidoptera	Noctuidae
Melanagromyzaobtusa (Malloch)	Pod fly	Diptera	Agromyzidae
Maruca vitrata (Geyer)	Spotted podborer	Lepidoptera	Pyralidae
Exelastis atomosa (Wals.)	Plume moth	Lepidoptera	Pterophoridae
Etiella zinckenella (Treit.)	Spiny podborer	Lepidoptera	Pyralidae
Lampides boeticus (Linn.)	Blue butterfly	Lepidoptera	Lycaenidae
Clavigralla gibbosa (Spinola)	Pod bug	Hemiptera	Coreidae
Apion clavipes (G.)	Pod weevil	Coleoptera	Curculionidae
Mylabris pustulata (Thurnberg)	Blister beetle	Coleoptera	Meloidae
Callosobruchus spp. (L.)	Bruchids	Coleoptera	Bruchidae

Table 3: Major insect pests that contribute for yield loss in Green gram and Black gram

Scientific Name	Common Name	Order	Family
Bemisia tabaci (Gennadius)	Whitefly	Hemiptera	Aleyrodidae
Ophiomyia phaseoli (Tryon)	Stem fly	Agromyzidae	Diptera
Madurasia obscurella (Jacoby)	Galerucidbeetle	Coleoptera	Chrysomelidae
Spilosoma obliqua (Walker)	Bihar hairy caterpillar	Lepidoptera	Arctiidae
Amsacta moorei (Butler)	Red hairy caterpillar	Lepidoptera	Arctiidae
Spodoptera litura (Fab.)	Tobacco caterpillar	Lepidoptera	Noctuidae
Maruca vitrata (Geyer)	Spotted podborer	Lepidoptera	Pyralidae
Megalurothripsdistalis (Karny)	Bean thrips	Thysanoptera	Thripidae
Clavigralla gibbosa (Spinola)	Pod bug	Hemiptera	Coreidae

For effective management of insect pests in different pulses ecosystem the following integrated pest management (IPM) practices has to be followed.

IPM in Chickpea

All available management techniques are used in a complementary way in integrated pest management (IPM). All farmers must simultaneouslyplant less vulnerable cultivars at the best time for *H. armigera* management and they should use relatively safer insecticides based on economic threshold levels (ETL).

Before Sowing

- Deep summer ploughing

At Sowing

- Timely sowing
- Selection of resistant/tolerant varieties
- Use of trap crops marigold/intercropping with coriander/mustard

Standing Crop

- Regular field scouting
- Installation of pheromone trap at 20–25/ha
- Installation of bird perches at 35–40/ha
- At ETL (one larva/m row) or three to four moths trapped per night in four to five successive nights, first spray of NSKE (5%), second spay of HaNPV at 250 LE (larval equivalent), third need-based spray of relatively ecofriendly insecticide, i.e., spinosad 0.02% (0.4 ml/l water).

IPM in Pigeonpea

Before Sowing:

- Deep summer ploughing
- Application of neem seed powder at 50 kg/ha or neem cake at 500 kg/ha in nematode- infested soils

At Sowing:

- Timely sowing and sowing on ridges
- Selection of disease-resistant/disease-tolerant varieties
- Seed treatment with carbendazim + thiram (at 1 + 2 g/kg) or Trichoderma and carboxin (10 g + 1 g/kg)
- Seed treatment with imidacloprid 70WS at 3 g/kg
- Seed treatment with carbosulfan at 3 g/kg seed in nematode-infested soils
- Intercropping with sorghum, sesamum, finger millet, etc.

Standing Crop

- Intensive monitoring of crop
- Spraying of metalaxyl at 1 gm/l water or mancozeb 2.5 gm/l water, if phytophthora blight appears
- Installation of pheromone trap at 20–25/ha and bird perches at 35–40/ha
- Removal of diseased plants
- Handpicking and jarring of insects
- Spraying of insecticides like dimethoate 30 EC (0.03%) or spinosad 45 SC (0.02%), indoxacarb 14.5 SC at 60 g a.i./ha or emamectin benzoate 5WSG at 11 g a.i./ha

IPM in Green Gram and Black Gram

Before Sowing:

- Soil application: Phorate/carbofuran at 1 kg a.i./ha
- Seed treatment:
- Imidacloprid 70 WS at 3 g/kg seed
- Imidacloprid 17.8 SL at 3 ml/kg seed
- Dimethoate 30 EC at 5 ml/kg seed

After Sowing:

- Foliar spray: 30–35 days after sowing for the control of thrips
- Dimethoate 30 EC at 2.0 ml/lit
- Imidacloprid 17.8 SL at 0.2–0.4 ml/lit
- Triazofos 40 EC at 1.5 ml/lit

In Standing Crop:

- Removal and destruction of MYMV-infested plants
- Collection and destruction of egg masses and skeletonized leaves along with early instar larvae of hairy caterpillar and Spodoptera litura
- Deploying of light traps or bonfire against hairy caterpillar moth
- Need-based spray of any of the following insecticides: Quinalphos 25EC at 2.0 ml/lit Chlorpyrifos 20 EC at 2.5 ml/lit (blister beetle) Phosalone 35EC at 2.5 ml/lit.

ISSN : 3048 - 989X

Major insect pests of pulse crops (Chick pea, Pigeonpea, Greengram and Blackgram)

Spotted Pod Borer

Gram Pod Borer

Whitefly

Podfly

Blister Beetle

Blue Butterfly

Pod Bug

Plume Moth

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Thrips Infestation in Mango Orchards of Krishnagiri District

P. Thilagam[1] and S. Srividhya[2]

[1]Agricultural Research Station, Virinjipuram
[2]Horticultural College and Research Institute, Paiyur

Introduction

Krishnagiri District is known for its mango cultivation and cultivated in an area of about 40,000 ha. In the recent years, mango cultivation is being threatened by various insect species. Of late, thrips species causes substantial crop losses by feeding on the petals, anthers, pollen and floral nectaries and ovipositing in the panicles which leads to discoloration and reduced vigour of the panicles (Kirk, 1997). They also feed and oviposit on the pericarp of the fruits, which causes bronzing of the fruit surface and severe infestations often result in the cracking of the fruit skin. These cosmetic injuries reduce the economic value of mango fruits and their marketability Recently, thrips insect has created havoc in most of the mango growing areas of northern plains. Approximately, 50 per cent of damaged fruits were recorded in severely affected orchards. There are twenty thrips species reported to be inflicting mangoes. Among them, *Scirtothrips dorsalis, Rhipiphorothrips cruentatus* and *Thrips hawaiiensis* are found to be predominant in mango ecosystem. The abundance of thrips was high during the flowering period of the dry season and decreased during the flowering period of the rainy season. The later period coincided with decreased temperature and increased relative humidity. Percent of adult emergence from the soil was lower in the rainy season than recorded in the dry season. Fifteen thrips species were recorded associated with mango trees in South Africa. Thirteen species were identified from the flowers, five from the leaves and three from the fruits (Grove *et al*., 2001). Four species of thrips were collected from mango inflorescence, *Thrips palmi* was observed to be dominant followed by *T. hawaiensis* (Krishnamoorthy and Ganga visalakshi, 2012). The nymphs and adults lacerate epidermis of tender leaves, flower buds, flowers, inflorescence ratches and fruits.

Status of Thrips Infestation in Mango in Major Blocks of Krishnagiri District

Survey on thrips infestation in major blocks viz., Kaveripattinam, Mathur and bargur blocks of Krishnagiri district was made during the months of March and April 2023 which coincides with the flowering and initial fruiting phase (Table 1).

Approximately, 30-50 per cent of damaged fruits were recorded in severely affected mango fields. Some of the farmers practiced off-season mango cultivation and followed spraying of combination of insecticides, fungicides and plant growth regulators during December month at 20 days interval. A total of three applications of insecticide combinations were given, even though, the thrips damage was high (60% damage in fruits) and flowering was affected badly due to thrips and in severe cases, trees were found with minimum fruits per tree. In case of nursery field maintained, severe curling of upper leaves with stunted growth of trees were also recorded with 50 – 65 thrips per leaf.

Based on the survey of the affected fields, the farmers were sensitized on the biology of thrips, which is a pre-requisite for management of thrips at an early stage of infestation.

ISSN : 3048 - 989X

Table 1. Survey of Mango Gardens in Major Blocks of Krishnagiri District

S.No	Blocks	Varieties grown	Problems identified
1.	Kaveripattinam	Alphonso Neelum Offseason Bangalora	Mango thrips damage (50 %) Severe Hoppers damage with sooty mould growth on the entire leaf Anthracnose Poor nutrition
2.	Kaveripattinam	Bangalora	Thrips damage in fruits (40- 50 %). Farmer sprayed thrice with Imidacloprid + lambda cyhalothrin + MN + Wettable sulphur > Thiamethoxam + Fipronil + Sea weed extract + Wettable sulphur > Imidacloprid + Gypcel+ Profenophos + Cyhalothrin
3.	Kaveripattinam	Neelum	Mango thrips damage (50 %) Fruit size small Brownish lesions on fruits
4.	Mathur	Bangalora	Mango thrips damage (30-40 %) Fruit size small Brownish lesions on fruits
5.	Mathur	Bangalora	Mango thrips damage (30-40 %) Fruit size small Brownish lesions on fruits
6.	Mathur	Bangalora	Mango thrips damage (40-60 %) Fruit size small Brownish lesions on fruits
7.	Mathur	Bangalora Neelum	Mango thrips damage (30-50 %) Reduced fruit lesions Brownish lesions on fruits
8.	Bargur	Mango nursery Panchakalasa Kalepad Sendura Bangalora Imampasand Neelum Mallika Chakarakutti	Thrips population : 50 - 65 Nos/leaf Imidacloprid and thiamethoxam were applied

Biology

The life cycle consists of five stages: egg, larval, prepupal, pupal and adult. Gravid females insert the eggs inside plant tissues including leaves, buds, inflorescence and fruits. The eggs are hatched between two to seven days. The larval stage consists of 2 instars that feed and develop on the leaves, flowers and fruits. The two larval stages completed in eight to ten days and the pupal stage lasts for 2-3 days. The prepupal and pupal stages often complete their development on the ground, but sometimes pupation can also take place on the plant and plant debris. The adults are weak fliers, usually taking short flights from leaf to leaf or plant to plant. Thrips get spread over large distance by wind. The total lifecycle of thrips on mango varies from 15 to 20 days depending on the environmental conditions. Thrips population are low in winter whereas they reach their peak in summer. On mango, thrips infestation starts with the new flushes and panicle emergence during the 13 to 22nd standard meteorological weeks (last week of March to last week of May). The larval and adults stages are the damaging stages. They damage the mango young leaves, growing buds, inflorescence, flowers, immature and developing fruits by lacerating and sucking the sap from the tissues. This causes silvery or brown patches on the affected parts where the plant cells are destroyed. As a result of its damage, curling up of leaves and wilting of inflorescence were also recorded. In severe cases affected fruits become rusty in appearance. This pest can damage the entire new growth, if it is not treated properly.

Symptoms of Damage

The nymphs and adults lacerate epidermis of tender leaves, flower buds, flowers, inflorescence ratches and fruits They damage the mango young leaves, growing buds, inflorescence, flowers, immature and developing fruits by lacerating and sucking the sap from the tissues. This causes silvery or brown patches on the affected parts where the plant cells are destroyed. As a result of its damage, curling up of leaves and wilting of inflorescence were also recorded. In severe cases affected fruits become rusty in appearance. This pest can damage the entire new growth, if it is not treated properly.

Integrated pest Management

Monitoring the population levels of thrips is important for successful pest management. Commercially available blue or yellow sticky traps can be used to monitor the population densities of adult thrips. The traps should be checked at weekly intervals and the average number of thrips per trap be recorded.

Sanitation is the first and most important step in implementing an effective pest management programme. Effective sanitation will reduce or even eliminate thrips as a pest problem. Chemical control of thrips is very difficult. They are resistant to most pesticides and feed deep within the flower or on developing leaves. This makes them a difficult target for insecticides, so thorough coverage is essential.: Begin applications early, before thrips population grow too much.

Thrips are more easily managed when population levels are low. Although it is important to rotate chemical classes, use only one chemical class for the duration of the thrips' life cycle. Apply pesticides during early morning or late afternoon, when flight activity of thrips is at its peak. This increases exposure of the thrips to the pesticides.

Neem based pesticides control young nymphs effectively, inhibit growth of older nymphs and reduce the egg-laying ability of adults.

Spaying of Neem Seed Kernel Extract (5%) or Neem oil (2%) reduce the initial stages of the thrips effectively.

Promotion of natural enemies *viz*., predatory thrips, predatory mites (e.g. *Amblyseius* spp.) anthocorid bugs or minute pirate bugs (*Orius* spp.), ground beetles, lacewings, hoverflies, lady bird beetle and spiders in the orchard by conserving them in orchard will reduce the pest attack considerably.

If the infestation is severe, spraying of insecticides like thiamethoxam 25% WG (0.3 g / l) or Imidacloprid 17.8% SL (0.3 ml / l) or Spinosad 45%SC (0.4 g/l) or Tolfenpyrad 15 % EC (1.5 ml/l).

References

Krishnamoorthy, A and P.N. Ganga Visalakshi.2012. Record of thrips on mango. J. Hortl. Sci. Vol. 7(1):110-111.

Kirk WDJ. 1997. Feeding, pp. 119-174. In Lewis, T. (ed.), Thrips as Crop Pests. CAB International, Wallingford.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Microbiome for A Sustainable Tomorrow and One-Health

Sugitha Thankappan[1], Asish K. Binodh[2] and B. Jeberlin Prabina[3]

[1]School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore
[2]Department of Genetic and Plant Breeding, Tamil Nadu Agricultural University, Coimbatore
[3]Agricultural College and Research Institute, Killikulam, Tuticorin Dt

"Microbes, including bacteria, fungi, and other microorganisms, play a crucial role in maintaining soil health and directly impact crop yield through their intricate interactions with plant roots. These microbes contribute to nutrient cycling, disease suppression, and growth promotion, offering sustainable alternatives to chemical fertilizers and pesticides. Recent research has identified several promising microbial species, such as mycorrhizal fungi, plant growth-promoting bacteria (PGPB), and biocontrol agents, which hold significant potential for improving crop productivity and contributing to global food security. This review discusses key mechanisms through which microbes promote plant growth and induce systemic tolerance, such as root architecture modification, phytohormone production, reduction of ethylene stress via ACC deaminase, microbial volatile organic compounds (mVOCs)-induced systemic tolerance, and exopolysaccharide (EPS) production. Despite the potential of microbial technologies, challenges in translating laboratory findings to large-scale field applications persist, due to factors like inconsistent results across studies and variations in climatic and edaphic conditions. Emerging solutions, including advanced technologies like microfluidics-based platforms, the introduction of beneficial microbes into plant seeds, the development of microbial consortia, and breeding for 'microbe-optimized plants,' are being explored to overcome these challenges. Case studies highlight the success of various microbial interventions, including plant growth-promoting fungi (PGPF), bacteriophage-mediated biocontrol, microbial consortia for enhanced nutrient use efficiency, and the application of mycorrhizal fungi. These findings underscore the potential of integrating microbial technologies in sustainable agriculture, aligning with Sustainable Development Goals (SDGs) such as zero hunger (SDG 2), clean water and sanitation (SDG 6), industry, innovation, and infrastructure (SDG 9), climate action (SDG 13), and life on land (SDG 15), to enhance crop yields, ensure food security, and promote environmental sustainability".

Introduction

Microbes play a crucial role in maintaining soil health and directly impact crop yield. These microscopic organisms, including bacteria, fungi, and other microorganisms, form complex relationships with plant roots and contribute to nutrient cycling, disease suppression, and plant growth promotion. By harnessing the power of beneficial microbes, farmers and researchers can develop sustainable agricultural practices that enhance crop productivity while reducing the reliance on chemical fertilizers and pesticides. Recent research has identified several promising microbial species, such as mycorrhizal fungi, plant growth-promoting bacteria, and biocontrol agents, which have the potential to significantly improve crop yields and contribute to global food security. As our understanding of these microbial interactions continues to grow, we can expect further advancements in the field of microbial agriculture, leading to more environmentally friendly and efficient sustainable farming methods.

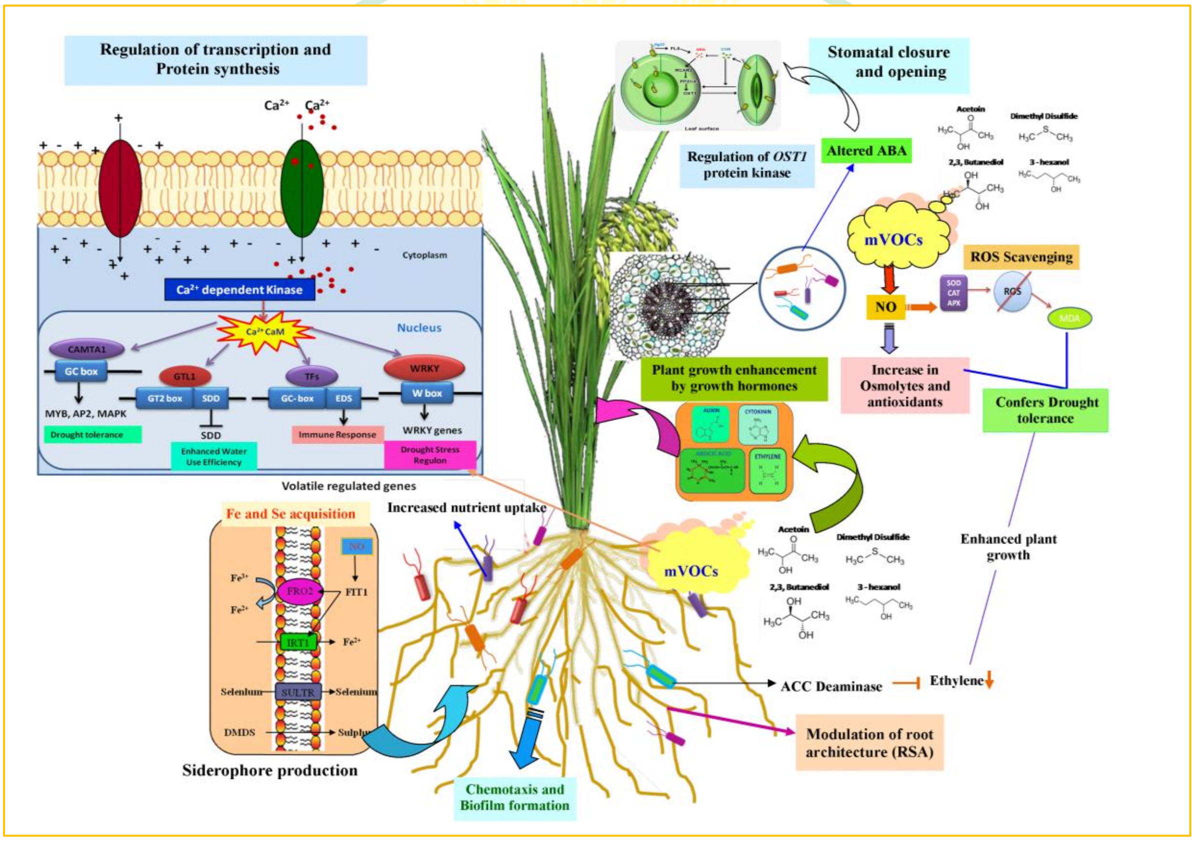
ISSN : 3048 - 989X

Sustainable Development Goals

Sustainable Development Goals (SDGs) set forth by the United Nations emphasize the importance of addressing global challenges such as zero hunger (SDG 2), no poverty (SDG 1), and good health and well-being (SDG 3). To meet the food requirements for a rapidly growing global population, it is crucial to enhance agricultural productivity while ensuring environmental sustainability and food security. Conventional intensive agricultural practices have led to soil degradation, loss of biodiversity, and negative environmental impacts, necessitating the development of alternative, sustainable methods for crop production. One such approach involves harnessing the potential of plant-associated microbiomes to improve crop growth, nutrient use efficiency, and disease resistance.

Unleashing the Power of Microbes: Boosting Crop Yields and Enhancing Soil Health

Microbes play a vital role in promoting plant growth and health. They can increase crop yields, improve nutrient use efficiency, and enhance biotic and abiotic stress tolerance. By fostering beneficial plant-microbiome interactions, it is possible to achieve sustainable crop production and contribute to the achievement of various SDGs, including SDG 2, 6, 9, 13, and 15.



Mechanisms of microbe mediated plant growth promotion and induced systemic tolerance (adopted from Sugitha thankappan et al., 2023)

The possible plant-associated bacteria-induced stress resilience mechanism includes: 1) Root architecture modification, 2) phyto-hormones like gibberellic acid, cytokinin, auxins and abscisic acid [ABA], 3) ACC deaminase to reduce the level of ethylene stress, 4) microbial volatile organic compounds (mVOCs) induced systemic tolerance, 5) exopolysaccharides (EPS)

Technical Challenges and Emerging Solutions

Despite the potential of microbial technologies, the translation of laboratory findings to large-scale field applications has been limited. Several factors contribute to this, including inconsistent results between studies, variations in climatic and edaphic conditions, and the complexity of microbe-plant-soil interactions. To overcome these challenges, researchers are employing innovative technologies and strategies.

1. **Advanced Technologies for Understanding Microbiome Interactions**: New technologies, such as microfluidics-based platforms, are being developed to study multitrophic plant-microbiome interactions under controlled and real-world conditions. These tools can help researchers better understand the factors that influence the efficacy of microbial products in field settings, ultimately leading to improved application techniques and formulations.
2. **Introducing Beneficial Microbes into Plant Seeds:** A promising approach to enhance the colonization and survival potential of inoculated strains is to introduce beneficial bacteria into progeny seeds during flowering. This method can introduce beneficial traits within one generation and offers several advantages over conventional application techniques.
3. **Development of Microbial Consortia:** The use of consortia, or communities of multiple compatible beneficial microbes, may improve the chances of survival and beneficial effects on the host plant compared to single-strain formulations. Systematic isolation procedures can be employed to capture the majority of species in natural rhizosphere and phyllosphere communities, leading to the development of synthetic microbial communities that promote plant performance.
4. **Breeding 'Microbe-Optimized Plants'**: Genotypic and phenotypic variations in plants select for different microbiomes, suggesting that the ability of a plant to support a beneficial microbiome is a plant trait under selection. Crop breeding programs have yet to incorporate the selection of beneficial plant-microbe interactions to breed 'microbe-optimized plants'. Genetic engineering and plant breeding can enable the generation of such plants that produce the right exudates and volatiles to attract and maintain beneficial microbes at the right time and location.

Case Studies

In recent years, research on the role of tiny microbes in enhancing crop yields has gained significant momentum and fascinated scientists. Numerous studies have explored the potential of these microorganisms in promoting plant growth, nutrient use efficiency, and disease resistance. Some of the latest research findings in this area are discussed below.

1. **Plant Growth-Promoting Fungi (PGPF):** A study published in Nature Communications in 2021 revealed the potential of plant growth-promoting fungi (PGPF) in improving crop yields. Researchers found that PGPF can enhance plant growth and nutrient uptake by forming symbiotic relationships with plant roots, leading to increased crop productivity without the need for chemical fertilizers. The study highlights the potential of PGPF as a sustainable alternative to conventional agricultural practices.
2. **Bacteriophage-mediated Biocontrol:** A 2020 study published in Frontiers in Microbiology explored the use of bacteriophages, or viruses that infect bacteria, as a biocontrol agent against plant pathogens. The researchers demonstrated that phage-mediated control of bacterial pathogens can significantly reduce disease incidence and increase crop yields. This approach offers a more sustainable and

environmentally friendly alternative to chemical pesticides.

3. **Microbial Consortia for Enhanced Nutrient Use Efficiency:** A 2019 study in the journal Nature Plants revealed that combining multiple microbial species can lead to improved nutrient use efficiency in plants. The researchers found that a microbial consortium, consisting of bacteria and fungi, could enhance the uptake of essential nutrients like nitrogen and phosphorus, resulting in increased crop yields. This approach has the potential to reduce the reliance on chemical fertilizers and promote sustainable agriculture.
4. **Metagenomics and Machine Learning for Microbial Discovery:** In a 2020 study published in Nature Biotechnology, researchers used metagenomics and machine learning techniques to identify novel plant growth-promoting microbes. This approach allowed them to discover new microbial strains with the potential to improve crop yields. The study highlights the power of integrating advanced technologies in the search for beneficial microbes.
5. **Microbial Communities in Organic Agriculture:** A 2021 review article in the journal Soil Systems explored the role of microbial communities in organic agriculture. The authors concluded that organic farming practices can promote the growth and activity of beneficial microbes, leading to improved soil health, nutrient cycling, and crop productivity. This research emphasizes the importance of adopting sustainable agricultural practices that support diverse and beneficial microbial communities.
6. **Mycorrhizal Fungi:** Mycorrhizal fungi, such as *Glomus* species, have been widely studied for their ability to enhance plant growth and nutrient uptake. These fungi form symbiotic relationships with plant roots, increasing the plants' access to essential nutrients like phosphorus and nitrogen. A 2021 study in the journal Soil Systems found that the application of mycorrhizal fungi significantly improved the growth and yield of various crops, including wheat, maize, and beans.
7. **Plant Growth-Promoting Bacteria (PGPB):** PGPB, such as species of Bacillus, Pseudomonas, and *Azospirillum*, have been shown to promote plant growth and improve nutrient use efficiency. A 2020 study in the journal Frontiers in Microbiology identified novel PGPB strains that could enhance the growth of rice and wheat under greenhouse conditions.
8. ***Bacillus amyloliquefaciens* FZB24**: This bacterium has been extensively studied for its plant growth-promoting and biocontrol properties. A 2019 review in the journal Frontiers in Microbiology highlighted the ability of *B. amyloliquefaciens* FZB24 to improve crop yields by producing plant hormones, solubilizing phosphorus, and suppressing plant pathogens.
9. ***Streptomyces lydicus* WYEC 108**: This actinomycete bacterium has been found to enhance plant growth and nutrient uptake by producing siderophores, which help in the solubilization and uptake of iron. A 2019 study in the journal Soil Biology and Biochemistry demonstrated that S. lydicus WYEC 108 improved the growth and yield of various crops, including tomatoes, peppers, and lettuce.
10. ***Pantoea agglomerans*:** This bacterium has been reported to promote plant growth and protect plants from pathogens. A 2020 study in the journal Frontiers in Plant Science found that *P. agglomerans* could enhance the growth and yield of cucumber plants by producing plant growth-promoting substances and suppressing the growth of pathogenic fungi.

Conclusion

Harnessing the potential of plant-associated microbiomes offers a promising approach to sustainable agriculture. By overcoming technical challenges and employing innovative strategies, researchers can develop improved and advanced methods for crop production that contribute to global food security and environmental sustainability. Continued research and collaboration between biologists, microbiologists, and agronomists will be essential to unlock the full potential of plant-microbiome interactions and achieve the United Nations' Sustainable Development Goals.

References

Miller, O.J., El, A., Mangeat, T., Baret, J., Frenz, L., El, B., Mayot, E., Samuels,M.L., Rooney, E.K., Dieu, P., et al. (2011). High-resolution dose-response Screening using droplet-based microfluidics. Proc. Natl. Acad. Sci. USA109, 1–6.

Hsu, R. H., Clark, R. L., Tan, J. W., Ahn, J. C., Gupta, S., Romero, P. A., & Venturelli, O. S. (2019). Microbial interaction network inference in microfluidic droplets. Cell Systems, 9(3), 229-242. E4.

Doi, R. H., & Kosugi, A. (2004). Cellulosomes: plant-cell-wall-degrading enzyme complexes. Nature Reviews Microbiology, 2(7), 541-551.

Thakkar, A., & Saraf, M. (2015). Development of microbial consortia as a biocontrol agent for effective management of fungal diseases in Glycine max L. Archives of Phytopathology and Plant Protection, 48(6), 459-474.

De Mandal, S., Sonali, S., Singh, S., Hussain, K., & Hussain, T. (2021). Plant–microbe association for mutual benefits for plant growth and soil health. In S. De Mandal, S. Sonali, S. Singh, K. Hussain, & T. Hussain (Eds.), Advances in Plant and Soil Science (pp. 95-121). Publisher.

Clavijo-Coppens, F., Torres-Barceló, C., Ansaldi, M., Taveau, N., & Costechareyre, D. (2022). Phage-mediated biocontrol against plant pathogenic bacteria: Recent advances and prospects in plant protection. Biocontrol of Plant Disease: Recent Advances and Prospects in Plant Protection, 173.

Berg, S., Dennis, P. G., Paungfoo-Lonhienne, C., Anderson, J., Robinson, N., Brackin, R., Royle, A., DiBella, L., & Schmidt, S. (2020). Effects of commercial microbial biostimulants on soil and root microbial communities and sugarcane yield. Biology and Fertility of Soils, 56, 565–580.

Dai, Z., Liu, G., Chen, H., Chen, C., Wang, J., Ai, S., Wei, D., Li, D., Ma, B., Tang, C., Brookes, P. C., & Xu, J. (2020). Long-term nutrient inputs shift soil microbial functional profiles of phosphorus cycling in diverse agroecosystems. The ISME Journal, 14, 757–770.

Khan, M. S., Zaidi, A., and Ahmad, E. (2014). "Mechanism of phosphate solubilization and physiological functions of phosphate-solubilizing microorganisms," in Phosphate solubilizing microorganisms, eds M. Khan, A. Zaidi, and J. Musarrat (Cham: Springer), 31–62.

Kumar, A., Maurya, B. R., and Raghuwanshi, R. (2015). Characterization of bacterial strains and their impact on plant growth promotion and yield of wheat and microbial populations of soil. Afr. J. Agric. Res. 10, 1367–1375.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Bridging the Gap: How Agronomy and Agro-Meteorology Drive Climate-Resilient and Sustainable Farming

Sourav Mandal[1] and Ravita[2]*

M.Sc. Research Scholar, Department of Agronomy
M.Sc. Research Scholar, Department of Agricultural Meteorology
Odisha University of Agriculture and Technology, Bhubaneswar 751 003
***E-mail: ravitafoujdar171@gmail.com**

"The twin fields of agronomy and agro-meteorology hold the key to addressing the challenges of modern agriculture, particularly in the context of climate change and sustainability. Agronomy, with its focus on crop production and soil management, complements agro-meteorology's expertise in understanding weather patterns and their impact on agriculture. Together, these disciplines provide a scientific basis for climate-resilient and sustainable farming practices. This article explores their interplay, emphasizing the integration of weather-based advisories, precision agriculture, and sustainable soil and water management to mitigate the adverse impacts of climate variability. By leveraging these synergies, farmers can adopt adaptive practices that ensure food security while safeguarding natural resources for future generations."

Introduction

The 21st century has witnessed unprecedented challenges in agriculture, driven largely by climate change, population growth, and the need for sustainable resource management. Erratic weather patterns, frequent droughts, floods, and rising temperatures have compounded the difficulties faced by farmers worldwide. At the same time, agriculture must evolve to meet the growing global demand for food, feed, and fiber.

Agronomy and agro-meteorology offer solutions to these intertwined challenges. Agronomy focuses on optimizing crop production through better soil, water, and crop management practices. Agro-meteorology, on the other hand, studies the interactions between meteorological phenomena and agricultural activities, enabling farmers to adapt to climatic uncertainties. When integrated, these disciplines provide a roadmap for developing farming systems that are both climate-resilient and environmentally sustainable.

This article delves into the pivotal role of agronomy and agro-meteorology in addressing the dual imperatives of resilience and sustainability. It examines their contributions to precision agriculture, soil health, water management, and crop improvement, ultimately advocating for a science-driven approach to modern farming.

The Role of Agronomy in Sustainable Farming

Agronomy, as a cornerstone of agricultural science, is indispensable for achieving sustainable farming. Its primary goal is to enhance crop productivity while maintaining or improving soil and ecosystem health. Agronomic practices are evolving to meet the demands of modern agriculture, incorporating innovative technologies and strategies to address pressing challenges.

1. Soil Health Management:

- Soil is the foundation of agriculture, and its health directly influences crop yields and sustainability. Agronomic practices such as crop rotation, intercropping, and the use of cover crops improve soil structure, enhance organic matter, and reduce erosion.
- Conservation tillage techniques minimize soil disturbance, preserving its microbial

diversity and structure. Non-puddled mechanical transplanting, for instance, reduces energy inputs and enhances soil health, as evidenced in research on rice systems.

2. Nutrient Management:

- Site-specific nutrient management (SSNM) optimizes fertilizer use, ensuring crops receive the right amount of nutrients at the right time. This reduces environmental pollution and increases nutrient use efficiency.
- Integration of organic amendments, such as compost and biochar, enhances nutrient cycling while reducing dependency on synthetic fertilizers.

3. Water Use Efficiency:

- Agronomic innovations such as alternate wetting and drying (AWD) in rice cultivation significantly reduce water consumption without compromising yields.
- Drip and sprinkler irrigation systems, guided by soil moisture sensors, ensure precise water application, reducing wastage.

4. Crop Diversification and Intensification:

- Diversifying cropping systems with pulses, oilseeds, and millets not only enhances income but also improves soil fertility through biological nitrogen fixation.
- Integrated farming systems, combining crops, livestock, and aquaculture, maximize resource use efficiency and diversify farm incomes.

Agro-Meteorology: Adapting to Climatic Uncertainties

Agro-meteorology bridges the gap between atmospheric science and agriculture, enabling farmers to adapt to climate variability and mitigate risks. Its role in sustainable farming is multi-faceted:

1. Weather Forecasting and Advisory Services:

- Short- and medium-range weather forecasts guide farmers in making timely decisions regarding sowing, irrigation, and pest management.
- Agro-advisory services, based on real-time weather data, empower farmers with actionable insights to mitigate risks and enhance productivity.

2. Climate-Smart Agriculture:

- Agro-meteorology supports the development of climate-resilient crops through modeling and simulation of future climate scenarios.
- Techniques such as crop modeling help predict growth stages, yield potential, and water requirements under varying climatic conditions.

3. Early Warning Systems:

- Early warnings for extreme weather events such as cyclones, hailstorms, and frost enable farmers to protect crops and livestock.
- Heat and drought stress indices inform strategic interventions, such as shifting planting dates or selecting drought-tolerant crop varieties.

4. Microclimate Management:

- Modifying the local microclimate through practices like agroforestry, mulching, and windbreaks enhances resilience to temperature extremes and wind erosion.

Synergies Between Agronomy and Agro-Meteorology

The intersection of agronomy and agro-meteorology creates a robust framework for sustainable and climate-resilient farming. By combining their strengths, these disciplines address challenges holistically:

1. Precision Agriculture:

- Integrating agro-meteorological data with precision agronomic practices optimizes inputs like water, fertilizers, and pesticides. This reduces costs, minimizes environmental impacts, and maximizes yields.

- Remote sensing and GIS technologies enable real-time monitoring of crop health and soil conditions, ensuring targeted interventions.

2. **Sustainable Soil and Water Management:**

- Agro-meteorological insights inform irrigation scheduling, reducing water wastage and enhancing efficiency.
- Agronomic practices like contour farming and terracing are tailored to local climatic conditions to prevent soil erosion and water loss.

3. **Resilient Crop Systems:**

- Developing cropping systems suited to local climatic conditions ensures stability in production despite weather variability.
- Combining traditional knowledge with modern science, such as the use of indigenous drought-resistant varieties, enhances resilience.

4. **Integrated Pest and Disease Management:**

- Weather-based pest and disease forecasts guide the timely application of biopesticides and integrated pest management strategies, reducing crop losses by using some model like: BLITECAST, TOM-CAST, EPIBLAST etc.

Challenges and Opportunities

Despite their potential, agronomy and agro-meteorology face several challenges in implementation:

1. **Knowledge Gaps:** Limited awareness and accessibility of weather-based advisories and advanced agronomic practices hinder their adoption by smallholder farmers.
2. **Resource Constraints:** High costs of precision technologies and limited infrastructure in rural areas restrict widespread implementation.
3. **Data Integration:** Integrating agro-meteorological data with agronomic practices requires robust data collection, analysis, and dissemination systems.

However, these challenges present opportunities for innovation and collaboration:

1. **Capacity Building:** Training programs for farmers and extension workers can bridge knowledge gaps, promoting adoption of climate-smart practices.
2. **Public-Private Partnerships:** Collaboration between governments, research institutions, and private enterprises can drive innovation and resource mobilization.
3. **Policy Support:** Policies promoting the use of renewable energy, subsidies for precision technologies, and incentives for sustainable practices can accelerate progress.

Conclusion

Agronomy and agro-meteorology are indispensable allies in the quest for climate-resilient and sustainable farming. By integrating their strengths, farmers can adapt to climatic uncertainties, optimize resource use, and ensure long-term agricultural productivity. The synergy between these disciplines not only enhances food security but also safeguards natural resources for future generations. As climate challenges intensify, the role of science-driven approaches in agriculture becomes ever more critical. Through collaborative efforts and innovative solutions, agronomy and agro-meteorology can pave the way for a sustainable and resilient agricultural future

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Consequence of Drought Stress on Yield and Quality of Groundnut

M. Umadevi, P. Shanthi, D. Kavithamani and R. Rajeswari

Centre for Plant Breeding and Genetics, TNAU, Coimbatore

Drought stress is widely known as the major factor limiting global agricultural production and food safety worldwide. Drought stress can occur at any stage of crop affects biochemical and physiological processes at the molecular, cellular, and whole-plant levels, including metabolism, stomatal conductance, photosynthesis, nitrogen fixation, mineral nutrition uptake, water relations, leaf expansion, grain development and yield. Yield reduction due to drought stress is highly variable depending on timing, intensity, and duration. Groundnut (*Arachis hypogea* L.) stands as a crucial oilseed and legume crop that contains 47-53% oil and 25-36% protein. The peanut was probably first domesticated and cultivated in the Paraguayan valleys.In addition to protein and oil, groundnut is a good source of Ca, P, Fe, Zn and B. Hence, it played an important role in nutritional security to the resource poor farmers. China ranks first in total annual production (18.3 million tons) and area of (4.4 million ha) whereas India stands first in area (5.7 million ha) and ranks second in production (10.1 million tons). Groundnut is cultivated predominantly in the tropics and subtropics, where the availability of water is a major constraint on yield. Yield decline caused by insufficient soil moisture has been documented on a global scale. The crop is subjected to water deficit stress at one stage or another leading to drastic reduction in productivity.

By comparing the annual rainfall with productivity of groundnut for past 11 years it shows a trend of lesser productivity for the year which has lesser annual rainfall and *vice-versa*. The amount of rainfall is not strictly correlated with productivity of groundnut this is due distribution of rainfall over the crop's life cycle. Drought during the pod and seed forming stages has been shown to reduce pod yield of peanut by 56-85% This necessitates development of cultivars which can withstand water stress and still can be productive.

The early season drought stress does not adversely impact peanut yield conversely it increases the yield of peanut. In the mid-season drought at flowering stage the pod yield of the groundnut is significantly reduced. The terminal drought in groundnut not only reduces the pod yield but also the quality of the kernels by aflatoxin contamination. Due to mid-season and terminal drought, the oil content in groundnuts decreased while the protein content increased.

Many physiological traits can lead to drought tolerance, such as cell protection, early stomatal closure, reduced leaf area, maintenance of vegetative growth or photosynthesis, high water use efficiency, large root systems, or reduced seed abortion rate under water deficit. These cultivar characteristics can be used to develop cultivars adapted to drought.In India, groundnut is cultivated mainly in three seasons *viz*., *Kharif* (rainy season), *Rabi* (winter season) and *Summer*. Gujarat, Tamil Nadu, Andhra Pradesh, Maharashtra, Karnataka, Rajasthan, Orissa, Madhya Pradesh and Uttar Pradesh are the land-producing states of India. Gujarat is the largest producer of groundnuts and it is cultivated both *Kharif* and *rabi* seasons followed by West Bengal and Rajasthan.

But in Tamil Nadu, it is grown in five seasons *viz*., Adipattam (June-July), Karthikaipattam (Oct-Nov), Margazhipattam (Dec-Jan), Masipattam (Feb-March) and Chithiraipattam (April-May) but nearly 90% of

ISSN : 3048 - 989X

acreage and production comes from kharif crop (June-October). The major groundnut growing regions is in North Eastern Zone (43%) which comprises of Cuddalore, Villupuram, Tiruvannamalai, Vellore, Kancheepuram, Tiruvallur districts and parts of Ariyalur district.

Groundnut cultivation regions experiencing hot, dry climates necessitate more frequent and consistent irrigation to alleviate water stress, Sandy soils drain quickly and require more frequent irrigation, while clay soils retain moisture better but may suffer from waterlogging if over-irrigated. Hence, compared to sandy soil, clay soils will be preferable to overcome the water stress.Identifying a suitable screening methods and donors for drought tolerance are crucial for the initiation of any breeding programme to introgress the drought tolerance trait in a well-adapted high yielding cultivar. Groundnut varieties of different parts of India *viz*., CO7, TMV 7, Dharani, RG 425, GKVK5, Amaravti, Ajeya, GPBD-4, Greeshma and Dh256 etc. performed well and produce more pod yield, good withstand under drought condition.

Future research should focus on the introgression of QTL through Genomic Selection (GS) or Marker Assisted Recurrent Selection (MARS) and the integration of transgenic approaches to secure groundnut production amidst changing climate conditions.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Health Benefits of Groundnut and It Can Help You Lose Weight?

M. Umadevi, P. Shanthi, D. Kavithamani, K.R. Nivetha and S.R. Mythili

Tamil Nadu Agricultural University, Coimbatore – 641003

Groundnut (*Arachis hypogaea* L.), is one of the world's most important legume cum oilseed crops cultivated around the world in tropical and semi-arid tropical conditions. It is cultivated largely for its premium protein (25-28 %) and edible oil (43-55%) content. In addition, it has 2.8% crude fiber and total carbohydrates (13.3%) and good source of all vitamins B except B12. The haulms also provide nutritious fodder for livestock which contains protein (8-15%), lipids (1-3%), minerals (9-17%) and carbohydrates (38-45%) higher than cereal fodder. It is the third-largest source of vegetable protein and the fourth-largest source of edible oil in the world. In India, groundnut plant is grown in many tropical states, including Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Gujarat, Maharashtra and Rajasthan. As it improves the fertility of the soil, groundnut is the first choice of crop for the farming community in our country.

Health Benefits of Groundnut

- Peanuts contain 13 different vitamins including A, B, C and E groups, 26 essential minerals like iron and calcium, zinc and boron. Low on salt, groundnuts also act as natural hunger suppressants as it is loaded with good fats.
- They are widely used as a healthy snack or dessert topping. peanuts are rich in healthy fats, proteins, and fiber, which take longer to digest. Peanuts are enriched with healthy fats such as monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs).
- A diet high in these fats has been linked to reduced rates of inflammation, obesity, and chronic conditions, such as heart disease and diabetes.
- In Indian kitchens groundnut occupies major role in the form of oil, legumes, and nuts. Rich and flavourful groundnut chutney serves as an ideal accompaniment to piping dosas or idlis and for the children peanut butter spread on their bread and roti is that quint essential and favourite delight.
- There is absolutely zero amount of cholesterol in peanuts. In fact, more than 80% of these fats are heart healthy fats that are often found in avocados and olive oil, which are known to lower the risk of cardiovascular diseases.
- Groundnuts are an perfect snack for the diabetics as it helps in lowering blood sugars. Studies reveal that peanuts are loaded with 21% of manganese for every 100 grams which plays a major role in absorption of calcium, regulation of blood sugar.
- They are a rich source of beta-sitosterol, which aids in prevention of tumors in the body. It blocks the growth of tumors, especially in the case of cervical and breast cancers.
- It helps in boosting immunity and arrest hair fall due to the presence of vitamin C. Regular intake of peanuts increases the production of collagen, strengthen hair follicles, prevent baldness and contribute to hair growth.
- It improve the functioning of the brain, thanks to its ample amounts of Vitamin B3 and niacin. Loaded with essential nutrients like niacin, protein, healthy fatty acids, and Vitamin E that play a crucial role

ISSN : 3048 - 989X

in improving the cognitive function of the brain.

- A rich source of protein, groundnuts help in digestion, boost metabolic activity, contribute to building muscles and stronger bones.
- Regular consumption of groundnuts provides a vibrant glow to the skin. The presence of vitamin E and vitamin C aid in the prevention of fine lines, wrinkles and avoid signs of ageing.

Nutrition in 100 g of Raw Groundnut

Calories	:	567 kcal	**Potassium**	:	705 mg
Total Carbohydrate	:	16.0 g	**Vitamin B1**	:	0.9 mg
Dietary fiber	:	9.0 g	**Vitamin B2**	:	0.2 mg
Sugar	:	4.0 g	**Vitamin B6**	:	0.5 mg
Protein	:	26.0 g	**Niacin**	:	17.6 mg
Total Fat	:	49.0 g	**Folate**	:	0.35 mg
Saturated fat	:	7.0 g	**Calcium**	:	134 mg
Polyunsaturated fat	:	16.0 g	**Iron**	:	6.7 mg
Monounsaturated fat	:	24.0 g	**Magnesium**	:	245 mg
Cholesterol	:	0 mg	**Phosphorus**	:	549 mg
Sodium	:	18.0 mg			

(Source as per USDA)

Are Peanut Good for Weight Loss?

- Peanuts are full of nutrition and make for a healthy snack. They are full of fiber, protein, and healthy fats, which can aid weight management by keeping you full longer.
- For good results, choose raw, boiled and roasted peanuts free of added salt and flavoring, and be mindful of your serving size.
- Peanuts are an excellent alternative to other high calorie and processed snacks to help you with your weight loss goals. However peanuts are high in calories, you may not absorb all the calories they provide, it means you're likely absorbing fewer calories while the rest is excreted through waste.
- Simple carbohydrates present in peanut are quickly absorbed into the bloodstream and lead to a quick spike in blood sugar followed by a rapid drop. This may cause you to feel hungry shortly after eating. Few studies has reported that the people who ate whole peanuts had significantly higher amounts of fat in their stool, indicating a lower absorption of calories.
- In disparity, peanuts are digested slowly and remain in your stomach longer. So, this helps you feel full and satisfied, allowing you to go longer between meals.
- But peanuts require more chewing, which allows you to eat your food more slowly. As a result, this gives your body time to send fullness signals that may prevent you from overeating.

Best Way for Intake of Peanut

- To select unflavored peanuts because it has minimal processing and do not contain any additional flavoured materials like added salt or other ingredients. Avoid preserved peanuts, which contain a sweetener and provide additional calories.
- To get extra fiber and antioxidants, enjoy peanuts with the skins on. The extra fiber can help increase fullness.
- To get low calories, advised to take boiled peanuts than raw or roasted peanuts. From the studies, with around 116 calories per 1/4 cup (146 grams), compared with 207 and 214 calories for raw and roasted peanuts, respectively. However, boiled peanuts contain 50% less fat than raw and roasted

peanuts, meaning they may not have the same filling effect.

Groundnut oil is the primary product of the groundnut crop, so oil content and oil yield of the crop are considered as principal factors for the production. The only problem with groundnut oil is that it would froth on heating. Traditionally people are doing to stop it, add a ball of dry tamarind to the oil for the froth to settle down. However, during the past years, the value of groundnut utilization has increased due to food and confectionery usage.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Economic and Environmental Sustainability of Protected Cultivation Systems

Paras Yadav

M.Sc. Student, Division of Floriculture and Landscaping, Veer Chandra Singh Garhwali Uttarakhand University of Horticulture and Forestry, Bharsar, Uttarakhand

"Protected cultivation systems are becoming increasingly popular in agriculture because they produce higher yields with less land, water, and other resources. These systems provide a controlled environment for plant growth and help to conserve water, increase crop yields and reduce pesticide use. This general article examines protected cultivation systems' economic and environmental sustainability by summarizing the literature on their benefits and challenges. The data sources used in this article include scientific articles, government reports, and industry publications."

Introduction

Protected cultivation systems refer to agricultural practices that use various materials to protect crops from external factors such as weather, pests, and diseases. These systems have gained significant attention in recent years due to their ability to improve crop yields, quality, and consistency while reducing water usage, land requirements, and other inputs. However, there are concerns about these systems' economic and environmental sustainability, and this article aims to address these concerns.

Protected Cultivation

Protected cultivation is growing plants within an enclosed environment, such as a greenhouse, to provide a controlled and protected growing environment. This method allows for manipulating environmental factors, such as temperature, humidity, and light, for optimizing plant growth and development. Protected cultivation can be used to produce a variety of crops, including vegetables, fruits, flowers, and ornamental plants.

According to a report by Mordor Intelligence, the global protected cultivation market was valued at USD 27.17 billion in 2020 and is projected to reach USD 42.82 billion by 2026, growing at a CAGR of 7.9% during the forecast period (2021-2026). The report cites factors such as increasing demand for food production, decreasing arable land, and rising adoption of technology in agriculture as driving the growth of the protected cultivation market. Protected cultivation is a boon for countries with alarming populations and others also. Protected structures can alone serve as a whole ecosystem. These structures are great examples of the sustainable use of limited land resources. For example, in a hydroponics system or a water reservoir, we can perform pisciculture or fishery production, while in growing trays, we can grow vegetables like - Lettuce, Spinach, Kale, Basil, Coriander etc. In other protected structures like greenhouses, glass houses, Net houses, etc., we can perform multi-layer cropping as well by combining different compatible crops. For instance, underground, we can grow like ginger, turmeric etc. then, just above the ground layer, we can grow herbs like coriander etc., which are short-duration crops, combined with crops like okra, baby corn etc. and crops like Tomato, Cucumber, Bell pepper or flower crops like Rose, Gerbera, Carnations, Chrysanthemum, Lilium etc. This system is so magnificently designed that it does not require or may have minimum requirements of external assistance. This assistance could only be in case of any disease, or insect-pest attack, so proper management is required for their control.

ISSN : 3048 - 989X

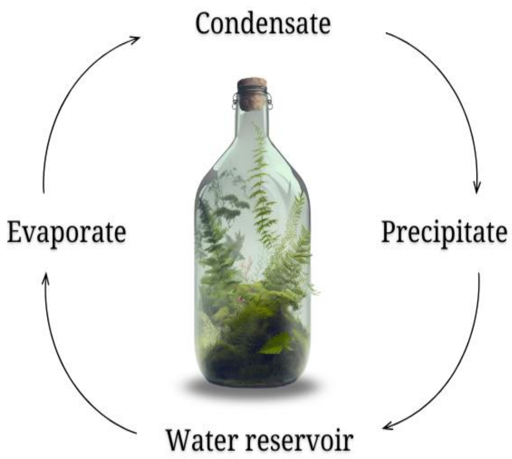
Otherwise, it is a completely autonomous system.

Case Study

In 1960, a man named David Latimer decided to plant a glass bottle with seeds of a perennial indoor plant, Spiderwort. He took a 10-gallon bottle and added compost with a quarter pint of water. Then till 1972, he never watered this plant nor opened the bottle; still, the plant was surviving well. After that, in 1972, the bottle was opened and watered once and again sealed and has never been opened to date.

So, what could be the reason for surviving these plants for so long?

Let us know about the science behind this self-sustaining sealed ecosystem.



Firstly, the plant very efficiently used the water provided in the bottle by David Latimer. The plant roots absorb the water in the mixture, so the plant mobilizes and utilizes nutrients. Then the water oozes out from the leaves through the process of transpiration, and the water gets mixed with the air inside the glass bottle; the moisture gets locked inside the bottle as it is sealed, gets back to the compost, and is mixed with it. In this way, this water cycle keeps going. Now for light, which is a crucial factor for growth and photosynthesis. As the bottle is made of glass, light can easily reach plant parts, i.e., leaves, and the plant can easily perform photosynthesis. Now you must be thinking, the plant can make food, have water and direct access to sunlight, then how it makes the air inside the sealed bottle?

As we know, Plants uptake CO_2 and release O_2. Here in the sealed ecosystem, there is a source of the ecosystem, and there is a source of CO_2 production as well. When the plant grows, leaves shed on maturity. After that, these leaves reach up to the bottom mixture. The bacteria in the bottle start degrading these leaves, which leads to the production of CO_2. This is how plants can obtain recycled nutrients, CO_2, and water in this sealed, self-sustaining ecosystem. So, this is how this small glass bottle garden is a completely autonomous body, and by using this concept, we can effectively grow indoor plants and create a great economy. This space-effective technique can also be used for carrying plants to space and other planets for research.

Economic Sustainability

One of the primary concerns about protected cultivation systems is their economic sustainability. These systems require significant investments in materials, equipment, and labour, and these costs can be a barrier to entry for small-scale farmers. However, studies have shown that the returns on investment can be significant, with higher yields and prices offsetting the initial costs. For example, a study by the Food and Agriculture Organization (FAO) found that protected cultivation systems can provide up to 10 times higher yields than conventional farming methods, leading to higher profits and a faster return on investment. Protected cultivation system offers several economic and environmental benefits that make them a sustainable alternative to traditional farming. First, these systems allow for more efficient use of fertilizer, water and energy resources. Water use can be optimized, and water conservation can be within the control of protected cultivation using drip irrigation systems.

Second, we can minimize or eliminate pesticide use and reduce the negative impact of these chemicals on the environment and human health. Thirdly, crop yield can be increased in a controlled environment, leading to higher profits for the farmer. Israel, the world's 4th most successful economy among the developed countries, is massively using these concepts of gardening and cultivars like: Bottle gardens, Vertical gardening, Glass houses, Greenhouses etc. Using these simple and cost-effective methods, this small country (A.T land) with just about 20% naturally arable area claims it can feed the whole world. India has also taken certain initiatives in collaboration with Israel and has established certain Fruits Excellence Centre and Vegetable and Flowers excellence centres. Names of some of them are stated below:

1. Potato Technology Centre, Shamgarh, Karnal
2. Guava Demonstration Centre, Bhuna, Fatehabad
3. Centre of Excellence for Flowers, Munipur, Jhajjar

Some Indo- Israel projects have also been set up in India using these advance, space and cost-effective, high-yielding technology. For example

1. Centre of Excellence for Vegetables, Gharunda, Karnal
2. Centre of Excellence for Fruits, Mangiana, Sirsa.

And many more.

People out there use their roofs for gardening and growing vegetables for their needs as kitchen gardening, like growing Tomatoes in plastic bottles in vertical gardens. Concepts like Barrel gardening, Terrace gardening are also practised in urban areas.

Challenges Associated with the Protected Cultivation System:

1. **High capital investment**: Protected cultivation systems require significant capital investment in materials, infrastructure, and technology to establish and maintain a controlled environment. This can be a significant barrier to entry for small-scale farmers.
2. **Maintenance and Operating Costs**: The ongoing costs associated with maintaining and operating a protected cultivation system can also be high. These include the costs of heating, cooling, lighting, irrigation, and pest control.
3. **Pest and Disease Management**: While protected cultivation systems can help prevent some pest and disease issues, they can also create ideal conditions for others. This means careful monitoring and managing of pests and diseases are required to avoid losses.
4. **Climate Control**: Maintaining optimal temperature, humidity, and ventilation levels can be challenging, especially in extreme weather conditions. Failure to maintain the correct environmental conditions can reduce crop yields, quality, and profitability.

Environmental Sustainability

Protected cultivation systems also have the potential to reduce greenhouse gas emissions. By growing crops in a controlled environment, growers can reduce the need for transportation and storage, which can contribute to carbon emissions. Additionally, some protected cultivation systems use renewable energy sources, such as solar panels, to power heating and cooling systems, further reducing their environmental impact.

However, there are also concerns about the environmental sustainability of protected cultivation systems. These systems require significant energy to maintain optimal growing conditions, which can contribute to greenhouse gas emissions if not sourced from renewable energy sources. Additionally, the materials used to construct protected cultivation systems, such as plastics and other synthetic materials, can have negative environmental impacts if not properly managed and recycled.

For example, a study by the European Union found that greenhouse gas emissions from protected cultivation systems were lower than those from conventional farming due to the reduced use of fertilizers and pesticides.

Despite these challenges, protected cultivation systems' economic and environmental benefits have led to their adoption in recent years. Government and industry organizations have supported the development of these systems through funding, providing subsidies and research initiatives. As a result, there has been a sprouting body of literature on the advantages and challenges of a protected cultivation system.

To ensure the environmental sustainability of protected cultivation systems, growers must take a holistic approach to their operations. This includes using renewable energy sources, implementing sustainable water management practices, and ensuring that materials used in the construction and operation of these systems are properly managed and recycled. Additionally, growers should consider incorporating regenerative agriculture practices, such as cover cropping and crop rotation, to improve soil health and biodiversity.

Conclusion

In conclusion, protected cultivation systems offer a promising solution for achieving economic and environmental sustainability in modern agriculture. These systems allow growers to control environmental factors, reduce the use of harmful chemicals, and increase crop yields while reducing the impact of farming on the environment. From an economic standpoint, protected cultivation systems can be profitable for growers willing to invest in infrastructure and technology. While there are high upfront costs associated with these systems, the potential for increased yields, higher quality crops, and reduced labour costs can result in long-term profitability. However, growers also need to consider the environmental sustainability of their operations. While protected cultivation systems can reduce harmful chemicals and improve water efficiency, they can also contribute to greenhouse gas emissions if not sourced from renewable energy sources. Additionally, the materials used in constructing and operating these systems can have negative environmental impacts if not properly managed and recycled. Overall, the benefits of protected cultivation systems for economic and environmental sustainability make them an attractive option for growers looking to improve their operations. However, growers need to take a responsible and sustainable approach to their operations to ensure the long-term viability of these systems for future generations.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Drones in Green Farming: Enhancing Sustainability with Precision Technology

N. Senthilkumar

Agricultural College and Research Institute, TNAU, Vazhavachanur 606 753, Thiruvannamalai (DT), Tamil Nadu, India.

1. What is a Drone?

A drone, also known as an unmanned aerial vehicle (UAV), is a flying device operated remotely or autonomously using onboard computers. Equipped with cameras, sensors, and navigation systems, drones are increasingly becoming integral to various industries, including agriculture. In farming, drones collect real-time data, monitor crop health, and deliver inputs like fertilizers and pesticides with unmatched precision. These aerial tools represent the fusion of technology and agriculture, revolutionizing traditional practices to meet the challenges of modern, sustainable farming.

2. History of Drones in Agriculture

The history of drones dates back to military applications in the early 20th century. However, their adoption in agriculture began in the 1980s, particularly in Japan, where Yamaha's R-50 drone was used for crop spraying. Over the decades, advancements in drone technology, coupled with the demand for precision agriculture, have expanded their applications globally. By the 2010s, drones evolved into powerful tools equipped with GPS, multispectral cameras, and IoT capabilities, enabling farmers to enhance productivity and sustainability. The integration of drones in agriculture signifies the convergence of traditional practices with cutting-edge innovation.

3. Types of Drones

Agricultural drones are categorized based on their design and functionality:

- **Fixed-Wing Drones**: These resemble small airplanes and are ideal for covering large areas quickly. They are commonly used for mapping and surveying extensive farms.
- **Multirotor Drones**: Known for their agility and precision, multirotor drones are perfect for targeted applications like crop spraying and close monitoring of plants.
- **Hybrid Drones**: Combining features of fixed-wing and multirotor drones, hybrids offer versatility in both coverage and maneuverability, making them suitable for diverse agricultural tasks.
- **Single-Rotor Drones**: Similar to helicopters, these drones are efficient for heavy lifting, such as transporting fertilizers or water in hilly terrains.

Each type of drone is tailored to specific agricultural needs, ensuring optimal results in various scenarios.

4. Applications of Drones in Agriculture

Crop Monitoring and Health Assessment

Drones equipped with multispectral cameras capture high-resolution images of crops, helping farmers detect stress, diseases, and nutrient deficiencies early. This proactive approach minimizes losses and enhances productivity.

Precision Farming

Drones are central to precision farming, offering unparalleled accuracy in monitoring and managing crops. They provide real-time data on plant health, soil conditions, and field variability, enabling farmers to make informed decisions. This targeted approach optimizes

ISSN : 3048 - 989X

inputs, minimizes waste, and enhances productivity.

Soil Types and Geospatial Applications

Drones equipped with advanced sensors analyze different soil types and their properties, such as texture, moisture levels, and nutrient content. Geospatial mapping through drones creates detailed 3D maps of fields, identifying variations and guiding soil-specific interventions. This technology ensures tailored practices that suit the unique requirements of each zone.

Seedlings Monitoring and Distribution

Monitoring seedling growth is another vital application of drones. They capture high-resolution images to evaluate germination rates and identify areas with poor growth. In some cases, drones are even used to distribute seeds in inaccessible or uneven terrains, promoting efficient reforestation or cover cropping.

Detecting Nutrient Deficiency

Using multispectral and thermal imaging cameras, drones detect nutrient deficiencies in crops. By analyzing the reflectance patterns of plants, they highlight areas with inadequate nitrogen, phosphorus, or potassium. This early detection enables precise nutrient application, preventing crop stress and maximizing yields.

Herbicide Spray

Drones revolutionize weed management through targeted herbicide spraying. By identifying weed-infested zones, they ensure that chemicals are applied only where needed, reducing chemical use and protecting surrounding flora. This precision approach minimizes costs and environmental harm.

Fertilizer Spray

Fertilizer application via drones ensures uniform coverage across fields. Drones distribute fertilizers in calculated amounts based on crop needs, avoiding over-application and nutrient leaching. This method improves soil health and enhances crop quality while conserving resources.

Insecticide Spray

Drones efficiently deliver insecticides to specific areas infested by pests. Their ability to hover close to crops ensures even distribution and better pest control. By reducing manual intervention, drones minimize health risks to workers and prevent overuse of chemicals.

Other Applications

Beyond these, drones are also used for tasks like assessing waterlogging, managing irrigation systems, and predicting harvest yields. These capabilities make drones indispensable tools for modern agriculture.

5. Environmental Benefits

Drones contribute significantly to sustainable farming by reducing the environmental footprint of agriculture:

- **Reduced Chemical Use:** Precision spraying minimizes the overuse of pesticides and fertilizers, protecting soil and water quality.
- **Water Conservation**: By monitoring soil moisture, drones enable efficient irrigation, conserving water resources.
- **Lower Carbon Emissions**: Drone technology replaces heavy machinery for certain tasks, reducing fuel consumption and greenhouse gas emissions.

ISSN : 3048 - 989X

- **Protection of Biodiversity**: Targeted interventions ensure that beneficial insects and surrounding ecosystems are preserved.

The adoption of drones supports the goals of green farming by promoting efficient resource use and reducing environmental harm.

6. Conclusion

Drones represent a transformative leap in agricultural technology, offering precise, efficient, and sustainable solutions to modern farming challenges. Their applications in monitoring, spraying, and resource management not only improve productivity but also align with the principles of environmental stewardship. As drone technology advances, its integration into farming practices will continue to evolve, paving the way for a greener, more sustainable future. By embracing drones, agriculture can achieve a harmonious balance between innovation and ecological responsibility.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Significance of Pulse Beetle, *Callosobruchus maculatus* (F.) on Pulses and Its Management

B. Keerthana, G. Preetha and J. Malathi

Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

Introduction

Pulses are an important legume crop that is rich in proteins and vitamins and is an essential dietary component. It is grown in tropical and sub-tropical regions in many parts of the world and these crops are rich in nitrogen fixation in soil. The production and productivity of pulses have been diminished for the past two decades, compared to cereals, oil seeds, and other crops. The green gram production was about 3 million tons and in India, production of green gram is 1.2 million tons and productivity about 3.5 million ha under cultivation. Various biotic and abiotic factors reduce crop productivity in agriculture. Among the biotic factors, insects are considered as the major threat and causing nearly 10 per cent of damage in total commodities (Hosamani *et al.*, 2018). Among them, the pulse beetle, *Callosobruchus maculatus* F. (Coleoptera: Bruchidae), is a major pest of pulses such as green grams, lablab, cowpeas, and black gram. *C. maculatus* is an important and primary pest of pulses. Infestation starts in the pods before harvest and carries over into storage. The larvae of *C. maculatus* bore into the seeds making them unfit for human consumption and leading to huge economic loss. They cause high levels of infestation and these insects can cause damage in almost all types of stored pulses. These insects prefer whole pulses for egg-laying. The presence of insects depends on the types of storage and warehouses.

Distribution and Host Range

It is more prevalent in tropical and subtropical regions of Asia and Africa and also widely spread around many parts of the world. The host range of the pulse beetle, *C. maculatus* includes green gram, black gram, cowpea, lentils, lablab, peas, horse gram, bengal gram, and red gram.

Life Cycle

Like other insects, the developmental stages comprise of egg, larvae (1st to 4th instar), pupa, and adult. These insects complete 7 to 8

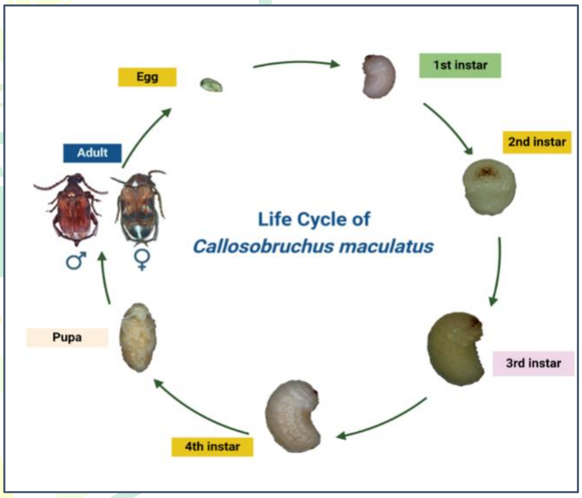


Fig 1. Life cycle of *C. maculatus*

generations/year. Adults do not feed on the stored pulses, they only lay eggs and complete their life cycle (Devi and Devi, 2014). Only the larval stages prefer to bore holes and feed the stored pulses. The symptoms include, circular exit holes and the infested seeds are filled with excreta. The eggs are laid singly, shiny, creamy white, translucent, and glued to the seed surface. The hatched eggs are dirty white because of the presence of grub's frass. The grubs of *C. maculatus* undergo four instars. The grubs are soft, creamy white and the head capsules are dark brown in appearance. Variations in the size of head capsules can be used to differentiate the different instar grubs. The life span from egg to adult varies among different hosts and may also vary due to abiotic factors. Under room temperature, it takes around 9-12 days for males and 10-14 days for females. The life cycle may vary according to temperature.

Symptom of Damage

Female lays eggs on whole grains and this is the initial symptom or early detection method of insects. The grub after hatching enters into the seed and devours completely the internal material and leaves the empty outer coat (Fig. 2).

Fig 2. Black gram seeds infested with *C. maculatus*

Management of Pulse Beetle, *C. maculatus*

1. Physical method

- Raising the temperature of pulses to 60-65 °C for a few minutes can effectively help to reduce the damage from *C. maculatus*.
- The moisture content of grains is reduced to below 9 per cent which affects the biology of *C. maculatus*.
- Sun drying can also help to manage the pulse beetle from green gram, black gram, lentils etc.

2. Resistant Varieties

- This resistance depends upon the variation in pod thickness, protein content, and chemical composition.
- Resistant varieties of *C. maculatus* include KM 2241, Pusa Vishal, TJM 3, PDM 139, Virat.

3. Sanitation

- Clean the storage area before introducing new pulses, removing all old grains, dust, and residues from previous storage.
- Pay attention to corners, cracks, and crevices where beetles might hide.

4. Use of Inert Materials

- Use of inert materials such as Sand/Ash/diatomaceous earth/silica aerogel/non-silica dust which causes Asphyxiation to Egg, larva adult stages.

4. Use of Botanicals

- Use of vegetable oils *viz*., castor (*Ricinus communis*), coconut (*Cocos nucifera*), sesamum (*Sesamum indicum*), and sunflower (*Helianthus annus*), among these castor oil @ 10 ml/ kg seed which inhibits the ovicidal activity.

5. Chemical Insecticides

- Four groups of pesticides come under chemically synthesized pesticides, such as carbamates, malathion, organophosphates, organochlorines etc. Mainly these pesticides were used against *C. maculatus*.

6. Molecular Approach

- The alternation of DNA with the help of recombinant technology comes under an ergonomic approach. It is an emerging technology that includes transgene introgressive, genome modification, DNA marker assisted breeding etc. (Hajam and Kumar, 2022).
- Development of pulse beetle-resistant transgenic crops by the introduction of gene-encoding lectins commonly found in the resistant legume grains.

Conclusion

In conclusion, pulses are an essential legume crop, vital for their high protein and vitamin content, and contribute significantly to soil fertility through nitrogen fixation. These pests destructive feeding habits lead to substantial economic losses and make affected pulses unfit for consumption. Effective management strategies, including physical, chemical, botanical, and molecular approaches, offer practical solutions to reduce infestation. The development of resistant crop varieties and advances in molecular technologies present promising directions for sustainable pest control, ultimately contributing to improved pulse yield and food security.

Reference

Devi MB and Devi NV. (2014). Biology and morphometric measurement of cowpea weevil, *Callosobruchus maculatus* F. (Coleoptera: Chrysomelidae) in green gram. *Journal of Entomology and Zoology Studies* **2**(3): 74-76.

Hajam YA and Kumar R. (2022). Management of stored grain pest with special reference to *Callosobruchus maculatus*, a major pest of cowpea: A review. *Heliyon* **8**(1): 74-76.

Hosamani GB, Jagginavar SB and Karabhantanal SS. (2018). Biology of pulse beetle *Callosobruchus chinensis* on different pulses. *Journal of Entomology and Zoology Studies* **6**(4): 1898-1900.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Global Trade Uncertainties: Market Challenges for Fruit Producers

Purvika[1] and Nikesh Chandra[2]
[1]M.Sc. Horticulture (Fruit science) & [2]Assistant Professor
Mata Gujri College, Fatehgarh Sahib140 406, Punjab

The study examined the difficulties and lucrative prospects associated with fruit crop marketing. Numerous problems in the smallholder food value chain are challenging to resolve. According to the findings, the marketing system for fruit crops like oranges and bananas was primarily limited by several issues, including weight deception, unfair broker pricing, low product quality, and a lack of cooperation. Fruit crops are a source of revenue that gives growers, brokers, transporters, and retailers, among other market chain participants, economic prospects. Although fruit crop marketing appears to be advantageous, as evidenced by the data results, careful consideration should be given to the marketing strategy to secure steady profits for the government and other market participants. This post will provide you with a summary of the issues with the present system, explain why they are so hard to fix, and explain how we do it.

Keywords: Production, Consumers, Global Production, Marketing, Productivity

Introduction

From the supply side to the demand side, Indian production encounters numerous obstacles along the value chain. Despite being the second-largest fruit grower in terms of production, the main issue is a decline in revenue, and the rate of waste is significant after harvest. According to the study, most indigenous fruit crops have low average productivity when measured against global norms. Existing yields and potential yields differ significantly. The study estimates that the amount of waste in India varies from 11% for mangoes to 90% for bananas. low marketable surplus and low trade in the sector are the results of this. Only 10.4% of India's total fruit harvest is now stored in cold storage facilities. To strengthen the export market, the data emphasized the importance of international quality compliance, production and post-harvest management, and marketing methods. "Yield improvement through technological interventions, decrease of waste through efficient post-harvest management, and diversification of markets through expansion of customized product," the data stated, citing analyses of production, yield, and major fruit trade as areas that require attention in the nation. Retailers, carriers, brokers, and finally customers are the main market participants in

the study industry. Customers typically buy from retailers because they provide products based on their needs and purchasing power. According to survey data, stores can typically keep fruit for two to seven days when the market is weak or prices are low, whereas bananas take two to five days. Retailers were occasionally forced to get rid of their products quickly and at a low selling price because there was not enough accurate and timely market information available. The global fruit industry has been struggling because of the corona virus pandemic because of rising production costs, significant logistical issues with transportation, and changes in fruit consumption, which initially benefited from the movement toward healthier foods but later declined sharply.

Some Serious Problems Faced by Farmers in India:

i) Increase in Input Cost

Farmers continue to face rising costs four years after the COVID-19 outbreak, largely due to labor shortages and supply chain disruptions. A recent report indicates that input expenses—including fertilizer, fuel, land, machinery, and labor—have surged by 28% since 2020, exceeding $100 billion. As a result, 2024 is projected to have the third-highest input costs in history. Smaller farmers struggle to afford essential supplies and turn a profit, compromising their ability to compete globally. Many farms have closed, been acquired by larger operations, or sold for development, leaving long-time owners feeling disheartened. In contrast, larger farms can benefit from economies of scale. Some growers have adapted by selling directly to consumers at farmers' markets and on-farm events, eliminating middlemen and gaining more control over pricing. Others have diversified by processing raw materials into products like pickles, cider, and jams, while offering unique experiences to customers.

ii) Logistical Problems

The wholesale market lacks air conditioning and sanitary regulations, resulting in lower-quality produce and a reduced shelf life for fruits bought by small vendors. Transportation from production regions to ports is challenging due to container shortages and delays in loading and unloading, contributing to significant food waste, which costs billions annually. Data from the Logistics Bureau indicates that over half of fresh fruit loses its shelf life during transport, with 33% of food wasted overall. Fruits like oranges, grapes, and cherries require storage at 0 to 2 degrees Celsius and 95% to 100% humidity. Specific freshness and safety requirements complicate optimal transportation conditions. However, advanced technologies like data logging can help. This involves sensors that monitor temperature, humidity, and other factors during transport, enhancing the freshness and safety of the products. In addition, the pandemic and the Russia-Ukraine conflict have led to shipment delays, disrupting fruit sales and reducing the quality of perishable items. Farmers often rely on brokers for sales, which necessitates moving sensitive crops, such as avocados and mangoes, between various transport modes. This handling damages the fruit and increases spoilage. Additionally, produce is often transported in heavy bags, leading to further quality loss before reaching the market.

iii) Ukraine-Russia Conflict

The conflict that began at the end of February 2022 has significantly impacted the global economy, as well as the trading relationship between Russia and other nations. Russia is a major importer of fresh fruit, but many of its suppliers have either reduced or halted their shipments entirely. India, which typically exports 40% of its pomegranates, 20% of its pears and limes, and 10% of its apples to Russia, is currently facing challenges with poor shipments and unpaid invoices. Additionally, about 11% of India's total fertilizer imports come from Russia and Ukraine, which are crucial for supplying various essential agricultural products. Specifically, Russia accounts for more than 17% of India's potash imports and 60% of its nitrogen, phosphorus, and potassium (NPK) fertilizers. Therefore, a shortage of these fertilizer components could disrupt crop production and affect farmers' incomes.

iv) Insufficient Product Handling Techniques

Nearly 99 percent of the retailers, according to the data, followed specific, acceptable pre-harvest and post-harvest handling procedures at the marketplace. The poor quality of fruit crops like bananas and strawberries, which ultimately

ISSN : 3048 - 989X

results in price reductions and product deterioration, is also caused by a lack of well-ventilated storage, harvesting that is both healthy and damaged together, physical damage during transportation, and improper agricultural practices on the part of the producer in the field. One of the main causes of post-harvest losses in rural areas has been the absence of storage facilities. Due to a shortage of storage facilities, around sixteen percent of fruit is wasted annually. Farmers struggle to sell food right after harvest, even at modest costs, because most agricultural products are perishable. This will give them a meager income. Use of unsanitary containers, over-loading of containers at producer's levels, rough handling and throwing products were also the main reason of post-harvest problems as respondents said

Suggestive Measures for Future Marketing

The absence of awareness and practice of digital marketing is an essential challenging factor for the economic growth of the farmers. There is a requirement to change the approach to implementing marketing strategies and direct sales from pomegranate and other fruits to the consumer for immediate benefit.

Trade Agreements

Trade agreements are crucial for standardizing regulations in agricultural trade. They lower tariffs, remove trade barriers, and create stable market access. A key example is the European Union Agricultural Policy, which encourages economic integration and trade liberalization for agricultural products among member and partner countries.

Improved Global Supply Chain

The global supply chain refers to the interconnected network of organizations, people, information, resources, and activities involved in food production, along with its handling and distribution to end consumers. It is a complex system. Increasing investment in the global supply chain can help simplify this complexity and promote economic growth.

Value Addition and Product Variety

Enhancing items to increase their market value and prolong their shelf life is part of this. In order to satisfy the growing expectations of clients with a wide range of tastes, value addition also adds product variety.

Technological Developments

Through genetic engineering, precision farming, and sophisticated irrigation, technological developments have revolutionized traditional agriculture and increased agricultural yields to satisfy the demands of an expanding population. Furthermore, e-commerce platforms and digital agricultural hubs have simplified international trade, increasing market accessibility and permitting direct commerce between producers and customers.

Direct Selling the Fruit Through Local Man Dies, e-Commerce Platforms, Social Media, and Mobile

Advertising For farmers trying to reach a wider audience and capitalize on the rising demand for direct-to-consumer (DTC) sales, e-commerce has revolutionized the industry. Selecting the appropriate e-commerce platform can have a significant impact on farmers' ability to manage inventories, maximize sales, and forge closer bonds with clients. Whether you sell dairy, meats, fresh produce, or other agricultural products, an efficient e-commerce system can help you expand your customer base and streamline operations.

Here Are Some Other E-Commerce Platforms in India:

Big Basket An online grocery delivery platform that sells groceries, home essentials, and food supplies.

Blinkit A quick commerce company that offers groceries, household items, and personal care products.

ISSN : 3048 - 989X

JioMart A grocery delivery app that offers hassle-free delivery to your doorstep

Conclusion

Because there were no producers or distributors in the market, the main players were retail consumers. It was observed that the infrastructure had improved, including the roads and communication systems. Fruit production and marketing must be improved and diversified in order to satisfy local market demands and guarantee equitable earnings. To increase shelf life and supply stability, producers must also receive pre- and post-harvest handling training. Because of its profitability, the government and market participants must pay close attention to efficient marketing techniques and implement the required reforms in the public and private sectors.

Reference

Barrett C B and Mutambatsere E (2005). Agricultural markets in developing countries. Cornell University. 12p BPEDORS (2000). Physical and Socio-Economical Profile of 180 District of Oromia Region.Bureau of Planning and Economic Development, Council of Regional State of Oromiya. Ethiopia *1 An International Peer-reviewed Journal* Vol.22, 2016.

Rede G D. "Marketing and Constraints Analysis of Pomegranate in Solapur District of Maharashtra." *Economic Affairs*.**3**(8):234-267.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Technology Advancement in Rural Management

Raushan Kumar Sanu[1] and Anubha[2]

[1]Student MBA (Rural Management) & [2]Assistant Professor
Ganga Global Institute of Management Studies, Begusarai, Bihar

Introduction

Rural management, a multidisciplinary field, integrates management practices with rural development to enhance the socio-economic conditions of rural areas. The advent of advanced technology has revolutionized this domain, offering innovative solutions to long-standing challenges. With nearly 65% of the global population residing in rural regions, the need for effective rural management has become more pressing. Technology plays an important role in optimizing agricultural practices, improving infrastructure, enabling financial inclusion, and better access to education and healthcare.

Importance of Technology in Rural Management

Technology can bridge the rural-urban divide by bringing modern tools and systems that improve productivity and standards of living. Some of the key areas where technology has really made a difference are:

1. Agriculture: Precision farming, remote sensing, and automated machinery have changed the way traditional farming was done.

2. Education: E-learning platforms and virtual classrooms have made quality education accessible to rural students.

3. Healthcare: Telemedicine and mobile health applications have brought medical expertise to remote locations.

4. Infrastructure: Advanced construction techniques and sustainable energy solutions have improved the quality of rural infrastructure.

5. Financial Inclusion: Digital banking and mobile payment systems have empowered rural populations financially.

Technological Innovations in Rural Management

1. Agriculture Development: Agriculture provides the base support to rural economy. Technological advancements have helped increase agricultural yield and sustainability remarkably:

1.1. Precision Farming: Using the GPS and IoT devices, real-time monitoring is possible for the soil health and water levels of crops.

1.2. Drones: These are utilized for aerial monitoring, pest controlling, and monitoring crop health.

1.3. Autonomous Machinery: Tractors, seeders, and harvesters with AI functions have reduced man power and maximized efficiency.

1.4. AgriTech Platforms: Mobile applications offer market prices, weather updates, and best practices to farmers.

2. Education and Skill Development: Technology has democratized education for rural populations by addressing accessibility and quality:

2.1. E-Learning Platforms: Websites and apps such as Khan Academy and Byju's offer courses customized for the rural student.

2.2. Virtual Classrooms: Zoom and Google Meet have helped create interactive learning sessions.

2.3. Skill Development Programs: In PMKVY (Pradhan Mantri Kaushal Vikas Yojana), the government provides vocational training utilizing technology.

3. Healthcare Transformation: Shortage of healthcare professionals and proper medical facilities always occurs in villages. Technology bridged this gap through:

3.1. Telemedicine: There are various platforms through which patients connect with doctors such as Practo and Apollo 24/7 for consultation purposes.

3.2. Mobile Health Units: Well-equipped with different diagnostic tools to provide basic healthcare services.

3.3. AI in Diagnostics: AI-based tools help detect diseases at the earliest.

3.4. Health Information Systems: Electronic records facilitate better patient care and healthcare service delivery.

4. Renewable Energy Solutions: Energy is a critical input for rural development. Thanks to technological advancement, renewable energy solutions are feasible:

4.1. Solar Power: Solar power can be harnessed for electrification of off-grid villages.

4.2. Biogas Plants: Organic waste can be converted into energy, thus helping to sustain it.

4.3. Microgrids: A localized grid will help reduce the dependence on a centralized source.

4.4. Energy Storage: Improved battery technology guarantees a stable power supply.

5. Financial Inclusion: Digital technology has transformed financial services in rural areas:

5.1. Mobile Banking: Apps like Paytm and Google Pay have made transactions easy.

5.2. Microfinance Platforms: Companies such as Bharat Financial Inclusion offer loans to rural entrepreneurs.

5.3. Digital Wallets: These allow secure and instant payments.

5.4. Blockchain: This technology provides transparency in financial transactions and supply chains.

Barriers to the Implementation of Technology in Rural Areas

Despite its vast potential, rural management integration through technology faces some challenges:

1. Infrastructure Deficit: The availability of internet access and electricity often hampers the adoption of technology.

2. Digital Illiteracy: Most of the villagers are not even aware of new tools and techniques.

3. Cost Factor: The high price of technology prohibits small-scale farmers and entrepreneurs.

4. Traditional and Social Constraints: People always resist change as it is also a part of their culture.

5. Policy Gaps: Inconsistent government policies and lack of coordination among stakeholders create obstacles.

Government Initiatives for Promoting Technology in Rural Areas

Governments around the world have initiated various programs to encourage technological development in rural management:

ISSN : 3048 - 989X

India:

Digital India: Promotes digital literacy and internet penetration.

Kisan Call Centers: Provides agricultural advice.

eNAM (National Agriculture Market): Facilitates online trading of agricultural commodities.

Global Examples:

USA: USDA's Rural Development Programs focus on infrastructure and technology.

Kenya: The M-Pesa mobile payment system has transformed financial transactions.

Role of Private Sector and NGOs

The private sector and NGOs have played a pivotal role in extending technology to the rural areas:

- **Corporate Initiatives:** TCS and Infosys have launched education and agricultural technology solutions.
- **NGOs:** Organizations such as PRADAN and Digital Green train rural people on the proper usage of technology.
- **Public-Private Partnerships:** Partnerships between the government and private sectors have magnified the reach of technological solutions.

Future Perspective

The future of rural management is to tap advanced technologies like artificial intelligence, machine learning, and blockchain. What can be envisioned in the near future includes the following:

- **Smart Villages:** Connecting IoT devices to build up interrelated social structures.
- **AI-based Decision Support:** Predictive analytics for optimized resource deployment.
- **Blockchain Use in Supply Chain Management:** Transparency and traceability of rural produce
- **Climate-Resilient Agriculture:** Utilizing technology to tide over the challenges posed by climate change upon agriculture.

Conclusion

Through technologies, rural management has emerged to be a major game-changer in addressing issues and unlocking future opportunities. Major progress has thus been made by overcoming the hitherto-mentioned barriers created by infrastructure deficit and digital literacy. Technology in this regard holds the potential of creating a more sustainable and inclusive rural future through engagements between governments and private entities alongside local communities. The aim is to enable rural populations, raise their standard of living, and bridge the gap between urban and rural regions.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

The Potential of Bioinformatics in Agriculture and its Ethical Dimensions

Praveen K.V. and Rajna S.

ICAR-Indian Agricultural Research Institute, New Delhi

Introduction

Agriculture has always been the backbone of human civilization, providing food, fiber, and raw materials. However, modern-day challenges such as climate change, pest outbreaks, dwindling natural resources, and the growing global population are placing unprecedented pressure on agricultural systems. In this scenario, bioinformatics emerges as a transformative technology, combining biology, computer science, and data analytics to provide innovative solutions. By leveraging bioinformatics, farmers can enhance productivity, reduce costs, and access premium markets, ultimately increasing their income. This article delves into how bioinformatics can revolutionize agriculture, focusing on its applications, benefits, and potential to improve farmers' livelihoods.

Bioinformatics is a multidisciplinary field that applies computational tools to analyze biological data. In agriculture, it encompasses various domains, including genomic analysis, microbial studies, and precision breeding. Genomic analysis helps identify genes responsible for desirable traits such as high yield, drought tolerance, and pest resistance. Microbial studies explore the soil and plant microbiomes to develop biofertilizers and biopesticides. Precision breeding employs bioinformatics tools to accelerate the development of superior crop and livestock varieties. By integrating these technologies, bioinformatics enables farmers to make data-driven decisions, optimize resources, and achieve sustainable growth.

Applications of Bioinformatics in Agriculture

Bioinformatics has revolutionized plant and animal breeding by enabling precision breeding. Through genomic selection, scientists can predict the performance of crops and livestock based on their genetic makeup. For example, CRISPR-Cas9 technology has been used to develop rice and wheat varieties resistant to abiotic stress such as drought and salinity (Haque et al., 2018). Genomic selection tools, such as predictive algorithms, allow breeders to identify high-performing plants even before field trials (Crossa et al., 2017). These advancements significantly reduce the time and cost of developing new varieties, ensuring farmers have access to superior seeds and breeds. The soil microbiome plays a critical role in plant health and productivity. Bioinformatics tools analyze microbial communities in the soil to identify beneficial microbes that enhance nutrient availability and suppress pathogens. Research by Mendes et al. (2011) demonstrated how rhizosphere microbiomes could be harnessed to develop biofertilizers and biopesticides. These bio-based solutions reduce farmers' reliance on chemical inputs, lowering costs and promoting sustainable farming practices. Bioinformatics provides predictive models that monitor pest populations and identify disease outbreaks. By analyzing genomic data of pathogens and pests, scientists can develop targeted pest control strategies (Gul et al., 2022). Early detection systems based on pathogen genomics help farmers take preventive measures, minimizing crop losses. Such interventions not only stabilize yields but also reduce the financial burden of widespread infestations. Climate change poses a significant threat to agriculture, with extreme weather events and changing rainfall patterns impacting yields. Bioinformatics aids in developing climate-resilient crops by identifying genes that confer tolerance to heat, drought, and flooding (Varshney et al., 2021). For instance, genomic research on wheat has led to the development of heat-resistant varieties, ensuring stable production in high-temperature regions. Post-harvest losses account for a significant portion of agricultural waste. Bioinformatics helps address this issue by identifying spoilage-resistant traits in crops. For example, genomic interventions in fruits and vegetables have extended shelf life, enabling farmers to reduce losses and access distant markets.

How Bioinformatics Directly Benefits Farmers

Bioinformatics has a direct and tangible impact on farmers' livelihoods by increasing productivity, reducing costs, and enhancing market access. By developing high-yield and pest-resistant varieties, bioinformatics ensures farmers can harvest more produce even under challenging conditions. For example, Zampieri et al. (2020) demonstrated that genomic selection for heat-resistant wheat improved yields by 15%, translating to higher income for farmers in heat-stressed regions. Similarly, bioinformatics-driven breeding programs in rice have increased productivity while maintaining quality standards. Bioinformatics helps optimize the use of fertilizers, pesticides, and water. Soil microbiome analysis, as highlighted by Sokol et al. (2018), reduces the overuse of chemical fertilizers by identifying the exact nutrient needs of crops. This not only lowers input costs but also enhances soil health, ensuring long-term productivity. Improving the quality of produce through nutrient-enriched or spoilage-resistant varieties allows farmers to access premium markets. Kumar et al. (2020) noted that bioinformatics-guided breeding programs in wheat enabled farmers to meet stringent export standards, significantly increasing their income. Bioinformatics provides predictive tools that alert farmers to emerging pest outbreaks and diseases. For instance, Chakraborty and Newton (2011) showed that early warnings based on pathogen genomic data allowed farmers to implement timely interventions, reducing crop losses. Predictive tools also help farmers plan better, mitigating risks associated with unpredictable weather events. In dairy and meat production, bioinformatics-driven breeding programs have significantly improved livestock productivity. VanRaden et al. (2018) demonstrated that genomic prediction tools enhanced milk yield, disease resistance, and growth rates, leading to a 25% increase in profitability for dairy farmers. Bioinformatics-powered mobile applications provide smallholder farmers with real-time recommendations on fertilizer application, irrigation scheduling, and pest management (Wolfert et al., 2017). These tools democratize access to advanced agricultural technologies, ensuring even resource-constrained farmers benefit from bioinformatics.

Several studies highlight the transformative impact of bioinformatics on agriculture. Zampieri et al. (2020) reported a 15% increase in wheat yields under heat stress conditions through genomic selection. This innovation directly benefited farmers in regions prone to high temperatures. A meta-analysis by Sokol et al. (2018) revealed that bioinformatics applications in soil microbiome management increased crop productivity by 10-20%, reducing dependence on chemical fertilizers. VanRaden et al. (2018) highlighted how genomic prediction tools improved dairy profitability by enhancing milk yield and reducing disease prevalence, significantly boosting farmers' income. Kumar et al. (2020) illustrated how bioinformatics-driven breeding programs enabled rice and wheat farmers to meet international quality standards, opening up lucrative export markets. Predictive models based on pathogen genomics allowed farmers to prevent pest outbreaks, ensuring stable yields and reducing financial losses (Chakraborty & Newton, 2011).

Challenges and the Way Forward

While bioinformatics holds immense potential, several challenges hinder its widespread adoption. These include high initial costs, lack of awareness among farmers, and limited access to computational infrastructure. Addressing these challenges requires collaborative efforts:

1. **Investment in Research and Development:** Governments and private organizations must invest in bioinformatics research tailored to local agricultural needs.
2. **Capacity Building:** Training programs and workshops can educate farmers about the benefits of bioinformatics and how to implement its tools effectively.
3. **Public-Private Partnerships:** Collaboration between research institutions, agritech companies, and policymakers can ensure the development and dissemination of affordable bioinformatics solutions.
4. **Infrastructure Development:** Establishing bioinformatics labs and data centers in rural areas can enhance accessibility and promote adoption among smallholder farmers.

The Ethical Dimensions of Bioinformatics in Agriculture

The use of bioinformatics in agriculture holds the promise of revolutionizing farming practices, enhancing productivity, and addressing global food security challenges. However, like any transformative technology, bioinformatics brings with it a set of ethical considerations that require careful deliberation. Issues related to data ownership, privacy, equity, environmental impact, and societal consequences are central to ensuring that bioinformatics applications in agriculture are both effective and just.

Data Ownership and Privacy

The foundation of bioinformatics lies in data collection and analysis, whether it pertains to genomic information of crops, livestock, or soil microbiomes. One critical ethical question is: who owns this data? Farmers contribute significant data about their land, crops, and farming practices, yet they often have limited control over how this data is used. Large agritech companies frequently collect and store agricultural data, which can lead to concerns about monopolization and misuse. For example, proprietary genomic databases could restrict access for public researchers, slowing down advancements in agricultural innovation. Farmers may also face the risk of losing autonomy over their practices if data-driven recommendations are controlled by corporations with profit motives rather than sustainability goals. To address these concerns, transparent data-sharing agreements and policies are essential. Open-access databases, as promoted by global initiatives like the CGIAR, can democratize access to agricultural data while ensuring that farmers maintain ownership and receive equitable benefits.

Equity and Accessibility

The deployment of bioinformatics tools in agriculture often requires substantial resources, including computational infrastructure, skilled personnel, and financial investment. This raises questions about equitable access. Wealthier farmers and regions with better technological infrastructure are more likely to benefit from bioinformatics, exacerbating existing inequalities in agriculture. For example, smallholder farmers in developing countries might struggle to adopt bioinformatics-driven precision agriculture due to high costs or lack of access to digital tools. This "digital divide" could widen socioeconomic disparities, leaving marginalized communities further behind. To promote equity, governments and international organizations must prioritize capacity building in resource-constrained areas. Subsidized access to bioinformatics tools, along with training programs for farmers, can ensure that the benefits of this technology are shared across different socioeconomic groups.

Environmental Impact

One of the goals of bioinformatics in agriculture is to promote sustainability by reducing the reliance on chemical inputs and improving resource use efficiency. However, ethical concerns arise when the environmental consequences of bioinformatics applications are not adequately considered. For instance, the widespread adoption of genetically modified organisms (GMOs) developed through bioinformatics could lead to unintended ecological consequences. The release of crops with pest-resistant traits may disrupt local ecosystems, affecting non-target species and biodiversity. Similarly, the overuse of specific microbial biofertilizers, without understanding their long-term impact on soil health, could degrade soil ecosystems. An ethical approach to bioinformatics in agriculture necessitates rigorous environmental assessments and the adoption of precautionary principles. Multidisciplinary collaborations involving ecologists, agronomists, and bioethicists can help evaluate potential risks and ensure that bioinformatics applications align with sustainability goals.

Intellectual Property Rights (IPR)

The development of bioinformatics-driven agricultural solutions often involves significant research and innovation, leading to the creation of intellectual property. Patents on genetically modified crops or proprietary bioinformatics algorithms raise ethical concerns about accessibility and affordability. Farmers, especially in developing countries, may face barriers to using patented seeds or tools due to high costs. This could increase dependency on multinational corporations, undermining the traditional practices of seed saving and exchange that form the backbone of smallholder agriculture. Ethical frameworks for IPR in agricultural bioinformatics should strike a balance between rewarding innovation and ensuring fair access. Public-private partnerships and the promotion of open-source bioinformatics tools can help mitigate these challenges.

Impact on Traditional Knowledge and Practices

Agricultural bioinformatics often prioritizes modern scientific approaches, which can overshadow traditional knowledge and practices that have been honed over centuries. This raises ethical questions about the marginalization of indigenous farming systems and the potential loss of cultural heritage. For example, the integration of bioinformatics into crop breeding programs might neglect traditional varieties that are well-adapted to local conditions. Similarly, the introduction of uniform bioinformatics-driven solutions may discourage diverse farming practices, reducing agricultural resilience. Engaging local communities in the development and implementation of bioinformatics applications is crucial to addressing these concerns. Collaborative approaches that integrate traditional knowledge with modern science can create context-specific solutions that respect cultural values and promote inclusivity.

Ethical Use of Genomic Editing

Genomic editing, facilitated by bioinformatics, offers unprecedented opportunities to enhance crop and livestock traits. However, ethical dilemmas arise regarding the boundaries of genetic modification and its implications for food safety and societal acceptance. One contentious issue is the labeling of genetically edited crops and their regulation. While some argue that genomic editing is simply an accelerated form of traditional breeding, others believe it requires stringent oversight to address potential risks. Transparency in the development and labelling of genetically edited products is essential to build public trust. Additionally, ethical questions about "playing God" with life forms remain a point of debate. Public consultations and ethical deliberations should accompany genomic editing initiatives to ensure that societal values and concerns are adequately addressed.

Societal Implications and Public Perception

The societal implications of bioinformatics in agriculture extend beyond individual farmers to encompass broader issues of food security, economic stability, and public health. Public perception plays a critical role in determining the acceptance and success of bioinformatics applications. For example, resistance to genetically edited crops in certain regions has hindered their adoption, despite their potential benefits. Ethical communication strategies that emphasize transparency, inclusivity, and evidence-based narratives can help address public concerns and foster trust. Moreover, ethical considerations should guide the prioritization of bioinformatics research to ensure that societal benefits outweigh commercial interests. Focusing on crops and regions most affected by food insecurity can maximize the positive impact of bioinformatics on global agriculture.

The Precautionary Principle

Given the potential risks associated with bioinformatics applications, the precautionary principle is an essential ethical framework. This principle advocates for proactive measures to prevent harm, even in the absence of scientific certainty. In agriculture, this means thoroughly evaluating the long-term consequences of bioinformatics-driven innovations before their widespread adoption. Regular monitoring and adaptive management strategies can help mitigate unforeseen risks while ensuring that bioinformatics continues to deliver benefits.

Conclusion

Bioinformatics is not just a technological advancement; it is a paradigm shift that has the potential to redefine agriculture. By enabling precision breeding, optimizing resource use, and mitigating risks, bioinformatics empowers farmers to achieve sustainable growth and financial stability. However, realizing its full potential requires concerted efforts from all stakeholders. Governments, researchers, and the private sector must work together to make bioinformatics accessible and affordable for farmers worldwide. In doing so, we can ensure that bioinformatics becomes a cornerstone of modern agriculture, driving prosperity for farmers and ensuring food security for generations to come. Bioinformatics has the potential to transform agriculture, offering solutions to some of the most pressing challenges faced by farmers and societies. However, the ethical dimensions of its use cannot be overlooked. Issues related to data ownership, equity, environmental impact, intellectual property, and societal implications must be addressed to ensure that bioinformatics serves as a force for good. A balanced approach that prioritizes inclusivity, transparency, and sustainability is essential for the responsible deployment of bioinformatics in agriculture. By engaging stakeholders, fostering interdisciplinary collaborations, and adhering to ethical principles, we can harness the power of bioinformatics to create a more equitable and resilient agricultural future.

References

Haque, E., Taniguchi, H., Hassan, M. M., Bhowmik, P., Karim, M. R., Smiech, M., & Zhao, K. (2018). Application of CRISPR/Cas9 genome editing for crop improvement: Progress and prospects. *Frontiers in Plant Science*, 9, 617.

Crossa, J., Pérez-Rodríguez, P., Cuevas, J., Montesinos-López, O., Jarquín, D., de los Campos, G., & Varshney, R. K. (2017). Genomic selection in plant breeding: Methods, models, and perspectives. *Trends in Plant Science*, 22(11), 961-975.

Mendes, R., Garbeva, P., & Raaijmakers, J. M. (2011). The rhizosphere microbiome: Significance of plant beneficial, plant pathogenic, and human pathogenic microorganisms. *FEMS Microbiology Reviews*, 35(5), 957-976.

Zampieri, M., Ceglar, A., Dentener, F., & Toreti, A. (2020). Wheat yield loss attributable to heat waves, drought and water excess at the global,

ISSN : 3048 - 989X

national and subnational scales. *Environmental Research Letters*, 15(10), 104017.

Sokol, N. W., Kuebbing, S. E., Karlsen-Ayala, E., & Bradford, M. A. (2018). Evidence for the primacy of living root inputs, not root or shoot litter, in forming soil organic carbon. *Ecology Letters*, 21(5), 668-677.

VanRaden, P. M., Olson, K. M., Null, D. J., & Hutchison, J. L. (2018). Predicting genomic fertility traits in dairy cattle. *Journal of Dairy Science*, 101(1), 650-665.

Zhang, X., Zhao, J., & Wang, H. (2019). Precision agriculture's role in sustainable agriculture. *Journal of Integrative Agriculture*, 18(4), 745-759.

Tester, M., & Langridge, P. (2010). Breeding technologies to increase crop production in a changing world. *Science*, 327(5967), 818-822.

Kumar, S., Kumari, R., & Singh, J. (2020). Role of bioinformatics in modern agriculture: A review. *Molecular Biology Reports*, 47(2), 2667-2677.

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). Big Data in Smart Farming–A review. *Agricultural Systems*, 153, 69-80.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Conservation Tillage Practices to Protect Soil Losses

Omprakash Rajwade[1], Sandeep Sharma[2] and Satyendra Gupta[3]

[1]Yong Professional-II, ICAR-National Institute of Biotic Stress Management, Raipur (C.G.)
[2]Senior Scientist & Head, Krishi Vigyan Kendra, Mainpath, (C.G.)
[3]Assistant Professor, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)

There are different types of land cultivation. Today, the use of conservation tillage is becoming more and more active, along with traditional methods. Conservation tillage can be an effective way to conserve soil, generate large yields, and promote agriculture's sustainability. FAO created the term Conservation Agriculture (CA) to describe a particular no-tillage system. According to the FAO definition, conservation agriculture aims to achieve sustainable and profitable agriculture and subsequently seek to improve livelihoods of farmers through the application of three principles: minimal soil disturbance, permanent soil cover and crop diversification. It is a way to combine profitable agricultural production with environmental concerns and sustainability and it has been proven to work in a variety of agro ecological zones and farming systems.

Key Principles of Conservation Tillage:

Conservation tillage is a soil cultivation technique that aims to reduce soil disturbance and erosion. The key principles of conservation tillage are:

- **Reduced Soil Disturbance:** Minimizing plowing and other tillage operations helps to maintain soil structure, reduce erosion, and improve water infiltration.
- **Soil Cover:** Maintaining a layer of crop residue on the soil surface throughout the year protects the soil from erosion, regulates soil temperature, and improves moisture retention. Leave a minimum of 30% of the soil surface covered by crop residues.
- **Diverse Crop Rotations:** Incorporating a variety of crops into the rotation helps to improve soil health, suppress weeds, and reduce the risk of disease.
- **Reduce erosion:** Conserve moisture by exposing a smaller volume of soil to erosion and evaporation.
- **Use biological products:** Use biological insecticides and fertilizers, and mild chemicals.

Benefits of Conservation Tillage:

- **Reduced Soil Erosion:** By minimizing soil disturbance and maintaining soil cover, conservation tillage significantly reduces wind and water erosion. This helps to protect topsoil, which is crucial for plant growth and overall soil fertility.
- **Improved Soil Health:** Reduced tillage promotes the growth of beneficial soil organisms, such as earthworms and microbes. These organisms improve soil structure, increase nutrient availability, and enhance water infiltration.
- **Increased Water Infiltration:** Conservation tillage practices improve soil structure, allowing water to infiltrate more easily into the soil. This helps to reduce runoff, recharge groundwater, and improve drought resistance.
- **Reduced Fuel Consumption and Costs:** Less tillage translates to lower fuel consumption and reduced equipment wear and tear, resulting in lower operating costs for farmers.

- **Improved Carbon Sequestration:** Conservation tillage practices can help to increase the amount of carbon stored in the soil, which plays a crucial role in mitigating climate change.

Challenges of Conservation Tillage:

- **Weed Control:** Reduced tillage can sometimes lead to increased weed pressure, requiring careful weed management strategies.
- **Equipment Investment:** Adopting conservation tillage may require an investment in specialized equipment, such as no-till planters and residue managers.
- **Soil Compaction:** In some cases, reduced tillage can lead to soil compaction, which can hinder root growth and reduce yields.

Practices of Conservation Tillage Systems

While each conservation tillage system is designed based on local conditions, there are some general principles and practices born out of research and experience from around the world over the past few decades.

1. No-Tillage (Zero-Till)

No tillage also known as zero tillage or direct seeding, is an agricultural technique that involves planting crops without prior soil tillage or disturbance. Instead of plowing or cultivating the soil, seeds are directly sown into the undisturbed soil. This method helps to conserve soil moisture, reduce erosion, and improve soil health by preserving the natural structure and organic matter. No till farming also reduces fuel consumption and greenhouse gas emissions, making it an environmentally friendly approach to agriculture.

2. Strip-Tillage

This type is also known as zonal tillage. The principle's essence is to divide a field into two parts: seedling and soil management. The first is processed mechanically to optimize the ground and microclimate. You shouldn't process the second one, just treat it with cover crops for conservation tillage systems. Additionally, rows can be made for better water penetration.

3. Ridge-Till

This kind of conservation tillage planting is characterized by creating beds with the special equipment's help; this process is called "scalping." It is suitable for spring crops, which is why it is gaining popularity in the United States to conserve soybeans and corn. The major problem with conservation tillage is the high cost of technology.

4. Mulch-Tillage

Mulching covers the ground with a layer of residues, which are cultivated with cultivators, sweeps, and chisels to mix with the soil partially. In this case, the mulch should cover one-third of the surface at least. The conservation tillage method was developed in the 1930s to combat wind erosion. Such a practice is suitable for large and small farmers alike when growing both annual and perennial crops.

5. Reduced or Minimum Tillage

The term minimum tillage has caused the greatest confusion because the minimum cultivation required to grow a crop varies from zero to a complete range of primary and secondary tillage operations depending on soil properties and crops. Reduced tillage allows a reduction in depth, degree, and frequency of tillage, while 'minimum tillage' refers to the minimum soil manipulation necessary for crop production or other soil tillage requirement. It often means any system that has few tillage requirements. It may also mean tillage of any part of the land, e.g. strip tillage or zonal tillage. It could also refer to a "stale-bed" in which the soil is ploughed at the end of the previous crop cycle. The crop is then seeded with a minimum of seedbed preparations performed at the onset of the next rains.

Minimum Tillage Practices Include:

A. Dibble Stick Planting

Planting stick or machete can be used to create holes to plant the seed in an un-ploughed field with stubble/crop residue. The cut hardwood stick from the bush is sharpened at one end and used to make planting holes. The holes are made in lines at evenly spaced intervals that make it easier to weed and apply fertiliser or manure.

B. Disc-Plant (Stubble-Harrowing)

This tool is used to loosen the soil, chop up crop residues and cut weeds. Afterwards planting is done without further soil disturbance and the crop residues are left on the surface

C. Strip and Spot Tillage

This involves scraping out shallow planting holes in un-ploughed soil, sowing the seed in the holes, then covering. This approach is common throughout the Sahel (Mali, Niger, Chad, and other countries). The only equipment needed is the hand hoe and a planting stick. You can plant in the dry or just after the rains. The following are the steps involved:

- Dig small shallow holes at the correct distance from each other. Make the holes just deep enough to plant the seeds.
- Put the correct number of seeds in the hole, and cover them with soil.
- About 2 weeks after the crop emerges, use a stick to make a hole about 10 cm away from each plant. Put fertiliser into the hole.

D. Ripping

A ripper is a chisel-shaped implement pulled by animals or a tractor. It breaks up surface crusts and opens a narrow slot or furrow in the soil, about 5 - 10 cm deep. In ripping, only shallow parallel furrows are cut using a ripper without disturbing the soil between the planting rows. The ripper should cut regular lines to facilitate subsequent weeding with ox-drawn weeders. Planting is usually done at the same time. The distance between the furrows depends on the recommended spacing for the crop. Ripping can reduce or eliminate the need for ploughing. The ripper is faster than ploughing, as tillage is limited to only a thin opening for planting.

Weed Management in Conservation Tillage System

- **Preventive Measures**: Preventive weed control encompasses all measures taken to prevent or arrest the introduction and arrest of weeds. Use fully decomposed manure, clean machinery or tool, use clean and good seed, weed seed screen to filter irrigation water, reduce weed seed bank.
- **Cultural Practices**: Tillage, mulching, inter-cultivation, intercropping, cover crops, crop rotation/diversification, higher seeding rate, Stale seedbed and narrow row spacing and other agro techniques.
- **Chemical Method**: before planting, the need for non-selective post emergence herbicide (e.g., glyphosate, paraquat and glufosinate) to control weed before planting crops would become inevitable.

Conclusion

Conservation tillage has become the standard, but implementation of conservation tillage systems is still being developed. Conservation tillage offers a sustainable and environmentally friendly approach to crop production. By minimizing soil disturbance, maintaining soil cover, and promoting healthy soil biology, these practices can help to improve soil health, reduce erosion, conserve water, and enhance agricultural productivity. While there are some challenges associated with conservation tillage, the long-term benefits for both the environment and farmers make it a valuable and increasingly important agricultural practice.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Organic Brinjal Cultivation

Dharmendra Bahadur Singh[1] and Rajiv[2]
Ph. D. Scholar[1] and Assistant Professor[2]
Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Introduction

Brinjal is one of the most common tropical vegetables grown in India. More commonly referred to as aubergine or aubergine, brinjal is a multipurpose vegetable that is farmed all over the world. Organic cultivation of brinjal has gained popularity due to increasing awareness of the harmful effects of chemical inputs on health and the environment. Organic farming not only ensures safe, chemical-free produce but also maintains soil fertility and biodiversity. Many cultivars differing in size, shape and colour of fruits are grown in India. Immature fruits are used in curries and a variety of dishes are prepared out of brinjal. Fruits are moderate sources of vitamins and minerals like phosphorous, calcium and iron and nutritive value varies from variety to variety.

Climate and Soil Requirements

Climate: Brinjal grows in warm and tropical areas. It prefers temperatures at 25°C to 30°C. Extreme temperatures can have an impact on germination and fruit set.

Soil: It thrives in well-drained, fertile loamy or clayey soil with a pH range of 6.0 to 7.5. Adding organic matter like compost or well-rotted farmyard manure improves soil structure and fertility.

Varieties

Pusa Purple Long

- It was developed at Indian Agricultural Research institute, New Delhi through pure line selection.
- Fruits are glossy, light purple in colour, 25-30cm long and smooth.
- It has a yield potential of 25-37 tones/ha.

Pusa Purple Round

- It was also evolved at Indian Agricultural Research Institute, New Delhi.
- The plants are very tall with a thick stem of greenish purple colour.
- Leaves are highly serrated and deep green in colour.
- Fruits are round with purple colour.
- Each fruit weighs on an average 130-140g.

Pusa Purple Cluster

- It is a cluster bearing type developed at Indian Agricultural Research Institute, New Delhi.
- Fruits are born in clusters.
- In cluster 2-3 fruits of dark purple colour, medium size fruits are present.
- Yield about 40-45tonnes/ha.

Arka Sheel

- It is a pure line selection from a Coorg type developed at Indian Institute of Horticultural Research, Bangalore.
- Fruits are medium long and deep purple in colour with less seed.
- It yields about 39 tones/ha in 120 days.

Seed Selection and Treatment

- Use high-quality, disease-free, organic seeds.
- Seed treatment with organic fungicides or biocontrol agents like Trichoderma or neem oil can prevent seed-borne diseases.
- Soak seeds in water for 24 hours to enhance germination.

ISSN : 3048 - 989X

Land Preparation

- Plow the field 2-3 times to remove weeds and break up clods. Add organic compost or farmyard manure at 20-25 tons per hectare during the final ploughing.
- Prepare raised beds or ridges and furrows for better water drainage, especially in areas with heavy rainfall.

Sowing and Planting

- Nursery Preparation: Seeds are usually sowed in a nursery. A well-prepared nursery bed with sufficient sunshine and proper drainage must be provided. Organic compost is placed to the nursery bed to provide nutrients.
- Transplanting: After 4-5 weeks, when the seedlings have 4-6 true leaves, they are prepared for transplant. Transplant them in rows, 60-75 cm separated, with 45-60 cm between each plant.

Organic Fertilization

- Apply well-decomposed organic manure like compost or vermicompost during land preparation.
- Use biofertilizers such as Azospirillum and Phosphobacteria to enhance nutrient availability.
- Liquid fertilizers like compost tea or cow urine can be applied during the growing season to promote healthy growth.

Irrigation

- Brinjal performs best with regularly avoids waterlogging. Irrigate every 4-5 days during the initial growing period, then every 7-10 days throughout flowering and fruiting.
- Drip irrigation is ideal for water conservation and maintaining uniform moisture.

Weed Management

Regular weeding is essential, particularly during the early stages of growth. Weeds can be controlled through hand weeding or mechanical methods. While mulching with organic materials such as straw, dry leaves, or grass clippings helps suppress weed growth and retain soil moisture.

Harvesting

Brinjal fruits are ready to harvest 60-80 days after transplanting. The fruits should be harvested when they are full size, shiny, and firm. Overripe fruits lose their glossy shiny appearance and becoming seedy, so regular harvesting is essential.

Yield

In organic farming, the yield of brinjal may be slightly lower than conventional farming. However, with good management practices, an average yield of 30-35 tons per hectare can be achieved.

Conclusion

Organic brinjal production not only provides safe and nutritious food, but it also helps to promote sustainable agriculture by enhancing soil health and minimizing the use of hazardous pesticides. Organic farmers may produce economic yields while protecting the environment by carefully managing pests, diseases, and soil nutrition.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Triple-Cross Method: A Way to Use Self-Incompatibility for Hybrid Development

K. Amarnath

Research Associate, Regional Agricultural Research Station, Nandyal, A.P., India

Self-incompatibility is the inability of a plant with hermaphrodite flowers producing developmentally functional male and female gametes to set seeds on self-pollination. This is, in effect, achieved by interposing a novel physiological barrier at any stage between pollination and fertilization. Where male sterility is non-existent, self-incompatibility can alternatively facilitate the production of F_1 hybrids in seed crops, forage, grasses, and ornamental plants to harvest the benefits of hybrid vigour. It can be used to produce single or double cross hybrids in the crops where self-incompatability has been identified and elaborated. The double cross hybrids are possible irrespective of the nature of self-incompatibility- gametophytic or sporophytic. Based on sporophytically controlled self-incompatability, Thomson (1959) was able to develop a double cross hybrid in marrow stem Kale (*Brassica oleracea var. acephala*). However, the production of selfed inbred seeds proved to be much laborious. In contrast, a triple-cross method of developing hybrid Kale, devised by Thompson (1964), is more desirable as the tedium involved in inbred seed production is considerably reduced.

The name "triple-cross method" was coined by him as there are three successive stages involving a single-cross, a three way cross and a final cross between two three-way hybrids. The triple cross hybrid is based on six different parental inbreds, each homozygous for an S allele and in each the reaction of pollen and style being essentially sporophytically controlled. The procedure of triple cross hybrid development in *B. oleracea var. acephala* involving six inbreds – A, B, C, D, E and F, all homozygous for 1 to 6 alleles, has been diagrammatically depicted in Fig. 1. Thus, for the production of almost 100 per cent hybrid seeds in the final cross, S allele 3 from inbred C must be active in pollen and style with both S alleles 1 and 2, and so the S allele 6 with both S alleles 4 and 5. If S allele 3 was inactive or recessive to either 1 or 2, then plants with the tow possible genotypes 13 and 23 from the three-way cross, would be cross-compatible with each other, when seeded with the other three-way cross to produce a triple-cross hybrid seed.

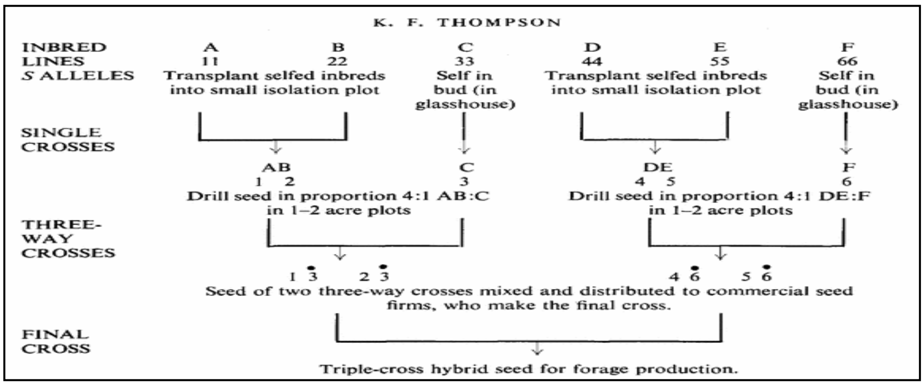


Fig. 1. Suggested method for the production of triple-cross hybrid Kale seeds (dots over S-alleles denote activity) (Courtesy: Thompson, 1964)

Thompson has further suggested that it is not essential for the six basic inbreds- A, B, C, D, E and F to be homozygous for six different S alleles – 1 2 3 4 5 6. If the S allele 1 was dominant to allele 2 in pollen and style, and so was the S allele 4 to 5, the same S allele, although not the same inbred, could be used for inbreds B and E. Further, if the S allele 3 or 6 were dominant in pollen and style to 1 and 2 or to 4 and 5, respectively, inbreds A and B could be homozygous for the same two S alleles as in inbreds D and E.

Advantages

1. Reduced amount of bud pollination, which is needed only for inbreds C and F, while all the four inbreds in a double cross hybrid are bud-selfed.
2. Superior winter survival
3. Better seed yield because triple cross hybrids are more vigorous and more seed-fertile than inbreds
4. Wider choice of inbred lines since inbreds that are too seed-sterile can also be used in triple-cross hybrids, but not in double cross hybrids.

Disadvantages

1. Existence of dominance relationships that may occur between tow S alleles in pollen and style, for example in Kale inbreds that tend to complicate the multiplication of a triple-cross hybrid.
2. It is restricted to a sporophytically controlled self-incompatibility system only, while the double-cross hybrid is not.
3. Lower forage yield and greater variability in triple-cross than in double-cross hybrid, since the former involves six inbreds and the latter only four.
4. Restriction on the rearrangement of inbreds in triple-cross poses further problems, but not so in double cross as C and F should necessarily be homozygous for S allele. However, this limitation can be offset by a wider choice of inbreds.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Role of Rural Entrepreneurs in Processing Technology in Millets

Anubha
Assistant Professor
Department of Rural Management, Ganga Global Institute of Management Studies, Ramzanpur, Begusarai

Background

Millets, often referred to as "nutri-cereals," have long been a staple in traditional diets, particularly in rural India. These drought-resistant grains, such as pearl millet, finger millet, and foxtail millet, are not only rich in nutrients but also vital for food security and sustainable agriculture. However, despite their advantages, millets have often been overshadowed by more popular cereals like wheat and rice. This has been largely due to the lack of efficient processing technologies and awareness about their nutritional benefits.

Rural entrepreneurs, with their grassroots knowledge of local agricultural systems, are key agents of change in transforming millet processing through innovation and technology. They are not only boosting the value chain of millets but also creating employment opportunities and contributing to rural development. By leveraging modern processing techniques—such as mechanized milling, fortification, and packaging—these entrepreneurs are enhancing the quality and shelf-life of millets, making them more attractive in both domestic and global markets.

Relevance to Bihar:

Bihar, with its vast rural population and agrarian economy, presents a unique opportunity for the promotion of millet cultivation and processing. Historically, millets have been grown in the state, particularly in arid and semi-arid regions where conventional crops like rice and wheat may not thrive as well. However, due to a lack of modern processing infrastructure and awareness, millet production in Bihar has remained largely underutilized.

Rural entrepreneurs in Bihar can play a transformative role in this process. By adopting and promoting modern millet processing technologies—such as de-hulling, milling, and fortification—entrepreneurs can create new opportunities for value-added products like millet flour, snacks, and health foods. These innovations not only increase the profitability of millet farming but also contribute to local economies by generating jobs in rural areas.

Moreover, promoting millet processing in Bihar can address key challenges like malnutrition and food insecurity. Given the state's high levels of undernutrition, especially among women and children, millets can provide a much-needed source of essential nutrients. Rural entrepreneurs, by developing millet-based food products, can ensure that these nutritious foods reach local markets, schools, and public distribution systems, helping improve overall health outcomes in the state.

With adequate support from government initiatives like the "Millet Mission" and access to financial and technical assistance, rural entrepreneurs in Bihar can unlock the potential of millets. This will not only revitalize traditional agricultural practices but also contribute to sustainable rural development, positioning Bihar as a leader in the millet value chain.

Current Scenario:

Millets, once a staple in many parts of India, are experiencing a resurgence due to their numerous health benefits and resilience to climate change. These nutrient-dense grains, including varieties such as pearl millet, finger millet, foxtail millet, and sorghum, are gaining global recognition as "superfoods" due to their rich content of proteins, fiber, vitamins, and

ISSN : 3048 - 989X

minerals. Despite this renewed interest, millets still face several challenges in terms of production, processing, and marketability.

Global and National Trends:

Globally, the demand for millets is on the rise, driven by the increasing consumer shift toward healthier, gluten-free, and climate-resilient crops. International bodies such as the United Nations have recognized the importance of millets, and 2023 was declared the "International Year of Millets" by the UN to promote the cultivation and consumption of these grains worldwide.

In India, millets were once widely cultivated, but their production declined significantly with the Green Revolution, which focused on high-yielding varieties of rice and wheat. However, in recent years, the Indian government has renewed its focus on millets as part of its strategy to promote sustainable agriculture and ensure food security. Initiatives like the "National Millet Mission" and various state-level programs have been launched to increase the production and consumption of millets, particularly in states like Karnataka, Maharashtra, and Tamil Nadu, where these grains have traditionally been grown.

Millets in Bihar:

Bihar has a history of millet cultivation, particularly in the drier, more arid regions. Despite their adaptability to Bihar's varying climatic conditions, millet cultivation has significantly declined over the years. Farmers in Bihar have largely shifted to more commercially viable crops like paddy and wheat due to better market access and government support for these staples. With increasing awareness about the environmental and health benefits of millets, efforts are being made to revive millet farming in Bihar. Several NGOs, government programs, and research institutions are promoting millets as a sustainable alternative crop, especially in drought-prone areas of the state.

Challenges in the Millet Value Chain:

Despite the growing awareness of millets, the crop faces several challenges that hinder its widespread cultivation and consumption:

1. Low Productivity: Traditional millet farming methods lead to lower yields compared to more commercial crops like wheat and rice. Without technological interventions, farmers often struggle with low productivity.

2. Processing Infrastructure: The lack of modern millet processing facilities—such as de-hulling, polishing, and packaging units—limits the availability of value-added millet products in the market.

3. Market Access: Farmers and rural entrepreneurs often face challenges in accessing markets that demand processed millet products, limiting their income potential.

4. Consumer Awareness: Millets are still not widely consumed, especially in urban areas where rice and wheat dominate. There is a need to raise awareness about the health benefits of millets to boost demand.

Opportunities:

The rising global demand for sustainable and nutritious foods presents an immense opportunity for rural entrepreneurs and farmers in India, especially in states like Bihar. With government initiatives promoting millet cultivation and the advent of modern processing technologies, there is potential for millets to regain their place as a key part of India's agricultural system. Further investment in millet value chains—from production to processing to marketing—can transform the current scenario and provide rural communities with increased incomes and nutritional security, while also contributing to climate-resilient agriculture.

Conclusion:

In summary, the resurgence of millets as a nutritious and climate-resilient crop presents significant opportunities, particularly for rural entrepreneurs in Bihar. By adopting modern processing technologies, they can enhance the value of millet products, extend their shelf life, and make them more appealing to consumers. This can lead to increased income for farmers, the creation of new jobs in rural areas, and the promotion of healthier food choices in local and national markets. The current challenges, including limited infrastructure, low consumer awareness, and poor market access, need to be addressed through greater investment in processing facilities, supportive government policies, and public-private partnerships. With the right support, rural entrepreneurs in Bihar can drive the millet value chain, transforming the crop into a vital contributor to the state's food security, nutrition, and rural economy.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Vegetable Pea (*Pisum sativum* L.): A Comprehensive Analysis of Its Cultivation, Importance and Water Management

Dr. Gurvinder Singh[1], Sambita Bhattacharyya[2], Sumit Gaur[2], Gopal Mani[3*]

[1]Professor, [2]Ph. D. Research Scholar, Department of Agronomy,
[3]Ph.D. Research Scholar, Department of Horticulture,
College of Agriculture, G.B. Pant University of Agriculture & Technology, Pantnagar, U. S. Nagar 263 145, Uttarakhand, India
[*]Correspondence Email: gaurgm97@gmail.com

Introduction

Vegetable pea (*Pisum sativum L.*) is a widely grown leguminous crop, primarily cultivated during the rabi (winter) season in India. Known for its rich nutrient profile, it is a significant source of protein, vitamins and minerals. Pea cultivation not only serves as a food crop but also plays an essential role in soil health due to its ability to fix atmospheric nitrogen. Understanding the crop's importance, production areas, and proper water management especially irrigation methods that avoid the harmful effects of traditional surface irrigation is crucial to enhancing its productivity.

Importance of Vegetable Pea

Vegetable peas are prized for their high protein content (20–25%), essential vitamins (A, C, and K), and minerals such as phosphorus, potassium and magnesium. This nutritional richness makes peas a staple in diets, especially in vegetarian cuisines. They are consumed fresh, frozen, canned, or dried and their versatility adds to their demand in global markets.

From an agronomic perspective, peas are a beneficial crop in rotations due to their nitrogen-fixing capabilities. Through symbiosis with *Rhizobium* bacteria, peas fix atmospheric nitrogen in the soil, reducing the need for synthetic fertilizers in subsequent crops.

Area, Production and Productivity in India and Uttarakhand

India is one of the world's leading producers of vegetable peas. The favourable agro-climatic conditions during the winter months support large-scale cultivation, especially in northern and central regions.

- **India**: The total area under vegetable pea cultivation in India is around 1 million hectares, with an annual production of 5.2 million metric tons. The average productivity is approximately 5.2 tons per hectare. Major pea-producing states include Uttar Pradesh, Punjab, Bihar, Madhya Pradesh and Haryana **(FAOSTAT, 2023)**.
- **Uttarakhand**: In Uttarakhand, the crop is cultivated both in the plains and in hilly regions during the winter. The state produces about 70,000 tons of peas annually, with an average yield of 3-4 tons per hectare. Peas are an important crop in this region due to the cooler climate, which is ideal for Rabi season cultivation **(Agricultural Statistics, 2023)**.

Cropping Systems and the Place of Vegetable Pea

Vegetable peas are typically grown in a Rabi season, but they are integrated into various cropping systems depending on the agro-climatic region. Common cropping systems with vegetable pea in India include:

1. **Wheat-Pea System**: This is a popular cropping system where vegetable pea is grown after the harvest of wheat during the Rabi season. The pea crop helps improve soil fertility and acts as a break crop in wheat monoculture.
2. **Maize-Pea System**: In regions with diverse climatic conditions, pea is grown after maize.

ISSN : 3048 - 989X

This system is commonly practiced in states like Punjab and Uttar Pradesh.

3. **Barley-Pea System**: Similar to the wheat-pea system, vegetable pea is grown after barley in areas with favourable agro-climatic conditions.
4. **Rice-Pea System**: In regions where rice is grown during the Kharif season, pea can be sown after rice in the Rabi season. This system is common in the Indo-Gangetic plains.
5. **Groundnut-Pea System**: In areas where groundnut is cultivated, vegetable pea is often grown as a second crop after harvesting groundnut. This system is practiced in states like Gujarat and Maharashtra.
6. **Soybean-Pea System**: In regions where soybean is grown during the Kharif season, pea can be cultivated after soybean harvest in the Rabi season.
7. **Sugarcane-Pea System**: In areas with sugarcane cultivation, pea is grown after sugarcane harvest during the Rabi season, making use of residual moisture and soil nutrients.
8. **Cotton-Pea System**: In some areas, particularly in central and southern India, vegetable pea is grown as a secondary crop after cotton during the Rabi season.

These systems help improve soil health, enhance yield, and reduce pest and disease pressure, making vegetable pea a beneficial crop in mixed cropping systems.

Average Duration of Vegetable Pea

Vegetable pea is a short-duration crop, with an average growing period of around 90 to 120 days from sowing to harvest. This duration may vary depending on the variety and climatic conditions. Early-maturing varieties may be harvested in as little as 60–70 days, while late-maturing varieties may take up to 120 days. The most critical growth phases, particularly in terms of water requirements, germination, flowering and pod development.

Water Requirement of Vegetable Pea

Peas have a moderate water requirement, needing around **350 to 450 mm** of water during their growth cycle. Adequate moisture is crucial for various growth stages, particularly during:

- **Germination**: Moisture is essential for uniform germination and seedling establishment.
- **Flowering and Pod Development**: Water stress during flowering can cause flower abortion, while moisture at pod-filling stages is critical for proper pod development and yield.
- **Maturity**: Reduced water supply at the maturation stage helps prevent waterlogging and fungal diseases that may affect the crop's quality and storage life.

Harmful Effects of Surface Irrigation on Vegetable Pea

Surface irrigation, commonly practiced in traditional farming systems, involves flooding fields or using furrows or basins for water application.

While it is simple to implement, it has several drawbacks, especially in vegetable pea cultivation.

1. **Water logging**: Peas are highly sensitive to water logging, as they require well-drained soils for optimal growth. Surface irrigation often leads to over-irrigation, resulting in poor drainage. Waterlogged conditions create an anaerobic environment around the roots, preventing the uptake of essential nutrients and leading to:
    - **Yellowing of Leaves (Chlorosis)**: Excess water interferes with nitrogen absorption, causing leaves to turn yellow and reducing the overall photosynthetic efficiency of the plant.
    - **Root Rot and Other Fungal Diseases**: Prolonged exposure to saturated soils increases the risk of root rot and fungal infections such as damping-off and powdery mildew. These diseases severely impact plant health and reduce crop yields.

ISSN : 3048 - 989X

2. **Pod Filling and Flower Drop**: Uneven water distribution in surface irrigation can lead to moisture stress in certain parts of the field while causing water logging in others. Moisture stress, particularly during the flowering and pod development stages, results in poor pod formation, reduced pod size, and increased flower and pod drop. This reduces the overall productivity and market value of the crop.
3. **Soil Erosion**: In areas with slight slopes or loose soil, surface irrigation often causes runoff, leading to soil erosion. Erosion not only removes the fertile topsoil but also leads to nutrient loss, degrading the soil quality over time. This further impacts the yield potential of future crops.
4. **Inefficient Water Use**: Surface irrigation is notoriously inefficient, with a significant portion of the water being lost to evaporation and deep percolation. Given the increasing water scarcity in many agricultural regions, such inefficiencies contribute to unsustainable water management and limit the availability of water during critical periods in the crop cycle.

Water Management Practices for Vegetable Pea

Given the harmful effects of surface irrigation, adopting modern irrigation techniques is crucial for optimizing water use and enhancing vegetable pea yields. Micro-irrigation systems, including drip irrigation and sprinkler irrigation, have been shown to mitigate the risks associated with waterlogging and moisture stress.

1. **Drip Irrigation**: Drip irrigation delivers water directly to the root zone through a network of pipes and emitters. This method is highly efficient, allowing precise control over the amount of water applied.

Advantages:

- By maintaining optimum soil moisture, drip irrigation prevents waterlogging and reduces the risk of yellowing leaves and root diseases.
- Uniform water distribution leads to better plant growth and improves pod filling, enhancing both the quantity and quality of the yield.
- Drip systems also facilitate fertigation (the application of fertilizers through the irrigation system), ensuring that nutrients are efficiently delivered to the plants.

2. **Sprinkler Irrigation**: Sprinkler irrigation mimics natural rainfall by distributing water uniformly across the field through a series of sprinklers. This method is particularly suitable for areas with uneven terrain or light soils prone to erosion.

Advantages:

- Sprinkler irrigation helps in maintaining uniform soil moisture and reduces the chances of water logging. This is crucial for avoiding fungal infections and flower drop.


Fig 1. Flooding and Furrow Irrigation

Fig 2. Drip Irrigation and Sprinkler irrigation

- It reduces water wastage by applying water only when necessary and prevents over-irrigation.
- Sprinkler systems can cover large areas efficiently, making them ideal for larger fields or hilly regions like Uttarakhand.

Benefits of Micro-Irrigation over Surface Irrigation

1. **Enhanced Water-Use Efficiency**: Micro-irrigation methods (drip and sprinkler) ensure that water is applied directly to the plants, minimizing losses due to evaporation, runoff, or deep percolation. This results in better water-use efficiency and helps farmers conserve water resources, especially in regions facing water scarcity.
2. **Reduced Disease Incidence**: By avoiding water logging, micro-irrigation systems significantly reduce the risk of soil-borne diseases such as root rot and damping-off. Healthy root systems ensure better nutrient uptake and plant vigour, leading to higher yields.
3. **Improved Yield and Quality**: Consistent moisture levels maintained by drip or sprinkler irrigation systems prevent the water stress that typically leads to flower drop and poor pod filling. As a result, micro-irrigation systems improve both the quantity and quality of the vegetable pea crop.
4. **Suitability for Hilly Regions**: In hilly regions like Uttarakhand, where vegetable peas are commonly grown, micro-irrigation systems are particularly advantageous. They can be adapted to uneven terrain, preventing soil erosion and ensuring uniform water distribution across the field.

Conclusion

Vegetable pea is a vital crop in Indian agriculture, particularly during the Rabi season. However, traditional surface irrigation methods pose significant challenges to pea cultivation, including water logging, poor pod filling, and increased disease pressure. The adoption of micro-irrigation systems such as drip and sprinkler irrigation can address these challenges by improving water-use efficiency, reducing disease incidence, and enhancing overall crop productivity. As water becomes an increasingly scarce resource, these modern irrigation practices are essential for sustainable pea cultivation

References

Agricultural Statistics, 2023. https://www.indiastat.com/uttarakhand-state/data/agriculture/peas-1465308

Bhardwaj, R. and Kaur, J. 2022. Advances in pea cultivation practices. *Agricultural Reviews*, 43(3): 321-331.

Global Food and Agriculture Statistics of FAO/FAOSTAT. 2023. https://www.fao.org/land-water/databases-and-software/crop-information/pea/en/

Kumar, S. and Sharma, P. 2021. Water management in legumes: A case study on peas. *Irrigation Science*, 39(2): 123-134.

Singh, R. 2020. Sustainable cultivation of vegetables in India. *Journal of Horticultural Science*, 15(4): 231-242.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

The Heat is On: Climate Change and its Toll on Dairy Animal Health

Dr. Sowjanya Lakshmi, R.K, Dr. M. Yugandhar Kumar, Dr. Shaik N. Meera

Krishi Vigyan Kendra, SVVU, Lam, Guntur

Introduction

Climate change is a global phenomenon that continues to cause profound changes in environmental conditions, and its effects on agriculture are increasingly noticeable. Among the sectors most vulnerable to these changes is the dairy farming industry, particularly in regions like South Asia, where agriculture and livestock farming are integral to the economy and food security. Dairy cattle, in particular, are sensitive to shifts in environmental factors, especially temperature. Elevated temperatures and the frequency of extreme heat events are major consequences of global warming, leading to significant impacts on the health, productivity, and welfare of dairy animals. Dairy farming is uniquely vulnerable to heat stress due to the physiological characteristics of dairy cattle and their metabolic demands.

The Direct Effects of Heat Stress on Dairy Animals

a) Metabolic Disorders

Dairy cattle exhibit a series of physiological responses when exposed to heat stress. The most noticeable of these is an increase in body temperature, often accompanied by an increase in respiration rates. These adaptations are the animal's way of attempting to maintain thermal homeostasis and prevent overheating. However, while these responses are essential for cooling, they also contribute to metabolic disruptions. One of the first consequences of heat stress is a reduced feed intake. Dairy cattle typically consume less food when temperatures rise above 25°C, which can significantly affect their overall nutritional intake. This reduced intake during heat waves often leads to negative energy balance. The body, in an attempt to compensate for this imbalance, mobilizes energy stores such as fat, leading to the release of free fatty acids. However, in cases of prolonged stress, this process can trigger ketosis—a condition where there is an abnormal accumulation of ketones in the body due to insufficient energy.

Furthermore, ruminal acidosis can develop due to the combination of reduced feed intake and the shift in feeding patterns. When dairy cattle eat less during the day and then compensate by eating larger amounts at night, they may develop an imbalance in rumen pH, leading to a decrease in fiber digestion and the onset of ruminal acidosis. Over time, this can lead to serious conditions like laminitis (inflammation of the hooves), which causes lameness and reduced mobility. Laminitis is one of the most painful and debilitating conditions for dairy cattle, and heat stress exacerbates its development.

b) Oxidative Stress

One of the most significant direct consequences of heat stress in dairy cattle is oxidative stress. Under normal conditions, the body's antioxidant mechanisms protect cells from damage caused by reactive oxygen species (ROS). However, under heat stress, the production of ROS accelerates due to the elevated metabolic rate required to regulate body temperature. This imbalance between antioxidants and ROS leads to oxidative damage at the cellular level. In heat-stressed dairy cattle, this oxidative stress impairs the function of vital organs and tissues. Studies have shown that during hot weather, the total antioxidant status of dairy cattle, especially in the peri- and postpartum periods, decreases significantly.

This reduction is coupled with increased activity of antioxidant enzymes such as superoxide dismutase and glutathione peroxidase, which are activated to combat the ROS.

Despite these adaptive responses, the high temperatures lead to a depletion of essential antioxidants like vitamin E and carotenoids, which are crucial for maintaining immune function and reproductive health. The depletion of these antioxidants further contributes to the deterioration of health and productivity, as dairy cattle become more vulnerable to infections and diseases.

c) Immunosuppression

Heat stress is also known to impair the immune system, making dairy cattle more susceptible to infections. The stress hormones released during periods of high heat, such as corticosteroids, can suppress immune function, reducing the ability of the body to fight off pathogens. This immunosuppression is particularly concerning for dairy farms that rely on high milk production, as it predisposes cattle to diseases like mastitis (inflammation of the udder). Mastitis is a significant concern for dairy farmers, as it leads to reduced milk yield, increased veterinary costs, and potential loss of herd members.

The extent of immune suppression varies depending on several factors, including the animal's breed, age, prior exposure to heat stress, and the level of production. High-producing dairy cows, in particular, are more susceptible to immune dysfunction due to their increased metabolic demands. The cumulative effects of poor immune response and the associated risk of infections underline the urgency of addressing heat stress in dairy cattle through improved management practices.

d) Mortality

In regions where heat stress is prolonged or becomes extreme, heat-induced mortality is a significant concern. Dairy cattle are particularly vulnerable to extreme heat because of their large body mass and high metabolic rate. During heat waves, the combination of high temperatures and humidity can cause heat exhaustion or heat stroke, which, in severe cases, can be fatal. Factors that increase the risk of mortality include the cow's age, nutritional status, and breed. Exotic dairy breeds, which are often imported for their high milk yields, are particularly susceptible to heat stress compared to native, heat-tolerant breeds. For example, Bos indicus (Zebu) cattle, which are adapted to warmer climates, exhibit higher heat tolerance than Bos taurus cattle, which are more common in cooler regions. The temperature-humidity index (THI) is a valuable tool for predicting heat stress and mortality risk. THI values above 80 (daily maximum) and 70 (daily minimum) are associated with significantly higher mortality rates.

The Indirect Effects of Heat Stress

a) Reduced Feed Intake

In addition to the direct effects of heat stress, there are several indirect effects that further complicate the management of dairy cattle in a changing climate. One of the most immediate responses to rising temperatures is a decline in feed intake. This physiological response is part of the animal's strategy to reduce metabolic heat production. When the ambient temperature exceeds 25–27°C, dairy cattle tend to reduce their voluntary feed intake. As the temperature rises further, reaching 35°C and beyond, this reduction in feed intake can range from 10% to as much as 35%. This reduced intake results in a negative impact on milk production and overall health, as the cattle are unable to meet their nutritional needs.

In addition to reduced feed intake, thermal stress also affects the digestion process. Heat stress reduces the efficiency of the gastrointestinal tract, leading to impaired nutrient absorption. Blood flow is redirected away from the gut toward the skin to aid in heat dissipation, which limits the supply of oxygen and nutrients to the digestive system, further compounding the negative effects on nutrient uptake.

b) Disturbances in Endocrine Function

Heat stress also disrupts the hormonal regulation in dairy cattle. The thyroid gland plays a crucial role in regulating metabolism, and heat stress can affect its function. Studies show that under heat stress, there is a reduction in thyroxine (T4) levels, which in turn increases the levels of tri-iodothyronine (T3). This imbalance can affect the cow's ability to maintain gastrointestinal motility, disrupting the digestion and absorption of nutrients. Additionally, heat stress leads to a decrease in aldosterone production, which impairs sodium reabsorption in the kidneys, leading to electrolyte imbalances. These disruptions in the endocrine system further exacerbate the negative effects of heat stress.

c) Electrolyte Imbalance and Energy Metabolism

Electrolyte imbalances due to heat stress are compounded by increased sweating and a reduction in mineral intake. Potassium, sodium, and other essential electrolytes are lost through sweat, and this imbalance can lead to dehydration and metabolic disorders. The reduced aldosterone secretion further disrupts sodium reabsorption, which can cause severe issues for the animal's health. Furthermore, the energy demands of thermoregulation—such as maintaining body temperature and cooling the body—lead to an increase in the maintenance energy requirements of dairy cattle. This increase can reach up to 20–30%, leaving less energy available for milk production and growth.

d) Reproductive Performance

One of the most notable indirect effects of heat stress is its impact on reproductive performance. Heat stress disrupts the secretion of reproductive hormones, leading to reduced estrus intensity, ovarian cyst formation, and lower conception rates. Dairy cows that experience heat stress during breeding may have difficulty conceiving, and the heat-induced stress may also result in embryonic mortality and prolonged calving intervals. The negative impact of heat stress on reproductive health is particularly concerning for dairy operations that rely on high reproductive efficiency for profitability. In males, heat stress impairs spermatogenesis, leading to poor semen quality and lower fertility.

The Impact on Disease and Health

Another significant concern arising from the combined effects of heat stress and climate change is the increased risk of vector-borne diseases. Rising temperatures create favorable conditions for the proliferation of vectors such as insects, which transmit diseases like gastrointestinal nematodes and tick-borne diseases. Heat stress weakens the immune system, making dairy cattle more susceptible to these diseases. The spread of pathogens and their vectors, combined with the compromised immune function due to heat stress, puts dairy cattle at even greater risk, exacerbating the overall health challenges faced by the industry.

Summary

Climate change presents significant challenges for the dairy farming industry, particularly with the increasing incidence and intensity of heat stress. This rising challenge requires immediate attention and action to protect animal health and sustain productivity. While there are ways to mitigate the effects of heat stress, such as improving cooling systems, modifying feeding practices, and adjusting farm management, the long-term solution lies in addressing the root causes of climate change. Reducing greenhouse gas emissions is crucial in the effort to minimize the adverse effects of climate change on dairy animals. In addition, adopting adaptive management practices that are tailored to the specific needs of different regions and breeds will be essential for ensuring the continued sustainability of the dairy industry in the face of a warming climate.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

The Science Behind the Fragrance of Flowers: Why Do Plant Smell So Good?

Khushboo Kumari Bharti

Late Chadrasekhar Ji Purva Pradhanmantri Smarak Mahavidiyalaya, Rampur, kanva, Seorai, Gahmar, Ghazipur, 232 333, Uttar Pradesh, India

The enchanting fragrance of flowers has captivated human senses for centuries. Beyond their aesthetic appeal, floral scents play a pivotal role in the survival and reproduction of plants. This article explores the evolutionary, ecological, and chemical foundations of floral fragrances, detailing how plants use these scents to attract pollinators, deter herbivores, and communicate with other organisms. The chemical compounds responsible for floral aromas, including terpenes, phenylpropanoids, and fatty acid derivatives, are discussed alongside their roles in plant-pollinator interactions. Additionally, the article examines the human fascination with floral scents and their cultural, therapeutic, and commercial significance. The intricate interplay between plants and their environment underscores the ecological importance of floral fragrances, making them a cornerstone of biodiversity and ecological stability.

Introduction

Flowers are nature's masterpieces, admired not only for their colors and shapes but also for their captivating fragrances. The pleasant aroma of flowers, such as roses, jasmine, and lavender, serves crucial functions in the natural world, primarily centered around reproduction and survival. This article delves into the scientific mechanisms behind floral fragrances, exploring their evolutionary purpose, chemical composition, ecological importance, and relevance to humans.

Why Do Flowers Produce Fragrance?

1. Attracting Pollinators

The primary function of floral fragrance is to attract pollinators such as bees, butterflies, birds, and bats. Volatile organic compounds (VOCs) emitted by flowers act as olfactory signals, guiding pollinators to the plant's nectar and pollen. Each species produces a unique blend of VOCs tailored to its specific pollinators.

For example:

Daytime pollinators: Bees and butterflies are drawn to sweet, floral scents.

Nocturnal pollinators: Moths and bats prefer musky or strong aromas.

2. Repelling Herbivores and Pests

Floral fragrances can also serve as natural deterrents against herbivores and harmful insects. Certain bitter or pungent aromas signal toxicity or unpalatability, protecting the plant from being consumed.

3. Facilitating Plant Communication

Some plants release specific VOCs to communicate with neighboring plants. For instance, when under attack by pests, a plant might emit warning signals, prompting nearby plants to activate their defense mechanisms.

The Chemistry of Floral Fragrances

Floral scents are composed of a complex mix of volatile organic compounds, including:

1. Terpenes

Example: Linalool, found in lavender, contributes a sweet, floral aroma.

Function: Attracts pollinators and deters predators.

2. Phenylpropanoids

Example: Benzyl acetate, responsible for the fruity aroma of jasmine.

Function: Enhances flower-pollinator recognition.

ISSN : 3048 - 989X

3. **Fatty Acid Derivatives**

Example: Methyl jasmonate, which imparts green, fresh notes.

Function: Plays a role in plant defence and signalling.

The specific blend and concentration of these compounds depend on the plant's genetic makeup and environmental factors such as temperature, humidity, and soil composition.

Ecological and Evolutionary Significance

Floral fragrances are essential for ecological balance and biodiversity. They:

Ensure plant reproduction through pollinator attraction.

Maintain food webs by supporting pollinator populations.

Enhance genetic diversity through cross-pollination.

The co-evolution of plants and their pollinators has created intricate ecological relationships, ensuring mutual survival and ecosystem stability.

Human Fascination with Floral Fragrances

1. **Evolutionary Connection**

Humans may have evolved to associate floral scents with beneficial resources like food and medicine, leading to a natural affinity for these aromas.

2. **Cultural and Therapeutic Importance**

Floral fragrances have been integral to rituals, perfumery, and healing practices across cultures. Aromatherapy, for example, utilizes essential oils derived from flowers to promote relaxation, reduce stress, and enhance mood.

3. **Commercial Applications**

The perfume and cosmetic industries rely heavily on floral scents, often recreating natural fragrances synthetically to meet global demand.

Modern Research and Applications

Advances in genetic engineering and biotechnology have enabled scientists to:

Enhance the fragrance of flowers for ornamental purposes.

Develop synthetic versions of floral scents for sustainable use.

Explore the potential of floral VOCs in pest control and crop protection.

Conclusion

The fragrance of flowers is a result of millions of years of evolution, serving critical roles in pollination, protection, and communication. For humans, these scents provide aesthetic pleasure, cultural significance, and therapeutic benefits. Understanding the science behind floral fragrances highlights their ecological importance and underscores the need to preserve biodiversity, ensuring these natural wonders continue to thrive.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Water Use Efficiency (WUE) and Crop Productivity (CP)

Mahendra Junjariya[1] and Komal Kumawat[2]

[1*] Ph.D. Research Scholar, Department of Agronomy, Agriculture University, Jodhpur, Rajasthan
[2]M.sc Scholar, Department of Agronomy and Agro meteorology, College of Agriculture, Rani Lakshmi Bai Central Agriculture University Jhansi, Uttar Pradesh

1. Introduction

Water scarcity is one of the greatest challenges in modern agriculture, especially in the face of climate change, growing populations, and increasing competition for freshwater resources. In this context, maximizing **Water Use Efficiency (WUE)** and optimizing **crop productivity** are critical for ensuring global food security. Understanding the relationship between water management and crop yields is fundamental for developing sustainable agricultural practices. This paper provides an in-depth analysis of the concepts of WUE and crop productivity, explores their interconnections, and highlights strategies to improve both through innovative agricultural techniques.

2. The Concept of Water Use Efficiency (WUE)

Water Use Efficiency (WUE) refers to the ratio of crop yield (biomass or economic output) to the amount of water used in crop production. WUE is an essential parameter for assessing how efficiently water is utilized in the agricultural production process, especially in regions prone to drought or experiencing water scarcity.

2.1. Defining WUE

WUE can be measured in several ways, depending on the perspective and the type of output being considered. Two common definitions of WUE are:

- **Biomass-based WUE**: The amount of biomass produced per unit of water used (typically measured in grams of dry matter per liter of water).
- **Economic WUE**: The economic return (e.g., profit or crop value) generated per unit of water used (measured in dollars or local currency per liter of water).

Mathematically, WUE can be expressed as:

$$WUE = \frac{\text{Crop yield (kg or g)}}{\text{Water used (L or mm)}}$$

Where crop yield can be either the total biomass (dry matter) or marketable produce, and water use is the amount of water applied through irrigation or precipitation that contributes to crop growth.

2.2. Types of Water Use Efficiency

Water Use Efficiency can be divided into different categories based on the specific agricultural practices, including:

- **Agronomic WUE**: Refers to the yield per unit of water applied in the form of irrigation.
- **Physiological WUE**: Refers to the ratio of biomass produced to the total transpiration (water lost through plant leaves) during the growth period.
- **Irrigation WUE**: Focuses on the efficiency of irrigation water application, ensuring that water is applied when and where it is needed most.

Each type of WUE provides valuable insights into how water resources are being utilized in agricultural systems.

2.3. Factors Affecting WUE

Several factors affect WUE, including:

- **Climate and Weather**: Temperature, humidity, and rainfall influence plant water requirements.

- **Soil Properties**: Soil type, structure, and moisture retention capacity determine how effectively water is absorbed and used by crops.
- **Crop Variety**: Some crops are more water-efficient than others, exhibiting better adaptation to dry conditions or utilizing water more efficiently during their growth stages.
- **Agronomic Practices**: Practices such as irrigation scheduling, crop rotation, mulching, and the use of drought-tolerant varieties can all influence WUE.
- **Water Management Practices**: Proper irrigation systems, including drip and sprinkler systems, help minimize water wastage and improve WUE.

2.4. Improving WUE

To enhance WUE, it is crucial to adopt integrated water management practices, such as:

- **Use of drought-resistant crop varieties** that require less water for optimal growth.
- **Precision irrigation** techniques that deliver the right amount of water at the right time.
- **Rainwater harvesting** and efficient storage systems to supplement irrigation during dry periods.
- **Soil moisture monitoring** to ensure water is applied according to crop needs, reducing waste.
- **Conservation tillage** to improve soil structure and moisture retention.

3. The Concept of Crop Productivity

Crop productivity refers to the ability of a crop to produce a specific output, often measured in terms of crop yield (tonnes per hectare) or biomass accumulation over a given period. It reflects how well a plant converts sunlight, water, and nutrients into useful outputs, such as grains, fruits, or fiber.

3.1. Defining Crop Productivity

Crop productivity is influenced by the genetic potential of the crop, environmental conditions, and management practices. The fundamental components of crop productivity are:

- **Biological Yield**: The total amount of biomass or plant material produced, regardless of its economic value.
- **Economic Yield**: The portion of the biological yield that has commercial value, such as grains, fruits, or other consumable products.

Productivity is often expressed in terms of **crop yield per unit area** (e.g., tons per hectare), but it can also refer to the efficiency with which inputs (e.g., water, nutrients) are converted into output.

3.2. Factors Influencing Crop Productivity

Several factors influence crop productivity:

- **Genetics**: The inherent characteristics of the plant species and its variety determine its maximum yield potential under optimal conditions.
- **Environmental Factors**: Climate, temperature, rainfall, and soil quality have a profound impact on how well crops can grow and yield.
- **Management Practices**: Agricultural techniques, such as fertilization, irrigation, pest control, and crop rotation, all contribute to maximizing crop productivity.
- **Soil Fertility**: Adequate soil nutrients are crucial for plant growth. Deficiencies in nitrogen, phosphorus, or potassium can severely limit crop yields.
- **Pests and Diseases**: Pest infestations or disease outbreaks can reduce crop productivity by damaging plants or reducing their ability to photosynthesize.

3.3. Enhancing Crop Productivity

To enhance crop productivity, several strategies can be employed:

- **Breeding and Biotechnology**: Development of high-yielding, disease-resistant, and drought-tolerant varieties.
- **Optimized Fertilizer Application**: Proper fertilization techniques to provide essential nutrients while avoiding excess.

- **Integrated Pest Management**: A combination of biological, chemical, and cultural practices to control pests and diseases.
- **Adoption of Precision Agriculture**: Technologies like GPS and sensors help in monitoring crop health, soil conditions, and optimizing inputs like water and nutrients.
- **Sustainable Practices**: Practices like conservation tillage, crop rotation, and agroforestry contribute to long-term sustainability and productivity.

4. Interconnection Between WUE and Crop Productivity

Water Use Efficiency and crop productivity are intricately linked. While maximizing productivity is the goal of any agricultural system, it cannot be achieved without considering the efficient use of water, especially in areas with limited water resources.

4.1. Water and Crop Yield

Water is the primary medium through which nutrients and minerals are transported within the plant. Adequate water supply is essential for photosynthesis, growth, and ultimately, crop yield. However, excessive or insufficient water can reduce productivity:

- **Water Deficit**: Under conditions of water scarcity, plants suffer from **water stress**, leading to reduced growth and productivity.
- **Waterlogging**: Over-irrigation can lead to waterlogging, depriving roots of oxygen and reducing crop productivity.
- **Optimal Irrigation**: Efficient irrigation, ensuring that crops receive water when needed most, can significantly enhance WUE and boost crop yields.
-

4.2. Maximizing Both WUE and Productivity

To maximize both WUE and crop productivity, the following measures should be considered:

- **Climate-Resilient Crops**: Utilizing varieties of crops that are not only high-yielding but also drought-resistant can ensure both high productivity and efficient water use.
- **Efficient Irrigation Practices**: Adopting precision irrigation systems such as drip irrigation, which deliver water directly to the plant roots, minimizes wastage and ensures optimal growth conditions.
- **Agroecological Approaches**: Integrating soil conservation, water management, and biodiversity conservation can ensure long-term improvements in both WUE and productivity.

5. Conclusion

As agricultural systems continue to evolve in response to climate change, global population growth, and environmental degradation, the concepts of **Water Use Efficiency** and **crop productivity** become increasingly critical. Improving WUE ensures that water, a limited resource, is used optimally to produce food, while increasing crop productivity ensures that global food demands are met. By adopting innovative techniques, sustainable practices, and better water management strategies, farmers can significantly improve both WUE and crop productivity, contributing to global food security and sustainable agriculture.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Flax (*Linum usitatissimum*) Genomics: Unlocking the Potential for Improved Yield, Disease Resistance, Quality Traits, and Human Health

Dr. Vinay Kumar Singh

Centre for Bioinformatics, School of Biotechnology, Institute of Science, Banaras Hindu University, Varanasi 221 005, Uttar Pradesh, India

"*Linum usitatissimum*, flax, is one of the most versatile crops that have important historical and modern significance in agriculture, industry, and medicine. The crop has been grown for thousands of years for its seeds, which are processed into linseed oil, and its fibers, which play a crucial role in textile production. Recent advances in genomic research have furnished deeper insights into its genetic makeup, which promises to enhance the breeding of flax, augment crop yields, and generate new biotechnological applications. This review gives a comprehensive view of the biology, genetics, and genomics of flax, which reflects the wide applications of the crop and discusses the latest breakthroughs in its genetic study, which promise to pave the way for more sustainable and efficient flax cultivation and utilization."

Introduction

Linum usitatissimum belongs to the Linaceae family; it is naturally found in the Mediterranean region and has spread over the world. It is so versatile in all its applications be it food, textiles, and medicine. There is a high historical significance about the production of linen. From time immemorial, seeds of flax were valued for rich content of essential fatty acids - omega-3, lignans, and fibers, providing valuable nutritional and medical benefits. The plant's tolerance to varying climatic and soil conditions, coupled with its economic value, has encouraged ongoing research on its cultivation. Flax mainly produces two products: seeds that are very nutrient-dense and stalks from which linen is processed. Progress in genetic research has been able to develop breeding techniques that better match specific expectations, such as improving crop yield, enhancing disease resistance, and improving the quality of both flax fibers and oil.

Botanical Characteristics

Linum usitatissimum is an annual herb with a growth range of 30 to 120 cm in height. The leaves are alternate, lance-shaped, and attached to slender stems. Its small flowers have five petals, typically blue or white. Flax seeds are small and oval in shape with a light brown, golden yellow, or dark brown color. The plant is primarily self-pollinating but may experience cross-pollination in specific environmental conditions. This is a rather versatile crop, grown in temperate and subtropical regions. Major cultivation countries include Canada, China, parts of Europe, and India.

Flax prefers fertile, well-drained soils and a moderate to cool climate. Though flax is tolerant of droughts, it requires good water supply during its growing season for high seed yields. Seeds of this plant are rich in linseed oil, which is widely used as a food item, industrial coating, paint, and as a dietary supplement. The plant's fibers are extracted from its stems and processed into linen, a strong textile used in garments and home fabrics. Flax seeds are very rich in their content of omega-3 fatty acids, fiber, and lignans, and these are factors that contribute to the many health benefits associated with flax seeds. In addition, flax is medicinal, offering anti-inflammatory and even anti-cancer properties from bioactive compounds such as lignans.

Genetic and Genomic Overview

The genome of the flax *Linum usitatissimum* consists of 15 chromosomes and about 370 million base pairs, rendering it rather complex. Inflax heterozygosity levels are indeed highly high and create problems when considering breeding; nevertheless, significant possibilities for boosting the genetic pool also exist. The sequencing of a reference genome has greatly enhanced understanding of flax's genetic structure, providing insights into gene content, regulatory mechanisms, and potential targets for genetic enhancement. While flax has a smaller genome size compared to most other crops, it shows complex gene expression patterns, especially in areas like fiber quality, seed composition, and disease resistance.

The genome of flax has an estimated range of 33,000 to 43,000 protein-coding genes that engage in various biochemical processes, from oil production to cell wall synthesis and disease resistance. Flax fibers, just like those from other plants, contain lignin, a polymer that makes their fibers strong and durable. A key gene, found in lignin biosynthesis pathways, holds some promise as an opportunity for better fiber quality. Flax is particularly abundant with omega-3 fatty acids, especially with alpha-linolenic acid, and several new studies uncovered genetic pathways leading to the creation of alpha-linolenic acid. Flax displays a strong level of heterozygosity in itself, most of its diversity located in the wild relatives of this crop species. Ongoing research into the flax gene pool underlines the possibility of improving such traits as drought and disease resistance, and increased oil content, through marker-assisted selection and genetic engineering.

Table 1: Available *Linum usitatissimum* Genomes in NCBI database

Assembly Accession	Assembly Name	Organism Infraspecific Names Cultivar	Assembly Level	WGS project accession	Assembly Stats Number of Scaffolds
GCA_030674075.2	EIMB_LUsi_3896_2.0	line 3896	Contig	JAUJYP02	
GCA_000224295.2	ASM22429v2		Chromosome		15
GCA_010665275.2	ASM1066527v2	longya 10	Chromosome	QMEI02	1608
GCA_014858635.1	EIMB_Lusi_1	Atlant	Contig	JACHUY01	
GCA_010665265.1	ASM1066526v1	Heiya 14	Scaffold	QMEH01	2772

Molecular Breeding and Biotechnology

Recent advances in flax genomics have made it possible to develop molecular markers associated with major agronomic traits. These markers are being used in MAS to accelerate breeding efforts that focus on seed yield, oil quality, disease resistance, and fiber properties. Although flax is drought-tolerant, scientists are working to enhance its drought resistance through genetic modification of genes that regulate water-use efficiency and stress response pathways. Flax seed oil is primarily composed of alpha-linolenic acid, an omega-3 fatty acid, and current efforts are focused on increasing oil production and modifying the fatty acid profile to enhance the nutritional quality of flax oil.

Several genetic factors influence the quality of flax fibers, primarily those that contribute to lignin synthesis and cellulose production. The studies of these pathways have led to fiber strength, fineness, and yield. Other approaches are transgenic approaches to introduce new traits in flax, such as increased pest resistance or higher oil content. For example, introducing genes from other plant species has been suggested as a means of increasing the omega-3 fatty acid content in flax seeds. However, the regulatory issues related to genetically modified flax have yet to be resolved in some parts of the world. The new genome editing technology of CRISPR/Cas9 can precisely alter the flax genome. This technology will be used to target specific genes that control desirable traits, such as improved oil composition or fiber quality, without the need for transgenic methods.

Flax and Human Health

Flax seeds are highly valued for their nutritional benefits, rich in omega-3 fatty acids, particularly alpha-linolenic acid, as well as fiber and lignans. These components play a significant role in supporting human health. Regular consumption of flax seeds has been associated with several health benefits. ALA in flax helps reduce the risk of heart disease by lowering cholesterol levels and alleviating inflammation. The lignans in flax seeds have proven to be antitumor by protecting against cancer caused by the hormones, breast and prostate being the most cited. Flax seeds also possess fiber content which helps in proper digestive health along with bowel movement. Flaxseed oil that is rich in omega-3 fatty acids mainly alpha-linolenic acid has been widely used for dietary supplements. This oil has anti-inflammatory properties and has been researched for its potential therapeutic effects on conditions such as arthritis, diabetes, and inflammatory bowel disease.

Future Perspectives and Challenges

Flax is susceptible to several diseases, including fusarium wilt and rust. Research in disease-resistant varieties, the molecular basis of resistance, and so forth is highly sought after. Yields in flax are often less compared to other oilseed crops like soybean. The genetic improvement and agricultural practices that will help in yield improvement are also challenges in this crop. Moreover, susceptibility to environmental variability like temperature stress and water deficit calls for climate-resilient flax. Though GMO flax continues to face serious regulatory issues, consumer acceptance concerns in most places, the challenge for flax improvement still appears open both by traditional breeding approach and by employing genome editing technology such as CRISPR.

The future of flax (*Linum usitatissimum*) genomics holds immense promise in improving various aspects of its cultivation and utilization. Advances in genomic selection and marker-assisted breeding are expected to significantly enhance yield potential by identifying genes associated with traits like seed size, oil content, and stress tolerance. With the increasing challenges posed by climate change, genomics will play a key role in developing flax varieties that are more resilient to heat, drought, and other environmental stresses. Additionally, genomic research can uncover disease resistance mechanisms, allowing for the creation of flax cultivars resistant to common pathogens like flax rust and Fusarium wilt. These improvements would reduce the reliance on chemical treatments, promoting more sustainable farming practices.

In terms of quality traits, flax genomics offers the potential for enhancing the nutritional value of the crop, particularly its omega-3 fatty acids, lignans, and fiber content. By identifying and manipulating the genes involved in the biosynthesis of these compounds, flax could become an even more potent source of functional food. Furthermore, flax's role in human health could be amplified, with genomic tools enabling the development of varieties tailored to specific health benefits, such as cardiovascular health or cancer prevention. The ongoing exploration of synthetic biology and metabolic engineering could also optimize flax for bioenergy production, contributing to the growing demand for sustainable biofuels and bioproducts. Overall, the integration of genomics in flax breeding and research promises to unlock the crop's full potential, positioning it as a critical player in food security, sustainability, and human health in the future.

Conclusion

Linum usitatissimum, or flax, is a crop of great economic, nutritional, and medicinal importance. Recent advances in flax genomics have provided valuable information about its genetic structure and the potential for enhancing its characteristics. Flax plays an important role in various industries, including textiles, food, and medicine, and thus continues to be a subject of ongoing scientific investigation. Application of genomic techniques in flax breeding coupled with biotechnological innovations like CRISPR is a good way of developing superior flax varieties with better yield, quality traits, and higher resilience to biotic and abiotic challenges.

References

Chen T. J. (2023). ChatGPT and other artificial intelligence applications speed up scientific writing. Journal of the Chinese Medical Association : JCMA, 86(4), 351–353.

Dmitriev, A. A., Pushkova, E. N., Novakovskiy, R. O., Beniaminov, A. D., Rozhmina, T. A., Zhuchenko, A. A., Bolsheva, N. L., Muravenko, O. V., Povkhova, L. V., Dvorianinova, E. M., Kezimana, P., Snezhkina, A. V., Kudryavtseva, A. V., Krasnov, G. S., & Melnikova, N. V. (2021). Genome Sequencing of Fiber Flax Cultivar Atlant Using Oxford Nanopore and Illumina Platforms. *Frontiers in genetics*, *11*, 590282

Dvorianinova, E. M., Pushkova, E. N., Bolsheva, N. L., Borkhert, E. V., Rozhmina, T. A., Zhernova, D. A., Novakovskiy, R. O., Turba, A. A., Sigova, E. A., Melnikova, N. V., & Dmitriev, A. A. (2023). Genome of *Linum usitatissimum* convar. *crepitans* expands the view on the section *Linum*. *Frontiers in genetics*, *14*, 1269837.

Homolak J. (2023). Exploring the adoption of ChatGPT in academic publishing: insights and lessons for scientific writing. Croatian medical journal, 64(3), 205–207.

Venglat, P., Xiang, D., Qiu, S., Stone, S. L., Tibiche, C., Cram, D., Alting-Mees, M., Nowak, J., Cloutier, S., Deyholos, M., Bekkaoui, F., Sharpe, A., Wang, E., Rowland, G., Selvaraj, G., & Datla, R. (2011). Gene expression analysis of flax seed development. *BMC plant biology*, *11*, 74.

Wang, Z., Hobson, N., Galindo, L., Zhu, S., Shi, D., McDill, J., Yang, L., Hawkins, S., Neutelings, G., Datla, R., Lambert, G., Galbraith, D. W., Grassa, C. J., Geraldes, A., Cronk, Q. C., Cullis, C., Dash, P. K., Kumar, P. A., Cloutier, S., Sharpe, A. G., … Deyholos, M. K. (2012). The genome of flax (*Linum usitatissimum*) assembled de novo from short shotgun sequence reads. *The Plant journal: for cell and molecular biology*, *72*(3), 461–473.

Wiwanitkit, S., & Wiwanitkit, V. (2024). ChatGPT, medical research and scientific writing. Malaysian family physician : the official journal of the Academy of Family Physicians of Malaysia, 19, 3.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Effect of Nanoparticles on Soil Microbial Populations

Deepshikaa R and JayaMugundha P

Centre for Agricultural Nanotechnology, TNAU, Coimbatore

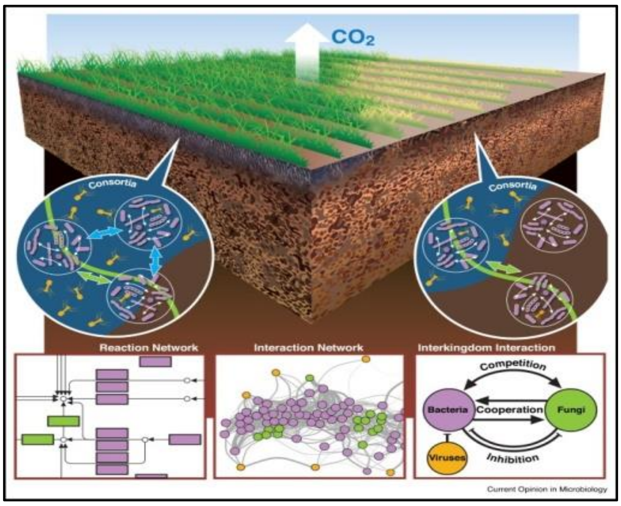
Soil Microbiome and Its Role

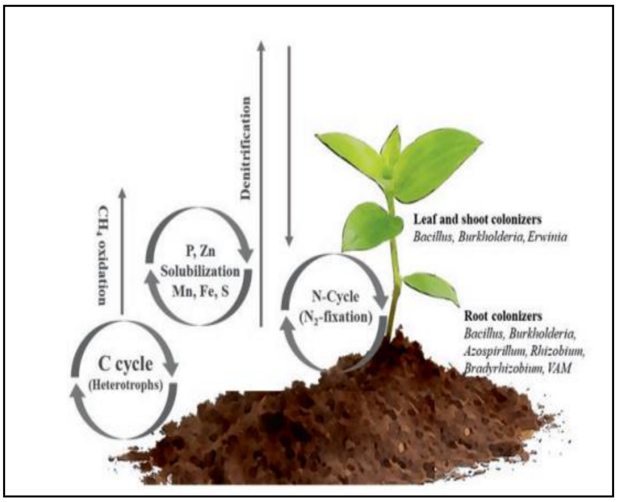
Soil represents one of the most highly diverse ecosystems on our planet with an interacting community of bacteria, archaea, viruses, fungi and protozoa which is collectively referred to as the 'soil microbiome'.

Based on data from 66 soil samples it was determined that, according to their abundance, the predominant fungi in soil belong to Agaricomycetes (Basidiomycota), Archaeorhizomycetes (Ascomycota), Zygomycota, Sordariomycetes (Ascomycota), Leotiomycetes (Ascomycota), Dothideomycetes (Ascomycota), Eurotiomycetes (Ascomycota), Glomeromycota and Chytridiomycota. The predominant bacteria in these samples belong to Acidobacteria, Verrucomicrobia, Bacteroidetes, Proteobacteria (Alphaproteobacteria, Gammaproteobacteria, Deltaproteobacteria, and Betaproteobacteria), Planctomycetes and Actinobacteria. The archaea can be arranged in the following order of abundance: Thaumarchaeota (Crenarchaeota), marine benthic group archaea (MBGA; Crenarchaeota), Thermoplasmata (Euryarchaeota), Parvarchaeota, and Euryarchaeota (unclassified groups). These microorganisms play important roles in soil including nutrient fixation (carbon and nitrogen), nutrient solubilization (phosphate and zinc), mineralization, and loss of nutrients from soil through processes like methane production and denitrification.

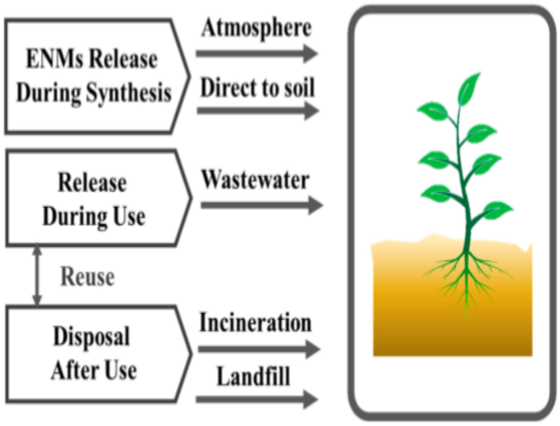
Nanomaterials in Soil, Their Release Routes, and Fate

Soil contains a number of naturally-occurring nanomaterials such as clay, iron oxides and organic matter. Several engineered nanomaterials, as discussed above, are also released to soil and other environments via the use and disposal of nanomaterial-based products. It is estimated that about 3000, 550, 5500, 55, 55, 55, 300, 0.6, 55 and 0.6 tons of TiO_2, ZnO, SiO_2, FeO_x, AlO_x, CeO_x, CNT Fullerenes, Ag and quantum dot nanomaterials, respectively, are produced worldwide annually. ENMs are released intentionally or unintentionally (a) during manufacturing; (b) during use; and (c) via disposal after use.





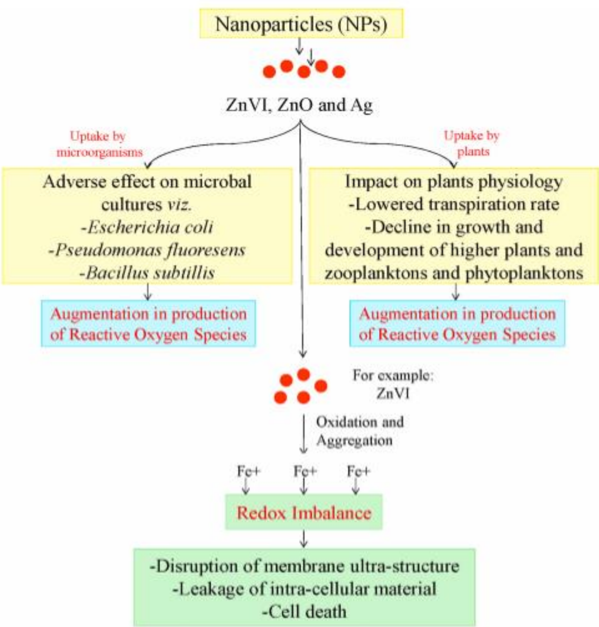
Products that contribute the most ENMs to the environment include coatings, paints, pigments, electronics, optics, and cosmetics. It is estimated that from 0.1 to 2% of all ENMs produced are released into the environment during production. Approximately 63–91% of ENMs are disposed in landfills, while the second largest volume (8–28%) is disposed in soil. The highest volumes of titania, iron and zinc oxides are released into soil, water and air.



Possible Ways of ENMs Accumulation in Soil

Impact of Nanoparticles on Microorganisms and Plants

In addition to directly affecting growth of plants, ENMs also influence the microbial community in the soil and plant microbiomes



consequently affecting the plant health. It has been reported that nano TiO_2 and ZnO influence soil microbial communities and a comparison of the two ENMs suggests that ZnO NPs induce more pronounced toxicity than does TiO_2.

Bacteria that carry out nitrogen fixation and methane oxidation were among the populations that decreased significantly with treatment of ENMs. Ag NPs exposure also led to a decrease in the abundance of nitrogen fixers, soil microbial biomass, and the leucine aminopeptidase activity. When the soils were treated with C60 fullerenes with an average size of 50 nm, a three- to four-fold decrease in the population of fast-growing bacteria was observed.

Mechanism Underlying Antimicrobial Activity of ENMs

The antimicrobial activity of ENMs is well-known and the mechanism of their antimicrobial activity has also been extensively studied and reported. Mechanisms include: (i) bacterial cell membrane disruption; (ii) perturbation of metabolic functions such as purine metabolism; (iii) protein denaturation; (iv) DNA damage; (v) inhibition of respiration through disruption of the respiratory chain; (vi) free radical formation and induction of oxidative stress; (vi) mutagenesis; and (vii) inhibition of DNA replication through DNA binding. ENMs are not always microbicidal in their action but simply be inhibitory to specific microbial enzymes and processes. The toxicity of nanomaterials also depends on their inherent properties including shape, size, chemical nature, surface charge, and hydrophobicity.

Cell Binding Mechanism

Amongst several pathways, direct binding of NPs with cell-surface is a major toxicity-inducing mechanism. Interestingly, NPs when present in close vicinity of cells or organisms, the interaction between them is dependent upon electrostatic attractions. Usually, a bacterial cell is observed to exhibit a negative charge on the surface. -NPs are directly associated with bacteria rather than negatively charged-NPs. In

ISSN : 3048 - 989X

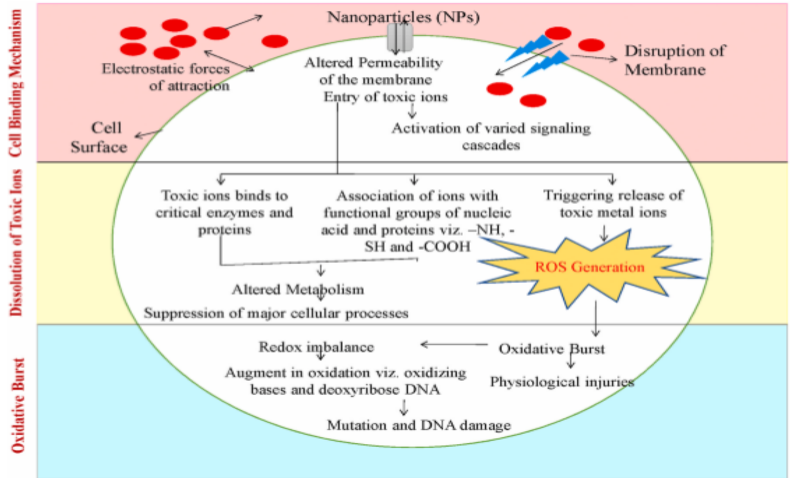
bacterial culture, NPs stay on the cell surface, causing damage to the membrane due to removal or disruption of membrane lipids. Such an alteration in physical features of membrane subsequently leads to stimulation of internal signaling cascade that disrupts cells.

Activation of Dissolution of Ions Mechanism

The most imperative mechanism of toxicity caused by NPs is the dissolution of toxic elements from NPs and elicit oxidative burst in affected organisms. A wide array of ways exist by which toxic ions are released from NPs and are indirectly dependent on the identity of ions released. Few ions bind to critical enzymes and proteins thereafter altering their metabolism and subsequently result in suppression of major cellular processes. The toxic ions are steadily released from metal oxides and absorbed by membranes resulting in direct association with functional groups of nucleic acids and proteins such as amino(-NH), mercapto(-SH), and carboxyl (-COOH). These associations also have huge effects on cellular structure and enzymatic activities, eventually disturbing the entire physiology of the exposed organism. Another way is by associating toxic ions directly with the phospholipid bilayer of the affected organism or even its genetic material. Consequently, metal-ions trigger oxidative burst by elevating ROS in organisms.

Induction of Oxidative Burst

The four major ROS types are superoxide anion, hydrogen peroxide, hydroxyl ion, and singlet oxygen, formed from short-term stress-induced reactions. Singlet oxygen has been identified to be responsible for physiological injuries. Under normal environmental cues, a balance is maintained between ROS-production and scavenging in exposed organisms. Conversely, when an excess of ROS is generated, intercellular redox balance is disturbed, which wires for oxidation. The prime consequence of ROS is lipid-peroxidation and disruption of major enzymes such as mononuclear iron proteins. Moreover, ROS-



generation results in oxidizing bases and deoxyribose of DNA, resulting in mutations and DNA damage.

Reference

Khanna Kanika et al., 2021. Enthralling the impact of engineered nanoparticles on soil microbiome: A concentric approach towards environmental risks and cogitation. *Ecotoxicology and Environmental Safety 222, 112459.*

Shams Tabrez Khan. 2020. Interaction of Engineered Nanomaterials with Soil Microbiome and Plants: Their Impact on Plant and Soil Health. *Sustainable Agriculture Reviews 41*.

Anna-Lena Grün et al., 2019. Impact of silver nanoparticles (AgNP) on soil microbial community depending on functionalization, concentration, exposure time, and soil texture. *Environmental Sciences Europe.*

Vishnu D. Rajput et al., 2017. Effect of nanoparticles on crops and soil microbial communities. *J Soils Sediments*

Hermes Pérez-Hernández et al., 2020. Effect of engineered nanoparticles on soil biota: Do they improve the soil quality and crop production or jeopardize them? *John Wiley & Sons, Ltd.*

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

The Agricultural Edible Products Revolution: Transforming Food Security and Human Welfare

Dr. Vinay Kumar Singh

Centre for Bioinformatics, School of Biotechnology, Institute of Science, Banaras Hindu University, Varanasi 221 005, Uttar Pradesh, India

"Agricultural edible products have been the foundation of human survival and nourishment for centuries, providing essential sustenance to populations worldwide. As we face unprecedented challenges driven by rapid population growth, climate change, and the growing demand for food, there is an urgent need for transformative changes in agricultural practices. The evolution of agricultural products, especially in the context of food security, sustainability, and nutritional enrichment, is now more critical than ever. This paper delves into the ongoing revolution in the agricultural sector, with a focus on how innovative agricultural methods and technologies are reshaping the landscape of food production and consumption. One of the key areas of focus is the advancement of crop breeding techniques, which aim to enhance yield, resilience, and nutritional value of staple crops, making them more adaptable to diverse environmental conditions. Through the development of crops that are not only more resistant to pests, diseases, and extreme weather conditions but also nutritionally enhanced, there is the potential to address global hunger and malnutrition more effectively. Furthermore, the role of sustainable farming practices has gained significant attention, with methods that prioritize ecological balance, soil health, and water conservation offering promising solutions for long-term agricultural productivity. In addition to advancements in crop science, the processing and preservation of food are also experiencing innovation, making it possible to extend the shelf life of nutritious foods, reduce waste, and improve accessibility to high-quality edible products. Technologies like precision agriculture, which utilizes data analytics and AI, are revolutionizing how we approach food production, ensuring higher efficiency and less resource depletion. Ultimately, this paper emphasizes how the agricultural sector can be a key driver in improving global food security, human health, and the environment. By adopting cutting-edge practices and embracing new technologies, agriculture can not only meet the food demands of a growing global population but can also enhance the nutritional quality of food, reduce environmental impact, and contribute to overall human welfare in the face of a rapidly changing world. This agricultural revolution is vital in ensuring a sustainable and prosperous future for all."

Keywords: Agricultural revolution, edible products, food security, sustainable agriculture, crop breeding, nutritional enhancement, food technology, human welfare, climate change, agro-tech, future of food.

Introduction

The 21st century has witnessed a pivotal transformation in the agricultural sector, driven by the need to address rising food demands, improve nutritional quality, and combat the adverse effects of climate change. As the global population continues to surge, there is an increasing urgency to create an agricultural system that is efficient, resilient, and capable of sustaining the world's food needs. Edible agricultural products, which include fruits, vegetables, grains, legumes, and animal products, play a crucial role in meeting these demands and ensuring human health.

ISSN : 3048 - 989X

Despite the critical importance of these food sources, numerous challenges stand in the way of achieving a secure and sustainable global food system. Issues such as land degradation, water scarcity, environmental pollution, and socio-economic inequalities continue to hinder progress. These challenges necessitate a holistic, forward-thinking approach to agriculture that integrates sustainable practices and technological innovations to enhance food production while safeguarding the planet's resources.

This ongoing agricultural revolution aims to enhance both the accessibility and quality of edible products. It leverages cutting-edge technologies, from precision farming techniques to genetic improvements, which promise to increase yields and nutritional value while reducing the environmental footprint. Innovations like vertical farming, hydroponics, and climate-resilient crops are helping to overcome land limitations and reduce dependency on water-intensive farming practices, making agriculture more sustainable and adaptable to changing climates.

In addition to technological advancements, policy frameworks play a key role in supporting this transformation. Governments and international bodies are working together to create policies that encourage sustainable agricultural practices, promote food security, and ensure fair access to nutritious food for all. These policy shifts aim to empower farmers, particularly those in developing regions, with the tools and knowledge they need to thrive in the face of new challenges.

Ultimately, this revolution in agriculture is not just about producing more food, but about producing food in a way that nourishes both people and the planet. It underscores the necessity of a systems approach where innovations in farming, technology, and policy work in harmony to create a more equitable and sustainable food system. By embracing these integrated solutions, we can address the growing challenges of food and nutrition security, ensuring a healthier, more resilient future for all.

The Need for Agricultural Innovation

By 2050, the world's population is projected to reach 9.7 billion, placing unprecedented pressure on food production systems. With rapid urbanization, traditional agricultural methods may struggle to keep up with the increasing demand for diverse and nutritious foods. To address this challenge, innovative agricultural practices and more efficient food systems are essential in ensuring we can feed the growing global population without compromising sustainability.

In addition to population growth, climate change is a major threat to food production. Unpredictable weather patterns, prolonged droughts, and more frequent flooding events disrupt the conditions necessary for crops and livestock to thrive. Furthermore, a changing climate may create a breeding ground for pests and diseases, further jeopardizing food security. As these challenges intensify, it becomes clear that agricultural innovation is not a luxury but a necessity.

One promising solution is the adoption of climate-smart agriculture (CSA), which includes practices aimed at making food systems more resilient to the impacts of climate change. This approach focuses on sustainable farming techniques that conserve resources, reduce emissions, and increase productivity. Additionally, the development of drought-resistant and heat-tolerant crop varieties is critical to help ensure stable food production even in harsher conditions.

While producing enough food is a priority, the quality of that food is just as crucial. Malnutrition, particularly micronutrient deficiencies, remains a widespread problem, affecting millions of people worldwide. To combat this, techniques like food fortification, biofortification, and the development of nutritionally enhanced crops are becoming more vital. These innovations not only improve calorie intake but also enhance the nutritional value of food, addressing deficiencies in essential vitamins and minerals.

In this rapidly changing world, agricultural innovation is key to ensuring that our food systems are sustainable, resilient, and capable of nourishing all people. By embracing new technologies and strategies, we can overcome the challenges of climate change, population growth, and malnutrition, ultimately advancing human welfare through a more equitable and efficient agricultural revolution.

Innovations in Crop Breeding and Biotechnology

In the quest to improve global food production and meet growing nutritional needs, innovations in crop breeding and biotechnology have been instrumental. Genetically modified (GM) crops, such as Bt-cotton and Roundup Ready soybeans, have significantly transformed agricultural practices. These crops are engineered to be more resistant to pests and herbicides, helping farmers reduce crop loss and improve yields. This has not only made food production more efficient but has also played a critical role in addressing some of the environmental challenges posed by conventional farming practices.

However, the potential of agricultural biotechnology has expanded even further with the advent of gene-editing technologies like CRISPR-Cas9. This powerful tool allows scientists to make precise changes in a plant's DNA, enabling the creation of crops that are not only more resistant to environmental stress, such as drought and heat, but also boast enhanced nutritional profiles. With gene editing, researchers can develop crops that yield higher harvests, contribute more to food security, and provide better nutritional benefits, which are essential as the global demand for food continues to rise.

In addition to genetic modification, biofortification is another innovative approach aimed at improving the nutritional quality of crops. Biofortification involves breeding crops to naturally increase their content of essential vitamins and minerals, making them more nutritious without requiring changes in the way they are consumed or processed. A well-known example is golden rice, which has been genetically engineered to contain higher levels of vitamin A, a vital nutrient for preventing blindness and boosting immune function in developing countries. Similarly, iron-fortified beans are designed to combat iron deficiency, which affects millions, especially in areas where diets lack sufficient amounts of this essential nutrient.

While biotechnology has brought about significant advancements, traditional practices still play an important role in fostering sustainability. Agro-ecology, for example, combines ancient farming wisdom with modern scientific approaches to create more sustainable agricultural systems. Practices such as crop diversification, organic farming, and agro-forestry emphasize the importance of soil health, biodiversity, and ecological balance. By reducing reliance on synthetic fertilizers and pesticides, these methods not only contribute to environmental preservation but also improve the nutritional quality of food. Crops grown in diverse ecosystems tend to be richer in nutrients, which supports both human health and the resilience of farming systems.

Together, these innovations in crop breeding, biotechnology, and sustainable farming practices are helping to pave the way for a future where food production is both more efficient and more beneficial to human welfare. By enhancing the nutritional quality of crops and promoting sustainability, we can ensure that food production meets the needs of a growing population while supporting the health of both people and the planet.

Sustainable Agricultural Practices for Food Security

In the face of global food insecurity and the challenges posed by a growing population, sustainable agricultural practices are essential to ensuring that everyone has access to sufficient, nutritious food. As the world's population

ISSN : 3048 - 989X

continues to urbanize and agricultural land becomes increasingly scarce, innovative solutions are needed to increase food production while minimizing environmental impact.

One such solution is precision agriculture, which harnesses cutting-edge technologies like GPS, drones, and sensors to optimize resource use. By gathering real-time data, farmers can make more precise decisions about when and how to apply water, fertilizers, and pesticides. This approach not only boosts crop productivity but also helps reduce waste and environmental harm. For example, farmers can use data to ensure they apply just the right amount of water, which conserves this vital resource and reduces the likelihood of water pollution. Precision agriculture is making farming more efficient and sustainable, aligning with the goal of providing sufficient food while preserving the environment for future generations.

As cities expand, vertical farming and urban agriculture have emerged as innovative solutions to food security in urban areas. These methods utilize limited urban space to grow crops in vertically stacked layers, often within controlled environments. This allows for the cultivation of fresh, nutritious produce in the heart of cities, minimizing the need for long-distance transportation and reducing food waste. Urban agriculture can significantly enhance food accessibility, offering a way to feed urban populations with local, sustainable produce and reducing the environmental impact associated with food transport.

Another promising practice is aquaponics, which merges two forms of agriculture: aquaculture (fish farming) and hydroponics (soil-free plant cultivation). In an aquaponic system, fish waste serves as a natural fertilizer for plants, while the plants help clean and filter the water for the fish. This creates a symbiotic environment where both the plants and fish thrive. Aquaponics is particularly valuable in regions with limited access to arable land or freshwater resources, as it requires less space and water compared to traditional farming. This integrated approach provides a sustainable way to produce both protein (from fish) and vegetables, offering a solution to food security in areas facing environmental challenges.

These sustainable agricultural practices precision agriculture, vertical farming, urban agriculture, and aquaponics are transforming food production systems. They offer a path forward that maximizes resource use, reduces waste, and enhances food security. By embracing these innovative solutions, we can meet the growing demand for food while ensuring that it is produced in a way that protects the environment and promotes long-term sustainability for future generations.

Advances in Food Processing and Technology

As the global demand for food continues to rise, advancements in food processing and technology are playing a vital role in improving the efficiency, sustainability, and nutritional quality of the food supply. These innovations help us tackle pressing challenges such as food waste, health concerns, and the environmental impact of food production.

Modern food processing techniques like freeze-drying, high-pressure processing (HPP), and ultraviolet (UV) irradiation have revolutionized the way we preserve agricultural products. These technologies extend the shelf life of foods while maintaining their nutritional integrity, making it possible to store and transport fresh produce without sacrificing quality. This is particularly important in reducing food waste, which is a major issue worldwide. By preserving foods for longer periods, these techniques help minimize spoilage and ensure that more food reaches consumers, reducing the significant losses in global food supplies.

In addition to improving shelf life, food processing is also playing a role in enhancing the nutritional content of our diets. Functional foods are gaining popularity these are foods that go beyond basic nutrition to offer additional health benefits. Through advanced food engineering,

ISSN : 3048 - 989X

ingredients such as probiotics, prebiotics, and omega-3 fatty acids are being integrated into everyday foods. These bioactive compounds contribute to better gut health, boost the immune system, and may even reduce the risk of chronic diseases. As people become more health-conscious, functional foods are becoming an essential part of the global food market, helping to prevent illnesses and improve overall well-being.

Another exciting innovation in food production is the development of **l**ab-grown meat**,** also known as cultured or cell-based meat. This technology creates meat in a lab setting without the need for traditional livestock farming, offering a solution to the environmental, ethical, and health concerns associated with conventional meat production. Lab-grown meat uses fewer resources, produces less waste, and has a smaller carbon footprint compared to traditional meat production, making it a more sustainable and humane option for the future of food.

Alongside lab-grown meat, plant-based protein sources are gaining traction as sustainable alternatives to animal protein. Crops like soy, peas, and quinoa are rich in protein and can be used to create nutritious, meat-like products that have a significantly lower environmental impact. These plant-based proteins are not only better for the planet but are also appealing to consumers who are seeking healthier, more ethical dietary options.

Through these technological innovations, the agricultural sector is evolving to meet the needs of a growing global population while also promoting health, sustainability, and ethical practices. Advances in food processing, functional foods, lab-grown meat, and plant-based proteins are not just changing the way we eat they are transforming the entire food system to ensure that we can nourish the world in a way that is both sustainable and beneficial for human welfare.

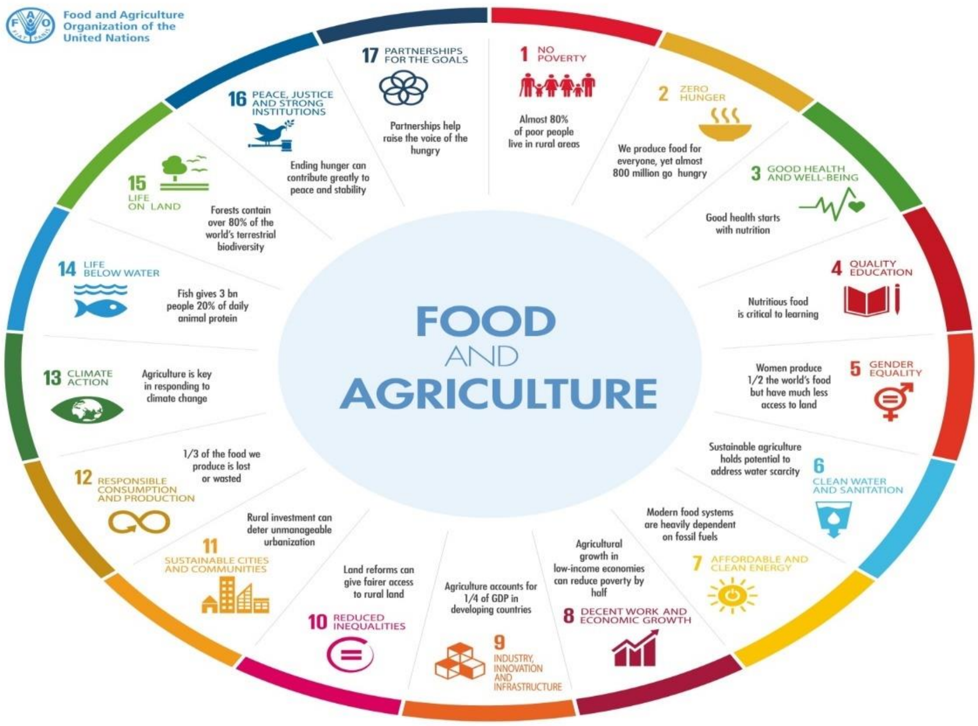


Figure 1: Foundation of SDGs: Food and Agriculture (opted from https://www.foodinspiration.com/)

ISSN : 3048 - 989X

Figure 2: Sustainable Development Goals (SDGs; opted from https://social.desa.un.org/)

Policy, Regulation, and Global Cooperation

Governments have a pivotal role to play in shaping the future of agriculture by fostering innovation and ensuring that policies are aligned with global sustainability goals. Effective policy frameworks can guide the transition to more resilient, efficient, and equitable agricultural systems, helping to address the growing challenges of food insecurity, climate change, and malnutrition.

International organizations such as the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) are instrumental in establishing global standards and frameworks that promote food security, sustainable agricultural practices, and public health. These organizations work collaboratively with governments, the private sector, and civil society to develop policies that support the efficient and responsible use of resources. By guiding policy decisions, the FAO and WHO help ensure that agriculture not only meets the food needs of today but also supports long-term environmental sustainability and public health.

However, the rapid advancements in biotechnology and genetic engineering have raised important questions about equity and access. As new technologies, such as genetically modified crops and gene-editing tools, continue to emerge, there are concerns regarding intellectual property rights and whether these innovations will be accessible to all farmers, particularly those in low-income or developing regions. For agriculture to be truly inclusive, it is essential that smallholder farmers who represent a significant portion of the global agricultural workforce are able to access and benefit from these advancements. Ensuring that innovations reach those who need them most can promote inclusive growth in the agricultural sector, improving the livelihoods of millions and contributing to global food security.

In this context, cooperation between governments, international organizations, and the private sector becomes crucial. By fostering an environment of collaboration, transparency, and equitable access to technology, we can ensure that agricultural innovations benefit all farmers and consumers, irrespective of their location or economic status. This collective effort can help build a more resilient and sustainable food system that supports human welfare globally.

Sustainable Development Goals (SDGs) and Agriculture

The United Nations' Sustainable Development Goals (SDGs) play a crucial role in shaping the future of agriculture and its impact on global welfare (**Figure 1 & Figure 2**). These goals highlight the interconnectedness of food security, sustainable farming practices, and better health outcomes, recognizing that addressing one aspect of human well-being can have ripple effects on others. By aligning agricultural practices with the SDGs, we have an opportunity to create a more inclusive, resilient, and sustainable food system that benefits all people, now and in the future.

Food security**,** as one of the core SDGs, is essential for human welfare. Ensuring that everyone has access to enough nutritious food is fundamental to ending hunger, improving health, and promoting economic stability. Agriculture is at the heart of this goal, as it is the primary source of food production. By adopting sustainable farming methods such as precision agriculture, organic farming, and agro-ecology we can produce more food while safeguarding the environment for future generations. This approach not only helps meet the growing global demand for food but also reduces the environmental impact of agricultural practices, ensuring that natural resources are preserved.

Additionally, the SDGs underscore the importance of improved health outcomes**,** which are deeply connected to the nutritional quality of food. Sustainable agriculture can contribute to better public health by promoting the cultivation of nutrient-dense crops and the development of functional foods. By integrating agricultural practices with health-focused innovations, such as bio-fortified crops and functional ingredients, the food system can help address global issues like malnutrition and vitamin deficiencies.

Furthermore, agriculture has a key role in fostering equity and resilience within food systems. The SDGs advocate for the inclusion of smallholder farmers and marginalized communities in the agricultural value chain. Ensuring that these groups have access to technology, markets, and fair policies can significantly reduce poverty and inequality. When farmers in developing regions can access innovative tools and techniques, they are better equipped to face the challenges posed by climate change, economic instability, and resource scarcity.

By aligning agricultural practices with the SDGs, the agricultural sector can become a powerful driver of positive change. Through sustainable farming, improved health, and greater equity, agriculture can contribute to a more resilient and fair food system that meets the needs of all people, fosters economic growth, and protects the environment for generations to come.

Conclusion

The ongoing revolution in agricultural edible products offers remarkable opportunities to improve human welfare by tackling some of the most pressing challenges of our time, including food security, climate change, and nutrition. Through a combination of cutting-edge technologies, sustainable farming practices, and increased global cooperation, the agricultural sector can be transformed into a powerful force for positive change, enhancing the quality of life for people worldwide.

As the global population continues to grow, the demand for food is rising at an unprecedented rate. The agricultural industry must evolve to meet these demands while also addressing the environmental and social impacts of food production. This includes embracing innovative solutions such as precision farming, climate-resilient crops, and new food processing technologies, which can increase efficiency, reduce waste, and improve the nutritional value of the food we consume. At the same time, sustainable practices like agro-ecology, urban farming, and plant-based proteins can help ensure that food is produced in a way that protects the planet's resources for future generations.

Global collaboration is key to this transformation. Governments, international organizations, and the private sector must work together to create policies and frameworks that support sustainable agriculture, equitable access to technology, and the promotion of public health. By ensuring that innovations are accessible to all, particularly smallholder farmers in developing regions, we can promote inclusive growth and make significant strides toward achieving the United Nations' Sustainable Development Goals.

In conclusion, the agricultural sector has the potential to address some of the world's most urgent challenges. By fostering innovation, embracing sustainability, and promoting collaboration, we can create a food system that is resilient, equitable, and capable of providing abundant, nutritious food for future generations. The agricultural revolution holds the promise of a healthier, more sustainable future for all.

References

FAO (2017). The Future of Food and Agriculture: Trends and Challenges. FAO.

FAO (2022). The State of Food Security and Nutrition in the World 2022. FAO.

UN (2023). Transforming Our World: The 2030 Agenda for Sustainable Development. United Nations.

Lyson T. A. (2002). Advanced agricultural biotechnologies and sustainable agriculture. Trends in biotechnology, 20(5), 193–196.

Homolak, J. (2023). Exploring the adoption of ChatGPT in academic publishing: insights and lessons for scientific writing. *Croatian Medical Journal*, *64(3)*, 205–207.

Silva, T. P., Ocampo, T. S. C., Alencar-Palha, C., Oliveira-Santos, C., Takeshita, W. M., & Oliveira, M. L. (2023). ChatGPT: a tool for scientific writing or a threat to integrity? *The British Journal of Radiology*, *96(1152)*, 20230430.

Chen, T. J. (2023). ChatGPT and other artificial intelligence applications speed up scientific writing. *Journal of the Chinese Medical Association*, *86(4)*, 351–353.

Wiwanitkit, S., & Wiwanitkit, V. (2024). ChatGPT, medical research and scientific writing. *Malaysian Family Physician: The Official Journal of the Academy of Family Physicians of Malaysia*, *19*, 3.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Weight Based Grading of Fruits

Shilpa S. Selven and Sumit B. Urhe*

ICAR-Central Institute of Post-harvest Engineering and Technology, Ludhiana 141 004, Punjab, India

*Corresponding author: sumiturhe31@gmail.com

"Grading of fruits is a crucial operation that significantly affects consumer acceptance and market value in both national and international trade. It enhances marketing efficiency, optimizes packaging, and ensures better quality standards. Among grading methods, weight-based grading has emerged as a precise and efficient approach, ensuring consistency in size, reducing labor costs, and improving profitability. This review highlights the evolution of grading technologies, comparing manual, mechanical, and electronic methods. Emphasis is placed on weight-based systems, their advantages, challenges, and integration with advanced technologies to meet stringent market demands."

Introduction

Grading of fruits and vegetables is an essential operation in the post-harvest value chain, ensuring uniformity in quality and enhancing marketability. It separates produce into homogenous groups based on characteristics like size, shape, weight, and color, directly influencing consumer satisfaction and profitability. High-value fruits such as sweet oranges must be carefully handled and graded to meet the quality standards of domestic and international markets. Grading not only prevents loss due to substandard produce but also increases marketing efficiency, facilitates fair pricing, and saves time during processing and transportation.

While manual grading remains a widely adopted practice in India, it is labor-intensive and time-consuming, making it unsustainable for perishable crops like sweet orange. The shift towards automated grading systems has been driven by consumer expectations for consistent quality and advances in technology. Among various grading techniques, weight-based grading is gaining popularity for its precision and ability to reduce errors in packaging and transportation costs.

Importance and Advantages of Grading

Grading ensures the exclusion of substandard products, preventing revenue losses. It enhances marketing efficiency by simplifying buying and selling without personal selection and enables consumers to purchase graded produce without inspection. Graded fruits and vegetables save time and energy during processing, reduce handling losses in transportation, and facilitate better pricing mechanisms.

Evolution of Grading Systems

Manual grading has been the traditional approach, but it poses challenges in terms of labor availability and accuracy. Mechanical grading systems addressed some of these limitations but lacked the precision and adaptability of electronic systems. Modern electronic graders offer improved efficiency, integrating sensors and automation to achieve high accuracy.

Weight-Based Grading

Weight-based grading has emerged as a preferred method for fruits like sweet oranges, apples, and mangoes. It ensures uniformity by grouping fruits into weight categories, which is crucial for meeting market standards and reducing errors in packaging. Research by Omre and Saxena (2003) demonstrated a multi-fruit grader capable of handling 150–200 kg/h with 96% efficiency. Similarly, an electronic grader for sapota developed by Ali et al. (2011) achieved a feed rate of 430 kg/h and 93.8% separation efficiency.

The automation of weight grading through load cells, microcontrollers, and stepper motors provides superior precision compared to size-based graders. This method reduces labor, time, and damage, aligning with consumer expectations and commercial requirements. However, challenges persist, including overlooking quality factors like sweetness or ripeness. Advances in technology now aim to integrate weight grading with parameters such as color and texture to provide a holistic assessment of fruit quality.

Advances in Weight-Based Grading Technology

The development of weight-based grading technology has been bolstered by the integration of electronic systems. Graders equipped with load cells and microcontrollers allow for precise weight measurements and seamless operation. Modern systems can handle large volumes of produce with minimal human intervention, offering consistent results across diverse fruit varieties. These advancements not only reduce operational costs but also ensure compliance with stringent quality standards in export markets.

The combination of weight-based grading with imaging and optical technologies represents the next frontier in fruit grading. These integrated systems can simultaneously evaluate weight, size, color, and surface defects, providing a comprehensive assessment of fruit quality. Such systems are especially valuable for premium fruits like apples, mangoes, and oranges, where buyers demand uniformity in appearance and quality alongside precise weight-based categorization.

Economic and Environmental Impact

Weight-based grading also contributes to economic sustainability by minimizing waste and maximizing efficiency in supply chain operations. Accurate weight measurement ensures optimal packaging configurations, reducing the use of excess materials and lowering transportation costs. Furthermore, it enhances the marketability of fruits by delivering products that meet consumer expectations, resulting in better financial returns for growers. By reducing handling losses and spoilage during transportation, weight-based grading indirectly contributes to environmental sustainability, aligning with global efforts to minimize food waste.

Implications and Challenges

Weight-based grading benefits both producers and consumers by ensuring fair pricing and transparency. It reduces packaging and transportation wastage, making it vital for export markets with strict quality standards. However, it does not address other critical quality parameters like flavor or appearance. Future advancements integrating weight with additional parameters will enhance grading efficiency and product quality. Weight-based grading remains a cornerstone of modern fruit grading practices, driving efficiency, consistency, and marketability in the agricultural sector.

Conclusion

Grading is a critical post-harvest operation that ensures the marketability and profitability of fruits and vegetables. Among various grading techniques, weight-based grading has emerged as a precise and efficient method, offering numerous advantages such as improved accuracy, reduced labor costs, and optimized packaging. Advances in automation and technology have further enhanced the efficiency and versatility of weight-based graders, making them a valuable tool for both domestic and export markets.

However, challenges such as the exclusion of non-weight quality parameters like ripeness or sweetness remain a limitation. The integration of weight-based grading with other advanced technologies, such as optical and imaging systems, holds the promise of addressing these gaps. By ensuring consistency, reducing wastage, and meeting consumer expectations, weight-based grading is poised to play a pivotal role in transforming fruit grading practices and enhancing the agricultural value chain.

References

Ali, S.M., Mandhar, S.C. and Ganachari, A. 2011. Design and evaluation of electronic weight grader for sapota grading. Engineering and Technology in India. 2(1&2): 6-9.

Chakraborty, S.K. and Dubey, K. 2017. Embedded system for automatic real time weight-based grading of fruits. International conference on recent innovations in signal processing and embedded systems (RISE). 512-515.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Fungi as Biological Warriors: Innovations in Eco-Friendly Pest and Disease Control

Aarti Kumari[1], Bhagshali Patle[2], Piyush Kumar[3]

[1,3]M.Sc. (Ag) and [2]Ph.D. Research Scholar

Department of Plant Pathology and Nematology, RPCAU, Pusa, Samastipur 848 125, Bihar, India

"The growing awareness of the negative impacts of synthetic pesticides has driven the search for sustainable and environmentally friendly alternatives in pest and disease management. Fungi, as a diverse group of eukaryotic organisms, have shown great promise as biocontrol agents due to their unique life cycles, diverse metabolic capabilities, and ability to interact with other organisms. This article explores the mechanisms by which fungi act as biocontrol agents and discusses their applications in managing various pests, diseases, and even weeds. The study also addresses the challenges and limitations associated with fungal biocontrol agents and provides future directions for research and development, including advancements in strain improvement, formulation technologies, and commercialization efforts."

Introduction

The use of synthetic pesticides has been central to modern agriculture for decades, yet the detrimental consequences, including pesticide resistance, environmental contamination, harm to non-target organisms, and biomagnification, have sparked a global shift toward more sustainable approaches. Biocontrol, which leverages naturally occurring organisms or their derivatives, has emerged as a viable alternative, with fungi being prominent due to their adaptability and diverse mechanisms. For instance, recent advances include the utilization of *Beauveria bassiana* for enzymatic pest control, synthesizing proteases and chitinase to target insect cuticles effectively (Sumbal *et al.*, 2024). Nanotechnology-enhanced formulations are further enhancing fungal biocontrol applications, solidifying their role in sustainable agriculture. This paper examines the role of fungi in biological control, emphasizing their mechanisms, applications, and challenges.

Entomopathogenic Fungi

1. ***Beauveria bassiana***
   Mechanism: Produces enzymes (proteases, lipases, chitinase) to degrade insect cuticles, along with toxins like beauvericin and bassianin that disrupt the nervous system.
   Applications: Effective against *Bactrocera dorsalis* (Oriental Fruit Fly), providing an environmentally friendly alternative to chemical pesticides (Sumbal *et al.*, 2024; Wahjono *et al.*, 2024).
2. ***Metarhizium anisopliae***
   ***Mechanism*:** Targets insect pests through RNA interference (RNAi) and produces insecticidal metabolites (e.g., camphor and caprolactam).
   ***Applications*:** Demonstrates trans-generational effects on pests, reducing reproductive rates and longevity (Hu *et al.*, 2022; Shaukat *et al.*, 2023).
3. ***Lecanicillium spp.***
   ***Mechanism*:** Attaches to the insect's cuticle, germinates, penetrates, and produces toxic compounds.
   ***Applications*:** Controls aphids, whiteflies, thrips, and nematodes; highly effective against *Bactrocera dorsalis* (Yu *et al.*, 2024).

4. ***Isaria fumosorosea***
   Mechanism: Blastospores penetrate insect exoskeletons and proliferate within hosts.
   Applications: Effective against sap-sucking insects like *Bemisia tabaci* and *Aphis gossypii* (Zou *et al*., 2014; Bugti *et al*., 2018).

Nematophagus Fungi

1. ***Verticillium chlamydosporium-*** Attacks nematode eggs, showing potential as a control agent for root-knot nematodes (Kerry, 1996).
2. ***Pochonia chlamydosporia-*** Targets sedentary endoparasitic nematodes, including *Meloidogyne* and *Heterodera* species (Manzanilla-López *et al*., 2013).
3. ***Hirsutella spp.-*** Parasitizes second-stage juveniles (J2) of nematodes like *Heterodera glycines* (Sun *et al*., 2015).

Mycoparasitic Fungi

1. ***Trichoderma spp.***
   Mechanism: Employs mycoparasitism to attack fungal pathogens, secreting chitinase to degrade cell walls.
   Applications: Controls soil-borne diseases and promotes plant growth (Saravanakumar *et al*., 2017).
2. ***Talaromyces spp.***
   Mechanism: Exhibits mycoparasitism against harmful fungi like *Aspergillus flavus*.
   Applications: Enhances biocontrol potential through enzyme production (Wang *et al*., 2020).

Fungi for Weed Control

1. ***Alternaria alternantherae-*** Controls invasive alligator weed (*Alternanthera philoxeroides*), showing over 90% disease severity (Basak *et al*., 2024).
2. ***Gibbago trianthemae-*** Targets horse purslane (*Trianthema portulacastrum*), significantly reducing weed populations.
3. ***Puccinia spegazzinii-*** Rust fungus used for managing *Mikania micrantha*, though its establishment requires further evaluation (Kumar *et al*., 2016).

Limitations and Challenges

1. ***Environmental Sensitivity:*** Effectiveness depends on temperature, humidity, and UV exposure.
2. ***Slow Action:*** Biocontrol agents often act slower than chemical pesticides.
3. ***Host Specificity:*** While advantageous, it limits broader applications.
4. ***Formulation Challenges:*** Cost-effective and durable formulations are difficult to develop.
5. ***Regulatory Barriers:*** Lengthy approval processes hinder commercialization.
6. ***Inconsistent Performance:*** Field efficacy varies due to environmental factors.

Future Directions

1. ***Strain Selection and Improvement:*** Focus on enhancing virulence and environmental tolerance.
2. ***Understanding Interactions:*** Optimize efficacy through deeper insights into microbial and plant interactions.
3. ***Advanced Formulations:*** Use nanotechnology and controlled-release systems for better application.
4. ***Broadening Applications:*** Expand to diverse ecosystems and target organisms.
5. ***Streamlined Commercialization:*** Simplify production and regulatory processes.

References

Sumbal, G. A. K., Umer, H. M., Sumbal, M. W. K., & Sanaullah. (2024). Biological management of *Bactrocera dorsalis* (oriental fruit fly) through enzymatic activity of *Beauveria bassiana*. *Asian Journal of Research in Crop Science*, *9*(4), 1–6. https://doi.org/10.9734/ajrcs/2024/v9i4293

Eko Wahjono, T., Yuliani, Y., & Hadiyanto. (2024). *Beauveria bassiana*: Insect pathogen and biopesticide producer as an effective and environmentally friendly alternative for biological control. *Jurnal Ilmiah Agrineca*, *24*(1), 97–112. https://doi.org/10.36728/afp.v24i1.2885

Hu, J., Cui, H., Hong, M., Xia, Y., & Zhang, W. (2022). The *Metarhizium anisopliae* strains expressing dsRNA of the *NlCHSA* enhance virulence to the brown planthopper *Nilaparvata lugens*. *Agriculture*, *12*(9), 1393. https://doi.org/10.3390/agriculture12091393

Shaukat, R. F., Freed, S., Ahmed, R., Raza, M., & Naeem, A. (2023). Virulence and transgenerational effects of *Metarhizium anisopliae* on *Oxycarenus hyalinipennis*. *Pest Management Science*, *79*, 3843–3851. https://doi.org/10.1002/ps.7568

Perumal, V., Kannan, S., Alford, L., Pittarate, S., Mekchay, S., Reddy, G. V. P., et al. (2023). Biocontrol effect of entomopathogenic fungi *Metarhizium anisopliae* ethyl acetate-derived chemical molecules: An eco-friendly anti-malarial drug and insecticide. *Archives of Insect Biochemistry and Physiology*, *114*, e22037. https://doi.org/10.1002/arch.22037

Yu, J., Hussain, M., Wu, M., Shi, C., Li, S., Ji, Y., Hussain, S., Qin, D., Xiao, C., & Wu, G. (2024). Whole genome sequencing of the entomopathogenic fungus *Lecanicillium lecanii*, KMZW-1 and its efficacy against *Bactrocera dorsalis*. https://doi.org/10.20944/preprints202407.1518.v1

Zou, C., Li, L., Dong, T., Zhang, B., & Hu, Q. (2014). Joint action of the entomopathogenic fungus *Isaria fumosorosea* and four chemical insecticides against the whitefly *Bemisia tabaci*. *Biocontrol Science and Technology*, *24*, 315–324. https://doi.org/10.1080/09583157.2013.860427

Bugti, G., Na, C., Wang, B., & Feng, L. (2018). Control of plant sap-sucking insects using entomopathogenic fungi *Isaria fumosorosea* strain (Ifu13a). *Plant Protection Science*, *54*, 10.17221/118/2017-PPS.

Kerry, B. R. (1996). Ecological considerations for the use of the nematophagous fungus, *Verticillium chlamydosporium*, to control plant parasitic nematodes. *Canadian Journal of Botany*, *73*(S1), 65–70. https://doi.org/10.1139/b95-226

Manzanilla-López, R. H., et al. (2013). *Pochonia chlamydosporia*: Advances and challenges to improve its performance as a biological control agent of sedentary endo-parasitic nematodes. *Journal of Nematology*, *45*, 1.

Sun, J., Park, S. Y., Kang, S., et al. (2015). Development of a transformation system for *Hirsutella* spp. and visualization of the mode of nematode infection by GFP-labeled *H. minnesotensis*. *Scientific Reports*, *5*, 10477. https://doi.org/10.1038/srep10477

Saravanakumar, K., Li, Y., Yu, C., Wang, Q. Q., Wang, M., Sun, J., et al. (2017). Effect of *Trichoderma harzianum* on maize rhizosphere microbiome and biocontrol of Fusarium stalk rot. *Scientific Reports*, *7*, 1771. https://doi.org/10.1038/s41598-017-01680-w

Wang, B., Li, G., Ye, K., & Wang, L. (2020). Chromosome-scale genome assembly of *Talaromyces rugulosus* W13939, a mycoparasitic fungus and promising biocontrol agent. *Molecular Plant-Microbe Interactions*, *33*(12), 1446–1450. https://doi.org/10.1094/MPMI-06-20-0163-A

Basak, P., Dutta, W., Basu, J., Ghosh, M., Chakraborty, A., & Ray, P. (2024). Phytopathogenic fungi and their active metabolites with bioherbicidal potential against the invasive alligator weed, *Alternanthera philoxeroides*. *Journal of Phytopathology*, *172*(5). https://doi.org/10.1111/jph.13406

Prakya, S. K., Dev, U., Ellison, C. A., Puzari, K. C., Sankaran, N. L., & Joshi, N. L. (2016). Exotic rust fungus to manage the invasive mile-a-minute weed in India: Pre-release evaluation and status of establishment in the field. *Indian Journal of Weed Science*, *48*(2), 206–214. https://doi.org/10.5958/0974-8164.2016.00051.4

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Advancing Crop Breeding Through Allele Mining

P. Agalya[1], K.S. Vijai Selvaraj[2], A. Bharathi[3]

[1]Research scholar, Department of Vegetable Science, Tamil Nadu Agricultural University, Coimbatore, Tamilnadu, India

[2]Associate Professor and Head, Vegetable Research Station, Palur, Cuddalore, Tamilnadu, India

[3]Assistant Professor, Department of Crop Improvement, TNAU, Eachangottai, Thanjavur, Tamilnadu, India

Allele mining represents a burgeoning domain of research dedicated to the identification and application of allelic variations within genetic resources, thereby elucidating aspects of plant phenotypic characteristics. This field is instrumental in tracing the evolutionary trajectory of alleles, uncovering novel haplotypes, and facilitating the development of allele-specific markers pertinent to marker-assisted selection. With substantial implications for enhancing resistance to biotic and abiotic stresses, improving nutrient use efficiency, augmenting yield, and refining quality traits, allele mining employs methodologies such as TILLING, Eco-TILLING, and sequence-based strategies to harness genetic diversity. Despite its considerable promise, persistent challenges such as the generation of high-quality mutant populations and the management of natural polymorphisms in heterozygous species remain. This review elucidates the methodologies, applications, and challenges associated with allele mining in contemporary plant breeding.

What is Allele Mining?

The availability of allelic variants that alter plant phenotypes is critical for the appropriate use of genetic resources, especially in the context of varietal plant development. Given the large number of accessions preserved by gene banks, collections of genetic resources are thought to contain a significant pool of unknown allelic variations. The key challenge is determining the approach for unlocking this variety. Allele mining is a research topic that focuses on identifying allelic variations associated with key features within collections of genetic information.

Significance of Allele mining

- This field enables tracing of allele evolution.
- Identifying novel haplotypes and creating allele-specific markers for marker-assisted selection.

Such capabilities are critical for providing breeders with direct access to essential alleles that confer

(1) Resistance to biotic stresses,
(2) Tolerance to abiotic stresses,
(3) Enhanced nutrient use efficiency,
(4) Improved yield,
(5) Superior quality, including aspects of human nutrition.

Furthermore, it provides insights into the molecular mechanisms underlying unique trait variants and reveals nucleotide sequence changes associated with beneficial alleles. Furthermore, it clarifies the rate at which alleles evolve.

ISSN : 3048 - 989X

Approaches of Allele mining

1) TILLING-based allele mining
2) PCR-based or sequencing-based allele mining

TILLING (Targeted Induced Local Lesions In Genomes)

TILLING is a sophisticated mutagenesis technique that induces point mutations within specific genes, enabling researchers to investigate and leverage genetic variations to enhance desirable traits. The methodology is characterized by its noncontroversial nature and high efficiency, rendering it applicable across a diverse array of species. It utilizes a chemical mutagen known as ethyl methane sulfonate (EMS), which facilitates minute, single-nucleotide alterations in the DNA of the target organism.

The initial demonstration of this technique occurred in the model organism Arabidopsis thaliana (McCallum et al., 2000), with its successful application rapidly expanding to encompass other plant species and animal models, including agricultural staples such as maize, barley, and wheat, alongside model organisms such as Drosophila melanogaster and Danio rerio.

How Does TILLING Work?

The procedural framework of TILLING encompasses four principal stages:

1. **Chemical Mutagenesis**: The seeds or embryos undergo exposure to EMS, resulting in the induction of minor genetic alterations (mutations) within their DNA.
2. **Population Establishment:** The treated organisms are cultivated to form a population, wherein each individual possesses distinct mutations.
3. **Mutation Detection:** Employing advanced methodologies, scientists screen for mutations in predefined genes of interest, identifying individuals that exhibit the sought-after genetic modifications.
4. **Exploiting Mutants:** Once identified, these mutants are included into breeding programs aimed at developing novel plant types with improved characteristics such as greater yield, increased disease resistance, or superior nutritional profiles.

Eco-TILLING

Eco-TILLING represents a modified iteration of TILLING, developed by Comai et al. in 2004. This approach is particularly advantageous in heterozygous populations and serves to elucidate natural polymorphisms. In this context, TILLING is employed as a tool for the discovery of single nucleotide polymorphisms (SNPs) to analyze DNA variation present within natural populations, demonstrating robust capabilities in characterizing genetic diversity.

Eco-TILLING Procedure

Instead of utilizing a mutant population, any germplasm accession, landrace, etc., may be employed. The procedure encompasses the following steps: DNA extraction and pooling, PCR amplification, denaturation and annealing leading to the formation of heteroduplexes, enzymatic cleavage of mismatches, identification of individual variants, and mutation discovery through electrophoresis and fragment separation via capillary electrophoresis, culminating in the identification of genetic variations.

Applications of Allele mining

- Screen many individuals at one locus.
- Not good for few individuals at many loci.

- Discover rare haplotypes
- Good in heterozygous populations

Tilling Vs Eco-Tilling

Tilling	Eco- Tilling
Mutant population is created	Natural population or association mapping population is used
Sequence information needed	Sequence information is not needed

Sequence Based Allele Mining

- It is developed by Huang in 2009
- Sequencing-based allele mining involves amplifying alleles in different genotypes using PCR and identifying nucleotide variations using DNA sequencing techniques.

Procedure of Sequence Based Allele Mining

- Collection of accession
- DNA extraction
- Primer design
- PCR amplification
- Sequencing and identification of allelic variation.

Merits and Demerits

Merits

- Rapid and cost-effective reverse genetics technique.
- Detect chemical mutagenesis at the single nucleotide level.
- It is unaffected by genome size, reproductive system, or generation time.
- Valuable for critical genes.

Demerits

- Skilled labor is necessary.
- Rely on primary design.
- Reduced mutation rate.

Challenges

- Developing a high-quality mutant population could take two to three years.
- Generating a population to test the lethality of various chemical mutagen concentrations and determine the ideal concentration for research.
- Generating mutant populations in vegetative propagated plants slows their progress.
- Highly heterozygous species may exhibit natural polymorphism in the genome.

Conclusion

Allele mining represents a transformative approach in the utilization of genetic resources for plant improvement. By enabling the identification of valuable allelic variations, this field bridges the gap between genetic potential and breeding outcomes. Techniques like TILLING, Eco-TILLING, and sequencing-based allele mining have proven effective in uncovering genetic diversity and facilitating the development of superior crop varieties. While challenges such as generating quality mutant populations and addressing heterozygosity persist, advances in molecular biology and bioinformatics promise to overcome these hurdles. As the agricultural sector faces increasing pressures to produce resilient and high-yielding crops, allele mining will undoubtedly play a central role in meeting these demands.

References

Raddy, A.M. Gambhire, V.B. and Raddy, R.T. (2014). Allele mining in crop improvement. International Journal of Development Research 4: 300-305.

Sharma, M.K. Singh, S. and Senger, R.S. (2014). Allele mining and its applications. Biotech Today 4:34-37.

Kumari, R. Kumar, P. Sharma, V.K. and Kumar, H. (2018). Allele Mining for Crop Improvement. Indian Journal of Pure and Applied Biosciences. 6: 1456-1465.

Carriero *et al*. TILLING in tomato: development of a EMS mutant collection and molecular screening for point mutations. *Plant GEM5* – Venice, 11-14 October 2006.

Marzena Kurowska et.al., TILLING - a shortcut in functional genomics. *J Appl Genetics* (2011) 52:371–390

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

How Increased Agriculture Knowledge Leads to Greatest Pesticides Use

Alliya

B.Sc. (Hons) Horticulture
Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu

Introduction

As we progress in development, modernize agriculture, establish universities, and research centres, we're simultaneously witnessing a surge in the use of pesticides and chemicals. However, this growth comes at a steep environmental cost. The excessive application of these substances is rapidly degrading soil fertility, killing beneficial microorganisms, and annihilating earthworm populations. despite our increasing education and technological advancements, our actions are having devastating consequences on the environment. The supposedly healthy fruits and vegetables we consume are, in reality, tainted with residual pesticides, leading to a plethora of diseases. This article will look into the pressing issue of agricultural advancements and their unintended environmental consequences, exploring alternative solutions to mitigate the damage.

How is It Dangerous for Us?

Pesticides, designed to protect crops from pests and diseases, have become a part of modern agriculture.

A) Human Health Impacts

1. Cancer Risk: Exposure to pesticides has been linked to an increased risk of cancer, particularly non-Hodgkin's lymphoma, leukemia, and brain cancer. (Source: International Agency for Research on Cancer)
2. Neurological Damage: Pesticides have been shown to cause neurological problems, including Parkinson's disease, Alzheimer's disease, and amyotrophic lateral sclerosis (ALS). (Source: National Institute of Environmental Health Sciences)
3. Reproductive Issues: Exposure to pesticides has been linked to reproductive problems, including birth defects, miscarriage, and infertility. (Source: Environmental Protection Agency)

B) Environmental Impacts

1. Water Pollution: Pesticides can contaminate water sources, posing a risk to aquatic life and human consumption. (Source: Environmental Protection Agency)
2. Soil Degradation: Pesticides can alter soil ecosystems, reducing fertility and affecting microorganisms. (Source: Food and Agriculture Organization)
3. Air Pollution: Pesticides can volatilize and drift, contributing to air pollution and climate change. (Source: National Oceanic and Atmospheric Administration)

C) Ecosystem Impacts

1. Bee Decline: Pesticides have been linked to the decline of bee populations, threatening pollination and food security. (Source: National Geographic)
2. Wildlife Toxicity: Pesticides can be toxic to wildlife, including birds, fish, and other aquatic organisms. (Source: Wildlife Toxicity Assessment)
3. Soil Microbiome Disruption: Pesticides can disrupt soil microbiomes, affecting nutrient cycling and ecosystem function. (Source: Soil Science Society of America)

ISSN : 3048 - 989X

Statistics

1. 1.1 billion pounds of pesticides are used annually in the United States alone. (Source: Environmental Protection Agency)
2. 77% of non-organic produce samples contain pesticide residues. (Source: Environmental Working Group)
3. Pesticide exposure is estimated to cause 200,000 deaths annually worldwide. (Source: World Health Organization)

How it can be minimized

We acknowledge that completely eliminating pesticide use is not feasible, especially considering India's status as a populous country that needs to feed its massive population. Therefore, it's essential to educate farmers about the responsible use of pesticides in simple, understandable language.

Educating Farmers

Farmers must be trained to use pesticides judiciously, just as we take medicine only when we're ill. They need to understand the toxicity levels of chemical bottles and the devastating residual effects on the entire ecosystem. Currently, farmers often spray entire bottles of pesticides upon detecting disease, unaware of the long-term consequences.

Promoting Sustainable Practices

To promote sustainable agriculture, it's crucial to conduct frequent programs and workshops. Extension workers should regularly visit villages to build trust with farmers and encourage them to adopt eco-friendly technologies. In the past, traditional farming practices relied heavily on organic methods due to limited resources. However, with the increasing emphasis on productivity and profit, patience has given way to greed, leading to the indiscriminate use of pesticides.

Government Initiatives

The government must promote better schemes to encourage natural farming practices alongside traditional agriculture. Integrating agriculture as a compulsory subject in primary education can help raise awareness about sustainable farming methods. By adopting an integrated system, we can educate people about the dangers of pesticide overuse, including the increased risk of cancer, asthma, and allergies.

Raising Awareness

The Bathinda case, where numerous breast cancer cases were linked to pesticide use, serves as a stark reminder of the risks involved. To mitigate these risks, we must promote kitchen gardening, terrace Reducing Pesticide Use: A Step-by-Step Guide to a Healthier Future .

As we strive for a more sustainable and environmentally conscious world, reducing pesticide use has become a pressing priority. The alarming consequences of pesticide overuse demand immediate attention and action. In this article, we'll explore practical steps to minimize pesticide use, promoting a healthier future for our planet and its inhabitants.

Step 1: Choose Organic Options

1. Options for organic produce: Whenever possible, select organic fruits, vegetables, and grains to reduce pesticide exposure.
2. Support local farmers: Encourage local farmers to adopt organic practices, promoting a healthier food system.

Step 2: Implement Integrated Pest Management (IPM)

1. Monitor crop health: Regularly inspect crops for signs of pests or diseases.
2. Use physical barriers: Employ physical barriers, like row covers, to prevent pests from reaching crops.
3. Encourage beneficial insects: Foster beneficial insects, such as ladybugs and lacewings, to naturally control pest populations.

Step 3: Adopt Sustainable Agriculture Practices

1. Crop rotation: Rotate crops to break disease and pest cycles.
2. Companion planting: Pair crops that naturally repel pests or improve growth.

ISSN : 3048 - 989X

3. Soil conservation: Implement conservation tillage and cover cropping to reduce soil erosion and promote soil health.

5. Precision agriculture: Utilize precision agriculture techniques, like drone monitoring and satellite imaging, to optimize crop management.

6. Biological pest control: Explore biological pest control methods, such as using beneficial nematodes or parasitic wasps.

7. Pesticide-free crop protection: Develop and adopt pesticide-free crop protection products, like plant-based repellents.

8. Support policy change: Advocate for stricter regulations on pesticide use and increased funding for sustainable agriculture research

By implementing these steps, we can significantly reduce pesticide use, promoting a healthier environment, and a more sustainable food system. Join the movement towards Here's a simplified version:

Conclusion

As we finish exploring the issues with pesticide use in farming, we're left with a sad truth. Our quest for progress and high yields is unknowingly harming the planet that feeds us. It's ironic: in our rush to get a big harvest, we're sacrificing the long-term health of our planet.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Conservation Agriculture: A Pathway to Sustainable Farming

Ashwini Yadav[1], Samrat Rej[2], Surendra Singh Bagariya[3], Sanjay[4]

[1] Research Scholar, Division of Environmental Sciences, ICAR-IARI, New Delhi 110 012
[2] Research Scholar, Division of Seed Science and Technology, ICAR-IARI, New Delhi 110 012
[3]Research Scholar, Division of Agronomy, Suresh Gyan Vihar University, Jaipur 302 017
[4]Research Scholar, Department of Agronomy, Aligarh Muslim University, Aligarh 202 001

Conservation agriculture (CA) is increasingly seen as a pathway toward sustainable farming practices that improve productivity, enhance environmental health, and ensure food security. This article explores the core principles, benefits, challenges, and future perspectives of CA, with a focus on its role in achieving sustainability in modern agriculture. By emphasizing minimal soil disturbance, permanent soil cover, and crop diversification, CA offers a viable alternative to conventional farming methods that often degrade natural resources. Despite its potential, several barriers to widespread adoption exist, including knowledge gaps, financial constraints, and cultural resistance. This paper highlights the importance of addressing these challenges to unlock the full benefits of CA for global agricultural systems.

Introduction

Agriculture is facing significant challenges worldwide, including declining soil health, water scarcity, biodiversity loss, and the effects of climate change. Conventional agricultural practices, particularly intensive tillage, monoculture cropping, and excessive use of synthetic fertilizers and pesticides, have exacerbated these issues, resulting in long-term soil degradation, reduced productivity, and environmental harm. As a response, conservation agriculture (CA) has emerged as a promising solution to promote sustainable farming practices. CA seeks to address these problems by focusing on the sustainable use of land, improving soil fertility, conserving water, and reducing the environmental footprint of farming.

This research article reviews the principles of conservation agriculture, its benefits and limitations, and its role in fostering sustainability. By analyzing the ecological, economic, and social implications of CA, the article provides insight into how this approach can transform agricultural practices globally.

Core Principles of Conservation Agriculture

Conservation agriculture is based on three core principles:

1. Minimum Soil Disturbance

One of the most significant changes introduced by CA is the reduction or elimination of tillage. Traditional plowing practices are often responsible for soil degradation by disrupting the soil structure, leading to increased erosion, loss of organic matter, and reduced soil fertility. By minimizing soil disturbance, CA promotes the preservation of soil structure, enhances water infiltration, and supports the growth of beneficial soil organisms. No-till or reduced-till farming methods are central to this principle, allowing farmers to maintain healthy soils and avoid the negative consequences of conventional tillage.

2. Permanent Soil Cover

Maintaining continuous soil cover is another essential component of CA. This can be achieved through the use of cover crops, crop residues, or mulch from previous harvests. Permanent soil cover serves several functions: it protects the soil from erosion by wind and water, conserves moisture, suppresses weed growth, and contributes to the build-up of organic matter. Moreover, cover crops can improve soil fertility by fixing nitrogen, improving soil structure, and increasing biodiversity in the agroecosystem.

3. Crop Rotation and Diversification

Crop rotation and diversification are integral to CA's focus on building resilience within farming systems. By rotating crops and using a mix of plant species, farmers can break pest and disease cycles, improve soil health, and reduce the need for synthetic fertilizers and pesticides. Rotating nitrogen-fixing legumes with other crops can also improve nutrient cycling and reduce soil depletion. Crop diversification fosters biodiversity, enhances ecosystem services, and increases resilience to climate-related shocks, such as droughts and floods.

Benefits of Conservation Agriculture

Conservation agriculture provides numerous environmental, economic, and social benefits, making it a compelling option for sustainable farming practices.

1. Improved Soil Health

Reduced tillage and continuous soil cover enhance soil structure, increase organic matter, and improve microbial activity. This results in better soil fertility, increased water retention, and reduced erosion. Soil health is critical for maintaining agricultural productivity, and CA helps to restore the soil's natural balance, creating a more sustainable and productive system.

2. Water Conservation

Water scarcity is a significant concern in agriculture, particularly in arid and semi-arid regions. Conservation agriculture helps to conserve water by improving the soil's ability to absorb and retain moisture. The use of cover crops and mulch prevents evaporation and reduces water runoff, while improved soil structure enhances water infiltration. These practices contribute to more efficient water use, reducing the need for irrigation and enhancing crop resilience to drought conditions.

3. Enhanced Biodiversity

The diverse practices associated with CA, such as crop rotation and agroforestry, promote greater biodiversity in the agricultural landscape. By fostering a variety of plants, animals, and microorganisms, CA systems can support healthier ecosystems and provide essential services like pollination and pest control. Additionally, the reduced reliance on chemical inputs helps protect non-target species, further supporting biodiversity.

4. Climate Change Mitigation

Conservation agriculture has the potential to mitigate climate change by increasing carbon sequestration in soils. Reduced tillage and permanent soil cover help to store carbon in the soil, reducing the amount of carbon dioxide released into the atmosphere. This carbon sequestration can contribute to reducing the overall carbon footprint of agricultural activities. Additionally, by improving soil health and water retention, CA systems can help farmers adapt to climate variability and extreme weather events.

5. Increased Farm Resilience and Productivity

By diversifying crops and using sustainable practices, farmers can build more resilient systems that are less vulnerable to pests, diseases, and weather extremes. CA practices can lead to higher yields in the long term, as improved soil health, better water management, and reduced input costs enhance overall farm productivity. Furthermore, farmers adopting CA practices often report lower costs for synthetic fertilizers and pesticides, increasing profitability.

Challenges to Widespread Adoption

While conservation agriculture offers numerous benefits, its adoption is not without challenges. Several factors influence the willingness and ability of farmers to adopt CA practices:

1. Knowledge and Technical Capacity

Farmers, especially those in developing regions, may lack the knowledge and technical expertise required to successfully implement CA practices. Transitioning from conventional farming systems to CA often requires training and access to information about new practices, tools, and equipment. Extension services and farmer-to-farmer knowledge exchange are critical in addressing these knowledge gaps.

2. Initial Investment and Financial Constraints

While CA can lead to long-term financial benefits, the initial costs of transitioning to CA practices can be prohibitive. Farmers may need to invest in new equipment (such as no-till planters), seeds for cover crops, and other inputs. Access to financial resources and credit is essential for enabling farmers to make these investments, particularly in regions where smallholder farmers dominate the agricultural landscape.

3. Cultural and Institutional Barriers

In many regions, conventional farming practices are deeply ingrained, and farmers may be resistant to change. This cultural resistance can slow the adoption of CA, particularly when farmers are uncertain about the benefits or are hesitant to experiment with new methods. Additionally, government policies and subsidies may still favor conventional farming practices, hindering the promotion of CA at the policy level.

4. Environmental and Climate Variability

While CA can help mitigate climate change and reduce vulnerability to extreme weather events, it is not a one-size-fits-all solution. The effectiveness of CA practices may vary depending on local environmental conditions, such as soil types, rainfall patterns, and temperature. Tailoring CA practices to specific regional contexts is essential for maximizing their effectiveness.

Conclusion

Conservation agriculture represents a promising pathway to achieving sustainable farming practices that balance the need for food production with environmental stewardship. By reducing soil disturbance, maintaining soil cover, and promoting crop diversification, CA has the potential to enhance soil health, conserve water, protect biodiversity, and mitigate climate change. However, widespread adoption will require overcoming significant challenges, including knowledge gaps, financial barriers, and cultural resistance. Addressing these challenges through education, policy support, and investment in research and development is critical to unlocking the full potential of conservation agriculture as a tool for sustainable farming worldwide.

The future of agriculture depends on sustainable practices that protect natural resources while ensuring long-term productivity. Conservation agriculture provides a clear pathway toward achieving these goals, and its adoption is a step toward building a resilient and sustainable agricultural system for future generations.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

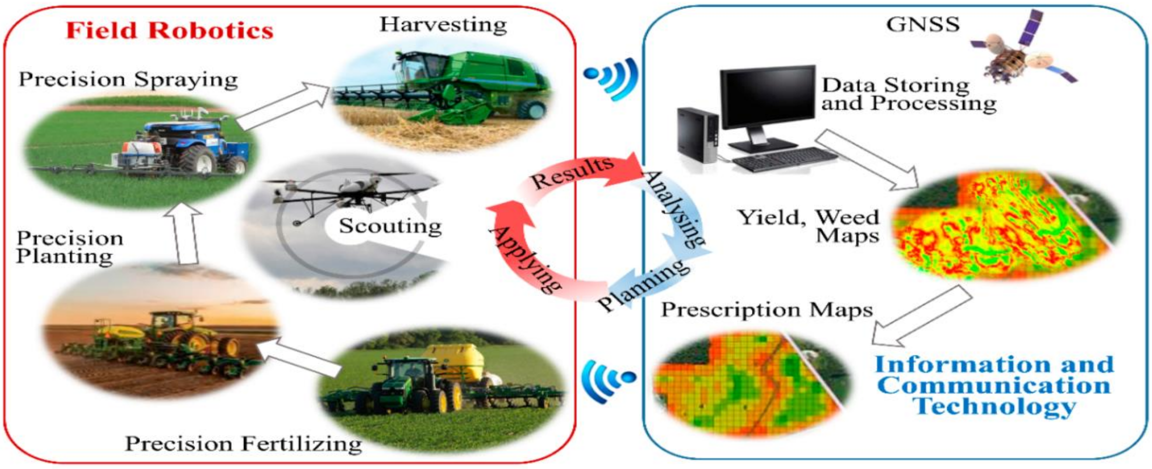
Application of Robotic (IoT) in Agricultural Practices and Plant Disease Detection

Satyam Ranjan[1], Bhagya Shree[2], Aakash Kumar Saini[3], Anshul Chauhan[4]

[1]M.Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj
[2]M.Sc. Scholar, Dept. of Plant Pathology, Naini Agricultural Institute, SHUATS, Prayagraj
[3]M.Sc. Scholar, Division of Soil Science, SKUAST-Jammu
[4]M.Sc. Scholar, Division of Vegetable Science, RVSKVV, Gwalior

Introduction

Research in agricultural robots has been growing in the last years, thanks to potential applications and industry efforts in robot development [Bogue 2016]. Their role was investigated for many agricultural tasks, mainly focused in increasing automation of conventional agricultural machines and covering processes such as ground preparation, seeding, fertilization, and harvesting. Systematic, repetitive, and time-dependent tasks seem to represent the best fields of application for robots, especially in an arable farming context with temporary crops [R. Strange 2005]. Plant diseases are major threat to green product quality and agricultural productivity [Aravind *et al*., 2017]. Beside agronomic practices, robotic plant protection has also been investigated, but may represent the most complex challenge for researchers and developers because questions relative to pathogen diagnosis have to be considered along with common robot-related issues. Such systems apply AI (Artificial Intelligence) algorithms to distinguish, almost in real-time, healthy from non-healthy plant leaves. Today agronomists and farmers can also rely on precision agriculture expert systems to deal with plant disease problems.]. Artificial intelligence and robotics in agriculture are bringing about a revolution. These technologies are enhancing crop production and improving real-time management, harvesting, processing, and marketing [Talaviya *et al*., 2020].



Internet of Things

The Internet of Things (IoT) is a term used to describe the interconnection of physical devices, objects, and systems with the Internet. Kevin Ashton first coined the term Internet of things in 1999. The IoT is a collection of technologies that enable devices to connect to each other over the Internet and it is a network of devices, from household appliances to industrial equipment, that are connected to the internet. This allows them to send and receive data and to be controlled remotely [Wikipedia, 2020].

Seed sowing robot

Robotics

Robotics is an interdisciplinary field of electronic, mechanical, and computer science engineering [Wikipedi, 2020]. Robotics involves the conception, design, manufacturing, and operations of robots. Robots are machines that are developed to perform complex actions. The goal of robotics is to design an intelligent machine that can help humans in day-to-day life activities. These types of machines were designed and developed over the centuries. However, the first modern robots were introduced in the late 1950s with the introduction of industrial robots. These were simple machines that performed specific manufacturing activities at a fixed position. Since then, robotics has expanded through a wide range of fields, including defence, medicine, and space exploration, and many more [Wikipedia, 2020]. Today, robotics is an increasingly growing field, with technological developments continuing.

Robotic Management of Plants

The rapid development of new technologies and the changing landscaping of the online world (e.g., the Internet of Things (IoT), Internet of All, cloud-based solutions) provide a unique opportunity for developing automated and robotic systems for urban farming, agriculture, and forestry.

Robotic Seeding

Seed planting represents an important task in plant management; thus, autonomous agriculture robot prototypes have been specifically designed and developed for seed sowing tasks [Naik et al., 2016].

Irrigation

The agricultural industry uses 70% of the world's available freshwater sources. Moreover, with the growth of population, the food demand is growing.

Irrigation robot

Which forces us for the need to establish more effective solutions to make sure the proper usage of water supplies for irrigation? Automatic water supply scheduling techniques replaced manual irrigation based on soil water measurement.

Weed Control

Tillett *et al*., 2006. Used a machine vision system to detect and remove weeds within rows of vegetables, utilizing conventional inter-row cultivation blades. This system can remove up to 80% of the weeds and the damage to the crops is low. However, weed re-growth and new germination was detected. Astrand and

Baerveldt [Astrand and Baerveldt 2002] developed an autonomous mechanical weeding system using two vision systems: one for navigation along crop rows, and another for identifying crop plants using color and shape parameters. A rotating weeding tool was used for weed removal; when a crop plant was encountered, the rotating tool was lifted out of engagement to avoid plant damage. To avoid crop plants, [Griepentrog et al., 2006], devised a continuously rotating ring of rigid steel tines that are moved individually.

Weed Control robot

Internet of Things (IoT) in Plant Disease Detection

Identification of diseases in the plant is most extreme requirement for farmers and agriculture specialists. The principle point of the proposed framework is to recognize plant diseases with the help of IoT (Internet of Things). In the greater part of the plants the sickness beginning happens on plant leaves. Subsequently, in the proposed work we have considered location of plant sickness present on leaves. The segregation of ordinary and influenced plant leaf can be estimated dependent on variety in temperature, dampness and shading. The pigments in leaves are in charge of the striking shading changes in the fall. Temperature, daylight and soil dampness all assume a job in how the leaves will look in the fall. Rich daylight and low temperatures after the abscission layer structures cause the chlorophyll to be demolished all the more quickly. We have utilized DHT11 temperature sensor. The DHT11 sensor detects the temperature of the leaf under thought. The parameters that are gathered from the sensor are sent to the cloud stage through the wifi shield associated with the Arduino UNO board. The information which is recorded for investigation in the cloud stage. We at first record the scope of the temperature of a sound leaf. Afterward, if the temperature of the leaf under thought does not fall into that run, at that point the leaf is said to be unhealthy. Changes in the shade of plant tissue are a typical indication of plant disease. Regularly these shading changes are realized by the yellowing of typical green tissue because of the annihilation of chlorophyll or an inability to frame chlorophyll. Such suppression of leaf shading might be finished or halfway. The shading sensor detects the shade of the leaf under thought which is another parameter that is being utilized to decide if the leaf is either disease or safe.

Step by Step Explanation of Methodology of IoT

1) Information obtaining: Here we accept tests of various leaves as the information. These leaves are then detected by the sensors to decide various parameters dependent on which it is perceived to be sound or infected.
2) Temperature sensors: The DHT11 is a fundamental, ultra simplicity modernized temperature sensor. It uses a capacitive moisture sensor and discharges a propelled sign on the data stick (no straightforward information pins required.
3) Humidity sensor: according figure 3 The DHT11 is a key, ultra simplicity propelled suddenness' sensor. It uses a capacitive moistness sensor and a thermistor to measure the incorporating air, and discharges an automated sign on the data stick.

4) Color Sensor: according figure 4 The TCS3200 is a programmable shading light-to-recurrence converter/sensor. The sensor is a solitary solid CMOS incorporated circuit that consolidates a configurable silicon photodiode and a currentto-recurrence converter.
5) Aurdino: according figure 5 The Arduino. United Nation Organization is an comprehensively use open source controller board dependent on the ATmega330P microcontroller as well as prepared by.Arduino.cc.
6) Cloud stage: Here we utilize "ThingSpeak" cloud stage to send the detected information to the cloud. This information sent is plotted against the diagram to see the adjustment in the temperature, mugginess and the shading. Contingent upon the information that is plotted against the diagram we check whether the qualities fall into a similar range. On the off chance that they do as such, at that point the leaf is sound or else it is sick.

Algorithm 1: Identification of plant disease using temperature and color sensor
Input: leaf (infected or Normal)
Output: Normal or diseased plant leaf
Description: Given temperature range for the leaf to be healthy is 15-300C
Start
Step 1: Get leaf for acquisition.
Step 2: measure temperature and color of the leaf using the DHT11 and TCS3200 sensor.
Step 3: calculate the color and temperature
if (minimum range < temperature< maximum range AND minimum range < color < maximum range)
Display “Leaf is Normal”
else
Display “Leaf is Diseased”
Stop [Usman *et al*., 2020].


Temperature sensor And Humidity sensor


Color sensor


Diseased or healthy Leaves

References

“Internet of things - Wikipedia.” https://en.wikipedia.org/wiki/Internet_of_things (accessed Dec. 14, 2020).
“Robotics - Wikipedia.” https://en.wikipedia.org/wiki/Robotics (accessed Dec. 14, 2020).
Aravind, K.R.; Raja, P.; Pérez-Ruiz, M. Task-based agricultural mobile robots in arable farming: A review. Span. J. Agric. Res. 2017, 15, e02R01.
Astrand, B.; Baerveldt, A.J. An agricultural mobile robot with vision-based perception for

mechanical weed control. Auton. Robot. 2002, 13, 21–35.

Bogue, R. Robots poised to revolutionise agriculture. Ind. Robot. 2016, 43, 450–456.

Griepentrog, H.W.; Norremark, M.; Nielsen, J. Autonomous intra-row rotor weeding based on GPS. In Proceedings of the CIGR World Congress Agricultural Engineering for a Better World, Bonn, Germany, 3–7 September 2006.

Naik, N.S.; Shete, V.V.; Danve, S.R. Precision agriculture robot for seeding function. In Proceedings of the International Conference on Inventive Computation Technologies, Coimbatore, India, 26–27 August 2016.

R. Strange, "Plant Disease: A Threat to Global Food Security", Annual Review of Phytopathology, vol. 43, pp. 83 - 116, Sept. 2005.

T. Talaviya, D. Shah, N. Patel, H. Yagnik, and M. Shah, "Arti fi cial Intelligence in Agriculture Implementation of arti fi cial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides," Artif. Intell. Agric., vol. 4, pp. 58–73, 2020, doi: 10.1016/j.aiia.2020.04.002.

Tillett, N.D.; Hague, T. Increasing work rate in vision guided precision banded operations. Biosyst. Eng. 2006, 94, 487–494.

Usman, A., Bukht, T.F.N., Ahmad, R. and Ahmad, J., 2020. Plant disease detection using internet of thing (IOT). *Plant Disease*, *11*(1).

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

The Potential of Liquid Biofertilizers for Sustainable Agriculture

[1]A. Chitra Devi and *[2]S. Barathkumar

[1]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India
[2]Department of Soil Science and Agricultural Chemistry, Adhiyamaan College of Agriculture and Research, Krishnagiri 635 105, Tamil Nadu, India
*Corresponding author email: barathkumar.pgsac2022@tnau.ac.in

"Liquid biofertilizers (LBFs) are microbial-based formulations that enhance nutrient availability and promote sustainable agricultural practices. They contain nitrogen-fixing, phosphate-solubilizing, and growth-promoting microorganisms that improve plant nutrient uptake and soil fertility. LBFs had significant benefits to various crops including improved seed germination, biomass production and stress tolerance. Application methods such as seed treatment, root dipping, and soil application ensure efficient microbial colonization and nutrient mobilization. The integration of LBFs with conventional fertilization practices offers a viable approach to enhancing crop productivity while reducing chemical inputs and environmental impact."

Introduction

Liquid biofertilizers (LBFs) are advanced liquid formulations containing viable cells of beneficial microorganisms suspended in a nutrient medium supplemented with specific cell-protectant chemicals. These protectants enhance microbial cell survival during storage, seed application, and under adverse soil conditions, such as elevated temperatures and desiccation (Khandare et al., 2020). LBFs function as natural microbial inoculants either individually or in combination that enhance nutrient availability for plants. These formulations consist of agriculturally beneficial microorganisms capable of fixing atmospheric nitrogen, solubilizing insoluble nutrients and making them accessible to plants. The use of LBFs is environmentally sustainable providing consistent performance across diverse agricultural crops while reducing the dependence on chemical fertilizers by 15–40%. Compared to solid matrix-based biofertilizers LBFs exhibit extended shelf life and are increasingly recognized as viable alternatives to chemical, organic and solid substrate-based fertilizers. Their application improves crop growth and promotes a healthy rhizosphere environment without requiring solid carriers. Furthermore, LBFs are particularly suited for modern agricultural practices including soilless farming systems. LBFs are formulations containing living microorganisms that applied to seeds, plants or soil colonize the rhizosphere or plant interior. They facilitate plant growth by enhancing nutrient availability to the host plant (Malusa & Vassilev, 2014). LBF technology offers several advantages over conventional carrier-based biofertilizers, positioning itself as a significant advancement in the field of biofertilizer technology with high potential for adoption by farmers, extension workers, and commercial manufacturers. The primary function of LBFs is to accelerate microbial processes that improve nutrient mobilization, thereby enhancing nutrient bioavailability for plant uptake. By fixing atmospheric nitrogen, solubilizing insoluble nutrients and producing plant growth-promoting substances LBFs significantly contribute to soil fertility (Mazid & Khan, 2015). This technology leverages the

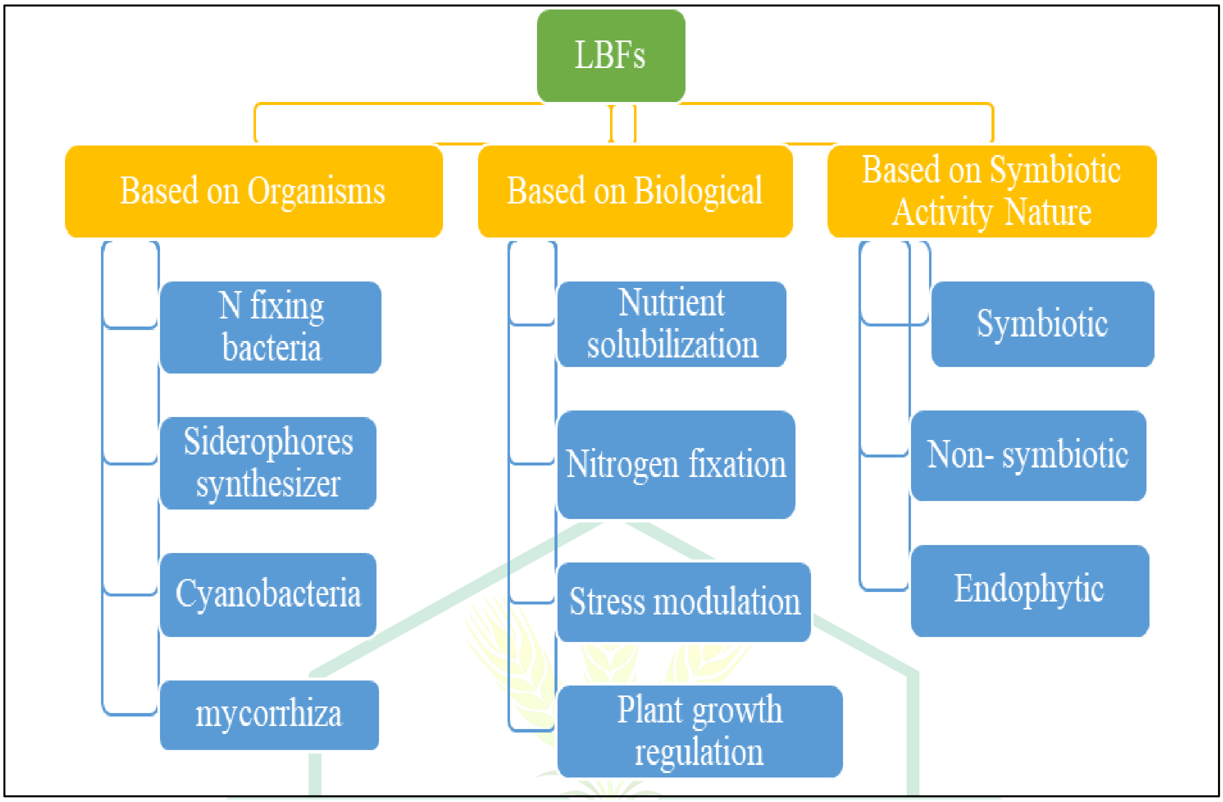


Figure 1: Classification of Liquid Based Fertilizers

natural biological systems for nutrient mobilization, leading to improved soil health and increased crop productivity.

Classification

Liquid biofertilizers (LBFs) are specialized formulations containing living beneficial microorganisms, which may include various combinations of nitrogen-fixing bacteria, nutrient-solubilizing microbes, siderophore-producing microorganisms, cyanobacteria, and mycorrhizal fungi Fig 1. These formulations can be categorized based on the type of microorganisms, their specific biological activity associated with biofertilization, and their symbiotic or non-symbiotic interactions with plants. These microbes inhabit the rhizosphere or the interior of plants, contributing to plant growth through multiple mechanisms, either directly or indirectly. Their activities include the fixation of atmospheric nitrogen to make it accessible to plants, mitigation of environmental stresses (biotic and abiotic), and regulation of plant growth and developmental processes in crops. Such multifaceted functionalities make LBFs highly effective in promoting sustainable agricultural practices.

Application

- ✓ **Synthesis of plant nutrients or phytohormones**: These are directly absorbed by plants to support growth and development.
- ✓ **Soil compound mobilization**: LBFs enhance the bioavailability of essential soil nutrients for plant uptake.
- ✓ **Stress mitigation**: They protect plants under adverse environmental conditions, alleviating the detrimental effects of biotic and abiotic stresses.
- ✓ **Pathogen defense**: LBFs suppress plant pathogens, reducing disease incidence and improving plant health and survival.

Effect of Liquid Biofertilizers (LBFs) on Agricultural Crops

The application of liquid biofertilizers (LBFs) has shown significant potential in enhancing plant growth, yield and overall productivity across a variety of crops. In *Beta vulgaris L.*, the combined use of *Azotobacter* and phosphate-solubilizing bacteria (PSB) resulted in significantly higher yields (Shinde, 2017). Similarly, in *Cicer arietinum* the application of *Azotobacter* and PSB improved seed germination, shoot length, and leaf chlorophyll content (Ansari et al., 2015). For *Glycine max*, the synergistic effect of *Bradyrhizobium* and PSB led to notable increases in both growth and yield (Raja & Takankhar, 2018). In *Ruta graveolens L.*, inoculation with *A. lipoferum*, *P. striata*, and *P. fluorescens* resulted in the highest recorded plant height, number of branches, compound leaves, stem girth, and fresh biomass yield compared to single inoculations (Vijendrakumar et al., 2014). In the case of *Solanum lycopersicum L.*, the use of marine macroalgae such as *Ulva lactuca*, *Caulerpa sertularioides*, *Padina gymnospora*, and *Sargassum liebmannii* significantly improved germination parameters including percentage, index, mean germination time, energy, and seedling vigor index as well as growth attributes like shoot length, root length, and biomass (Hernández-Herrera et al., 2014).

Further, in *Solanum lycopersicum "Roma"* seeds treated with *Acutodesmus dimorphus* extracts at concentrations above 50% (0.75 g mL^{-1}) germinated two days earlier than untreated seeds (Garcia-Gonzalez & Sommerfeld, 2016). Similarly, in *Solanum melongena L.*, the application of *Stoechospermum marginatum* enhanced shoot and root length, fresh and dry weight, and leaf area (Ramya et al., 2015). The combined application of *Azotobacter* and PSB with optimized nitrogen levels also showed significant improvements in yield attributes and growth across multiple studies (Saiyad, 2014). In *Trigonella foenum-graecum L.*, the integration of 75% recommended dose of fertilizers (RDF) with *Rhizobium* and PSB significantly enhanced growth attributes, seed yield, and straw yield (Kumawat et al., 2017). These findings highlight the effectiveness of liquid biofertilizers in improving crop performance while contributing to sustainable and eco-friendly agricultural practices.

Methods of Liquid Biofertilizer (LBF) Application

Liquid biofertilizers (LBFs) can be applied using several methods depending on the crop and growth stage. For seed treatment, seeds are mixed with a 10% jaggery solution and LBF to form a slurry, which is poured over the seeds spread on a cemented floor. The treated seeds are dried in the shade overnight before sowing. In the root application method, the roots of seedlings are dipped in an LBF solution for 30 minutes before transplanting. For one acre, approximately 2.0–2.5 Liters of LBF are required. For soil application, 20 mL of LBF is mixed with compost during planting, particularly for fruit trees. The inoculants are incubated with decomposed granulated FYM for 24 hours to enhance efficacy. In the self-inoculation method, 4–5 kg of biofertilizer is mixed in 50 liters of water and applied to tuber crops. The materials are dried in the shade before planting to ensure uniform inoculation. These methods ensure effective utilization of LBFs for improved crop growth and soil fertility.

Conclusion and Future Prospects

Liquid biofertilizers (LBFs) offer a sustainable solution to declining agricultural productivity and overreliance on agrochemicals by providing essential nutrients and promoting soil health. While advancements in molecular biology have improved understanding and optimization of plant–microbe interactions, further research is needed to identify efficient microbial strains and enhance their efficacy across diverse conditions. LBFs hold great potential to ensure global food security and sustainable agriculture, reducing environmental harm while supporting growing populations.

References

Ansari, M. F., Tipre, D. R., & Dave, S. R. (2015). Efficiency evaluation of commercial liquid biofertilizers for growth of Cicer aeritinum (chickpea) in pot and field study. *Biocatalysis and Agricultural Biotechnology*, *4*(1), 17-24.

Garcia-Gonzalez, J., & Sommerfeld, M. (2016). Biofertilizer and biostimulant properties of the microalga Acutodesmus dimorphus. *Journal of applied phycology*, *28*, 1051-1061.

Hernández-Herrera, R. M., Santacruz-Ruvalcaba, F., Ruiz-López, M. A., Norrie, J., & Hernández-Carmona, G. (2014). Effect of liquid seaweed extracts on growth of tomato seedlings (Solanum lycopersicum L.). *Journal of applied phycology*, *26*, 619-628.

Khandare, R. N., Chandra, R., Pareek, N., & Raverkar, K. P. (2020). Carrier-based and liquid bioinoculants of Azotobacter and PSB saved chemical fertilizers in wheat (Triticum aestivum L.) and enhanced soil biological properties in Mollisols. *Journal of Plant Nutrition*, *43*(1), 36-50.

Kumawat, K., Patel, P. P., Dambiwal, D., Reddy, T. V., & Hakla, C. R. (2017). Effect of liquid and solid bio-fertilizers (rhizobium and PSB) on growth attributes, yield and economics of fenugreek (Trigonella foenum graecum L.). *IJCS*, *5*(4), 239-242.

Malusa, E., & Vassilev, N. (2014). A contribution to set a legal framework for biofertilisers. *Applied microbiology and biotechnology*, *98*, 6599-6607.

Mazid, M., & Khan, T. A. (2015). Future of bio-fertilizers in Indian agriculture: an overview. *International Journal of Agricultural and Food Research*, *3*(3).

Raja, D., & Takankhar, V. (2018). Response of liquid biofertilizers (Bradyrhizobium and PSB) on nutrient content in soybean. *IJCMAS*, *7*(5), 3701-3706.

Ramya, S. S., Vijayanand, N., & Rathinavel, S. (2015). Foliar application of liquid biofertilizer of brown alga Stoechospermum marginatum on growth, biochemical and yield of Solanum melongena. *International Journal of Recycling of Organic Waste in Agriculture*, *4*, 167-173.

Saiyad, M. (2014). Effect of liquid biofertilizers on yield attributes of brinjal (Solanum melongena L.). *Trends in Biosciences*, *7*(22), 3754-3756.

Shinde, A. A. (2017). *Effect of biofertilizers on growth and yield of spinach (beta vulgaris. l)* Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani].

Vijendrakumar, R., Sreeramu, B., Shankarappa, T., Santhosh, K., Mallikarjuna Gowda, A., & Umesha, K. (2014). Effect of liquid bio fertilizers on growth, yield and survival of seedlings in garden rue (Ruta graveolens Linn.). *Plant Archives*, *14*(1), 171-175.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Radioisotopes in Soil and Nutrient Management for Advancing Sustainable Agriculture

*[1]S. Barathkumar and [2]A. Chitra Devi

[1]Department of Soil Science and Agricultural Chemistry, Adhiyamaan College of Agriculture and Research, Krishnagiri 635 105, Tamil Nadu, India
[2]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India
*Corresponding author email: chitraarumugam2001a@gmail.com

"Radioisotopes hold immense potential in agriculture, revolutionizing soil science, plant nutrition, and fertilizer management. By enabling precise tracking of nutrient uptake, soil fertility dynamics, and resource utilization, radioisotopes have facilitated advancements in crop productivity and sustainable farming. Their applications span mutation breeding, food preservation, pest control, and irrigation management. Radiotracer techniques, such as the use of isotopes like 32P, provide critical insights into nutrient transport, fertilizer efficiency, and soil transformations. Additionally, isotopic methods have proven instrumental in studying organic matter decomposition, cation exchange, and nutrient pools, enhancing soil health and environmental sustainability. This article highlights the multifaceted contributions of radioisotopes to agricultural and soil science research, with a focus on improving resource efficiency and minimizing environmental impact."

Introduction

In recent years, radioisotopes have gained significant importance in agricultural research offering potential applications in soil science, plant nutrition, and fertilizer management. Their use enhances crop production by providing precise insights into nutrient uptake, translocation and soil fertility. The application of radioisotopes spans various disciplines including soil chemistry, soil physics and ion exchange processes contributing to efficient resource management in agriculture. To understand the role of radioisotopes in agriculture, it is essential to grasp fundamental concepts such as atomic structure and radioactivity. The phenomenon of radioactivity was discovered by Henri Becquerel in 1896 and later expanded upon by Marie Curie involves the spontaneous emission of radiation from unstable atomic nuclei. Atoms consist of a positively charged nucleus surrounded by negatively charged electrons in discrete orbits, where energy absorption or emission occurs during electron transitions between orbits producing electromagnetic radiation such as X-rays and ultraviolet light. Max Planck's quantum theory (1900) states that energy is emitted in discrete packets called quanta, governed by the equation

$$\varepsilon = h\nu = \frac{hc}{\gamma} \qquad \text{where } (\nu = \frac{c}{\gamma})$$

where ε is quantum of energy in joules, ν represents the frequency of radiation and h is Planck's constant. This principle forms the basis for understanding the interaction of radiation with agricultural systems. The atomic nucleus, consisting of protons and neutrons, determines an element's properties. The mass number mm is the sum of protons (aa) and neutrons (nn), expressed as m= a + n. The nuclear binding energy, essential for atomic stability, is calculated using the formula:

$$E_b = 14.1A - 13A^{2/3} - 0.62\, Z^2/A^{1/3}$$

where A is the mass number and Z is the atomic number. Understanding these concepts aids in the effective use of radioisotopes in agriculture enhancing soil fertility, nutrient management and environmental monitoring. Radioisotopes contribute to modern agriculture by tracking nutrient dynamics, optimizing fertilizer use and supporting sustainable productivity particularly in resource-sensitive regions like India.

Basic Terminology and Definitions

Radioactivity: Radioactivity is a phenomenon in which the nuclei of certain elements undergo spontaneous disintegration, accompanied by the emission of α (alpha) or β (beta) particles and the formation or synthesis of the nucleus of a new element.

Half-Life Period: The time required for a given amount of a radioactive element to decay to half its initial value is called its half-life.

$$T = \frac{2.303}{K} log2 = \frac{0.693}{K}$$

Units of Radioactivity

The curie is the unit for specifying amounts of radioactivity. Rutherford (rd) is also used as a unit of radioactivity.

One rd = 1×10^6 disintegrations per second (d.p.s.)

1 curie = 3.7×10 rd.

Radioactive Tracer

A radioactive tracer is a small quantity of a radioisotope employed to trace or monitor a biological or chemical process. A carrier-free radioisotope refers to a radioisotope where all the atoms of the element present are radioactive, without any stable isotopic content. A carrier denotes the stable atoms of an element that may be introduced alongside a radioactive isotope to provide a measurable quantity, facilitating chemical operations. Additionally, a labeled or tagged compound describes a compound or organism containing modified isotopic content, where the symbol (*) denotes the presence of isotopes in labeled compounds.

Applications of Isotopes in Agriculture

Radioisotopes have been extensively utilized as indicators or tracers for studying chemical and biological processes due to their distinguishable mass and radioactive properties.

The agricultural applications of radioisotopes can be categorized into:

1. **Tracer Atoms:** Utilize radiation properties to identify specific elements. Radioactive atoms mimic stable isotopes and can be tracked via emitted radiation.
2. **Radiation Sources:** Include applications such as:
   - Mutation breeding for crop improvement.
   - Food preservation through irradiation.
   - Sterile male techniques for pest control.
   - Soil moisture determination.
   - Soil bulk density measurements.

Advantages of Radioactive Tracers

- ✓ Differentiation between native and added isotopic content.
- ✓ High sensitivity in detection.
- ✓ Flexibility in measurement protocols.

Limitations of Tracer Methods

- ✓ Isotopic effects on reaction kinetics.
- ✓ Radiochemical purity concerns.
- ✓ Chemical interference during analysis

Applications of Radiotracer Techniques

Radiotracer techniques can be applied in both physical and chemical labeling, depending on the physical characteristics. The chemical labeling is categorized into two main types:

1. Qualitative Applications:

- ➢ Focuses on qualitative measurements such as the rate of movement or surface uptake of nutrients by plants.
- ➢ For example, thyroid function is often studied using isotopes like I-131. Circulation and movement patterns within living organisms and plant systems can also be monitored, including gross movement of nutrients, effects of fertilizers, temperature variation and respiratory rates of microorganisms.

2. Quantitative Applications:

- ➢ Measures are based on the principle that the amount of radioactivity is proportional to the substance's stable counterpart.

- A labeled isotope is added to a system, and the radioisotopic contribution is assessed. This allows for precise measurement of labeled and unlabeled substances within a system.

Applications in Agriculture

Radiotracers provide insights into nutrient absorption and utilization. Radiotracers, such as radioactive phosphorus ^{32}P are utilized in agriculture to study the movement and utilization of nutrients. These isotopes allow scientists to monitor nutrient transport from the bulk soil to the rhizosphere (root zone) and track their translocation within plants. By labeling fertilizers with radioactive isotopes, the contribution of the applied fertilizer to plant nutrient uptake can be precisely quantified. This method helps determine the proportion of nutrients derived from fertilizers, the total nutrient uptake by plants and the percentage of fertilizer nutrients utilized effectively.

For example, phosphatic fertilizers labeled with ^{32}P are used to trace phosphorus movement from soil particles to the soil solution and subsequently into plant tissues. Through these techniques, researchers can assess the efficiency of fertilizer usage by calculating parameters such as phosphorus derived from fertilizers (Pdff), total phosphorus uptake and the percentage of applied phosphorus utilized. Such insights are crucial for optimizing fertilizer applications improving nutrient use efficiency and minimizing environmental impacts.

Phosphorus in Plants Derived from Fertilizer (Pdff)

$$\text{Pdff} = \frac{\text{(Specific Activity of Plant (Sf))}}{\text{Specific Activity of Fertilizer (Si)}} = \frac{Sf}{Si}$$

Total Phosphorus (P) Derived from Fertilizer

$$\text{Pdff} = \frac{\text{(Specific Activity of Plant (Sf)} \times \text{Total P in Plant)}}{\text{Specific Activity of Fertilizer (Si)}} = B$$

Percentage Utilization of Phosphorus:

$$\%\ \text{Utilization of P} = \frac{B}{Amount\ of\ applied\ P} \times 100$$

In addition to agricultural applications, radiotracers are used in medicine and other scientific fields. Radioisotopes like radioactive cobalt ^{60}Co are employed to diagnose blood disorders such as polycythemia and for radiation therapy in cancer treatment. Radioactive iodine is commonly used to locate and treat thyroid tumors due to its selective absorption by the thyroid gland. These examples demonstrate the versatility and significance of radiotracers in advancing agricultural practices, environmental management, and medical treatments.

Use of Isotopic Methods in Soil Science

Isotopic methods enable the quantification of nutrient pools and chemical transformations in soil by leveraging isotopic dilution techniques. These techniques allow scientists to evaluate elements in the soil that are in equilibrium with the soil solution (Schulz, 1965). For example, isotopic methods can calculate the decomposition rate of organic matter, the mean residence time of soil carbon, and distinguish between older and younger organic fractions. Such capabilities are vital for measuring small amounts of plant nutrients, particularly in specialized soil ecosystems like flooded rice soils (Bhat & Bhat, 2010).

(Diwan et al., 2019) studied the radioactive isotopes like ^{45}Ca are used to examine mineral interactions that control the release of nutrients, such as calcium exchange in soils. Similarly, isotopic methods are effective for analyzing the cation exchange capacity (CEC) of soils and clays, providing precise, adaptable, and cost-effective solutions for research.

These techniques also explore chemical equilibrium and the kinetics of soil transformations, such as phosphorus dynamics. Isotopes like ^{32}P, ^{33}P, ^{59}Fe and ^{90}Sr are used to study labile soil phosphate and to trace the fate of metabolites (Iwari, 2022).

Soil organic matter research heavily relies on isotopic methods to study the formation and decomposition of humic substances. Through these techniques, scientists can monitor transformations in soil organic matter and assess its influence on nutrient availability. Additionally, isotopic methods are used to observe soil organic matter turnover, including losses and gains, through radiotracers such as ^{32}P, ^{33}P (Hendricks & Dean, 1952). These isotopes play a key role due to their short half-lives, offering insights into phosphorus behavior and soil physics research.

Radiation techniques also enhance water-use efficiency and irrigation practices by tracing soil moisture dynamics. Isotopes like ^{32}P, ^{33}P and ^{35}S, ^{35}S are employed to elucidate the mechanisms involved in ion absorption, nutrient transport and the interaction between the soil and plant systems (Singh et al., 2013)

Finally, isotopic methods play an essential role in measuring plant-available nutrients within soils. Laboratory techniques like E-value and L-value applications estimate the equilibrium and labile pools of nutrients. These approaches improve fertilizer use efficiency, supporting sustainable agricultural practices (Diwan et al., 2019). The E-value method, in particular, is a direct application of isotopic dilution principles highlighting the practical benefits of these advanced methodologies in soil science.

Conclusion

The application of radioisotopes in agriculture has advanced our understanding of nutrient dynamics, soil fertility and resource management. Radiotracer and isotopic techniques provide precision in quantifying nutrient uptake and optimizing fertilizer use leading to improved crop yields and sustainable farming practices. Their role in studying soil organic matter, chemical transformations and moisture dynamics is pivotal for enhancing agricultural productivity while minimizing environmental harm. These tools represent a cornerstone of modern agricultural research, underscoring their vital role in addressing global food security and environmental sustainability challenges.

References

Bhat, M., & Bhat, M. (2010). Applications of stable and radioactive isotopes in soil science. *Current Science*, 1458-1471.

Diwan, G., Sahu, N., & Lal, N. (2019). Role of Radioisotopes in Agriculture. In: Marumegh.

Hendricks, S., & Dean, L. (1952). Radioisotopes in soils research and plant nutrition. *Annual Review of Nuclear Science*, *1*(1), 597-610.

Iwari, A. (2022). Chapter-3 Radioisotope: Their Effect on Soil and Agriculture. *TECHNOLOGIES*, 37.

Schulz, R. (1965). Soil chemistry of radionuclides. *Health physics*, *11*(12), 1317-1324.

Singh, B., Singh, J., & Kaur, A. (2013). Applications of radioisotopes in agriculture. *International Journal of Biotechnology and Bioengineering Research*, *4*(3), 167-174.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Safeguarding Farmers: The Importance of Pesticide Protective Clothing

Mrs. Radhika Damuluri[1], Dr. Neela Rani[2], Dr. Shirin Hima Bindu[3]

[1]Scientist, AICRP on WIA, PJTAU, Rajendranagar, Hyderabad
[2]Principal Scientist, AICRP on WIA, PJTAU, Rajendranagar, Hyderabad
[3]Scientist, AICRP on WIA, PJTAU, Rajendranagar, Hyderabad

I. Introduction

42.86% (2022) of India's population is involved in agriculture. The modern agriculture practices involve usage of chemical pesticides and fertilizers extensively to enhance the yields and quality. Most of the farmers and farm labourers are at risk of continuous exposure to the pesticides throughout farming, from planting to harvesting. However, application of these chemicals is a high risk for farmers, who are directly exposed, leading to skin allergies, respiratory diseases and cancer. Hence, there is a requirement for protective clothing for famers, which acts as a barrier against exposure to pesticides, providing necessary safety. Pesticides include a wide range of chemicals used to control pests, including fungicides, insecticides, herbicides, specifically weedicides. Though these chemicals have become necessary evil, in order to gain good quality crops and high yield, they pose critical health risk to the people involved in their application. The avenues of exposure to pesticides are majorly through inhalation of the dust, droplets, skin contact to hands, feet and face and accidental ingestion. The symptoms of health damage range from skin allergies, nausea, dizziness to long term respiratory problems and cancer also. The continuous application of the pesticides over the years will have prolonged half-lives of chemicals in the body. Hence the protective clothing should be designed to address all these problems in order to provide effective protection.

II. Functionality of Pesticide Protective Clothing

The principal role of pesticide protective clothing is to minimize the exposure. Thus, the primary functions include

- **Barrier Protection:** this is the most critical functionality, which involves providing a barrier between the skin and pesticides. Different textile materials provide different degrees of barrier. The most commonly used materials include Nylon, Tyvek and rubberized fabrics. The commonly used coating materials include polyurethane, fluoropolymers, gum rosin, Poly Vinyl Chloride, Butyl Rubber and Neoprene.
- **Comfort and Fit:** though the protective functionality has paramount importance, the comfort aspect can not be compromised. The farmers need to wear the protective clothing for prolonged periods. Hence, the garment must provide breathability, mobility and conductivity to dissipate body heat.
- **Visibility and Identification:** The protective clothing should be incorporated with reflective materials, high visibility colours, ensuring that farmers are visible during dusk and dawn, when sunlight is less, to avoid accidents.

III. Different Components of Pesticide Protective Clothing

There are different components encompassing protective clothing, each having specific design features to provide utmost safety, based on specific activities and levels of exposure.

- **Full body Coveralls:** the coverall cover the full body and are most commonly used protective clothing. They provide maximum coverage, protecting the whole body from hazardous chemical exposure. Most of the coverall are made with hoods and elasticated cuffs to prevent the pesticide from entering through gaps.

- **Gloves:** protective gloves, which are resistant to chemical seepage and corrosion are very essential for activities like mixing and spraying of pesticides. Textile materials such as Butyl rubber, Barrier laminate, Neoprene rubber, PVC, natural rubber and Viton are most suitable to provide barrier functionality.
- **Goggles and Face Shields:** safeguarding the eyes and face of the wearer is very crucial during pesticide application. Vented goggles and face shields provide safety. Polycarbonate is used for goggles due to its lightweight and strong impact resistance. For face masks, especially respirators, materials like silicone and thermoplastic elastomers are commonly used for their flexibility and ability to form a secure seal on the face.

- **Respirators:** if the pesticides emit harmful aerosols and vapours, respiratory protection is vital for safety. Hence, based on the level of exposure, different types of respirators ranging from basic N95 masks to more advanced powered air-purifying respirators (PAPRs) may be required.

- **Protective Boots:** protective footwear plays a crucial role in providing protection, particularly if the pesticide is spilled, or flooded. Hence, water and chemical proof, easy to clean and durable boots are essential part of pesticide protection clothing.

IV. Regulations and Standards

Various organizations set guidelines and regulations regarding the use of protective clothing in agricultural settings. The Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) enforce safety standards for PPE (personal Protective Clothing) in USA. The pesticide packages are usually labelled with associated hazards, level of exposure risk and protective features required. It is very essential to create awareness and provide education to farmers about the specific protection requirements associated with the pesticides

V.Best Practices for Using Protective Clothing

To maximize the effectiveness of protective clothing, farmers should follow the best practices:

- **Selecting Appropriate Gear**: Always select protective clothing specific to the pesticide being applied, check the label for recommended protection and always ensure the protection is adequate.
- **Regular Inspections:** Regularly inspecting the PPE for signs of wear and tear is mandatory. Replace the damaged materials immediately to ensure maximum protection.

- **Proper Cleaning and Maintenance:** After completing the application, the protective clothing should be cleaned according to the guidelines given by the manufacturer. This is to remove residual chemicals remaining on the clothing.
- **Training and Education:** The farmers and farm labour involved in pesticide application Farmers should be given training on pesticide safety, health hazards associated with pesticides and maintenance of protective clothing

VI. Innovations in Protective Clothing

The future of protective clothing for farmers is promising, with ongoing innovations aimed at enhancing safety and comfort. Key developments include:

- **Smart Fabrics:** Emerging technologies in textile design are leading to the creation of smart fabrics that can detect harmful chemicals and alert the wearer, providing an additional layer of safety.
- **Improved Breathability:** Manufacturing advancements are paving the way for lightweight and breathable materials that offer protection without sacrificing comfort. This is particularly important for farmers working in hot and humid conditions.
- **Eco-Friendly Materials:** There is a growing trend toward the use of sustainable and environmentally friendly materials in protective clothing. This not only aims to reduce the ecological footprint of agricultural practices but also to align with the increasing consumer demand for sustainability.

VI. Conclusion

Protective clothing is an essential component of agricultural safety, protecting farmers from the harmful effects of pesticide exposure. As the understanding of health risks associated with pesticides evolves, so does the need for proper protective gear. By prioritizing safety through the use of appropriate clothing, farmers can continue to utilize pesticides effectively while safeguarding their health. Hence, investing in high-quality protective clothing is an investment in the health and well-being of those who nourish our communities through their hard work in agriculture.

References

Environmental Protection Agency. (2021). *Pesticides: Personal protective equipment (PPE).* Retrieved from https://www.epa.gov/pesticides/personal-protective-equipment

Occupational Safety and Health Administration. (2014). *Personal protective equipment (PPE) standards*. Retrieved from https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9785

Punam, and & Pruthi, Neelam & Singh, Saroj. (2017). Development of protective clothing for agricultural workers. Agricultural Science Digest - A Research Journal.

Damalas, Christos & Eleftherohorinos, Ilias. (2011). Pesticide Exposure, Safety Issues, and Risk Assessment Indicators. International journal of environmental research and public health. 8. 1402-19. 10.3390/ijerph8051402Sarma, R., Patel, V., & Thomas, M. (2021). Advances in protective clothing materials for agricultural workers. *Textile Research Journal*, *91*(11), 1274-1286

Yang, X., & Chen, C. (2022). Smart textiles for agricultural protective clothing: Innovation and application. *Journal of Smart Textiles & Fabrics*, *16*(1), 98-109.

Zhan, Y., Fang, H., & Liu, W. (2023). Developing eco-friendly protective gear for agriculture: Current trends and future directions. *Journal of Cleaner Production, 365*, 132427.

Guptaa, D. (2011). Design and engineering of functional clothing. Indian Journal of Fibre and Textile Research.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Low Tunnel Technology for Vegetable Production

Virendra Kumar, Anil Kumar, D.K. Upadhyay*, Pravesh Kumar

Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya 224 229

Corresponding Author: dhananjay.gpb2011@gmail.com

Introduction

Vegetables are a rich source of vitamins, carbohydrates, salts and proteins. Due to increased health awareness, high population growth rate, change in diet patterns, there is a year-round high demand for fresh vegetables in the country in domestic and export market. Tunnel farming is the practise of growing out-of-season crops in a controlled environment inside polythene tunnels. This type of farming is typically used for off season summer vegetable cultivation. Because it is not possible to grow summer vegetables in open fields from December to February due to low temperatures and high frost levels, these are grown inside polythene tunnels to provide plants with the proper environment for maximum growth and yield which results in higher profits for farmers. Vegetable tunnel farming is becoming more and more popular nationwide due to its ability to boost output per acre, lower production costs, and facilitate off-season production. The goal of tunnel farming is to shield crops from a variety of environmental challenges, including direct sunshine, extremely cold temperatures, wind, hail, and so on. Additionally, the heat from the sun is captured to produce a microclimate that promotes better crop growth and higher yields.

Tunnel farming is becoming increasingly popular among farmers because it helps them to preserve input resources by using less than 40% of water, fertilizer, and other resources under controlled conditions. Tunnel farming comprises constructing tunnels similar to greenhouses--hut-like structures wrapped in plastic that serve as cocoons for growing cucumber, tomato, pepper, carrots, lettuce, strawberries, and other crops. Tunnel farming enables farmers to overcome three primary constraints to agricultural growth: chronic water scarcity, low yield per acre, and low crop production value.

History

- Hoop houses or poly tunnels have been existed since 1940s. With each passing decade their design continues to evolve.
- The first use of plastic film in agriculture has been done by Professor. E. M. Emmert in 1948 when he built the first plastic greenhouse, a wooden structure covered with cellulose acetate film. Later, he replaced that film with more effective polyethylene film due to unstable behaviour of cellulose acetate film on exposure to temperature and moisture.
- After this, introduction of plastic film in agriculture began on a wider scale and in 1950s, it replaces paper for mulching vegetables. The first plastic tunnels were used in Fresno County by Mr. Richard Espinoza to grow Japanese eggplants and Chinese long beans in 1981. He was introduced to this technique when he was on a tour to San Diego vegetable growers in 1981. Later on, he built the first tunnel laying machine followed by building many low tunnels for the local vegetable growers.
- Walk in tunnels, low plastic tunnels etc. were evaluated for cultivation during

ISSN : 3048 - 989X

normal and off – season at Indo- Israel Project in IARI, New Delhi during the year 1999-2003.

- In India, the low tunnel technique was launched in 1999, in Punjab as a pilot project by Agricultural Technology Management Agency (ATMA).
- This technique has proved a boon for vegetable growers, especially those with small land holdings.

Principle of Low Tunnel

Low tunnel farming works one the same principle as that of a greenhouse. It helps to create conditions during winter equivalent to those in summers. Therefore, the vegetables that are sown in summer can easily be cultivated in winters inside these low poly tunnels. In general, low tunnels allow shortwave solar radiation to pass through during the day and the plastic material slows longwave radiation from the surface at night It converts the light energy from the sun into heat energy which provides warmth to the plants grown inside it and promote early growth of plants. The interior of tunnel heats up faster from the incoming solar radiations as it passes through the transparent polythene sheet and is absorbed by black polythene sheet spread over the soil. The plastic sheet on the surface serves three purposes- 1) It traps heat
2) It reduces evaporation or conserves moisture
3) It eliminates the growth of weeds.

Advantages:

1. **For Raising Healthy Seedlings:** It is done by modifying the microclimate inside low tunnels which helps the grower to raise healthy and early nursery. This can be an extra source of income for a farmer by selling those seedlings to another village.
2. **Off-Season Production**: Because of the controlled atmosphere, it can produce fresh vegetables outside of their typical cropping cycle.
3. **Enhances Nutrient Uptake by the Plants:** The plants grown inside low tunnels have stronger root development in comparison with the plants in open field. Therefore, it enhances the uptake of nutrients.
4. **Maintain Optimum Temperature**: Every crop requires certain temperature to grow like cool season crops require around 21˚ C and warm season crops requires temperature as high as 32˚ C. Low poly tunnels are capable of maintaining an optimum temperature for summer sowing crops if cultivate in winter season.
5. **Reduces Evapotranspiration**: The use of mulching technique inside low tunnels reduces the water loss from the plants and soil. So, it takes longer for a plant to dry.
6. **Provides Protection**: The plants that are cultivated under low poly tunnels have a protection against wind, frost, rain and snow.
7. **Dissembled Easily:** This technique is light in structure and therefore can be dissembled easily and relocate to another place after cultivation has been done.

Disadvantages:

1. The initial cost of building a tunnel is high
2. The tunnel requires constant monitoring, maintenance and care.
3. Requires skill labour

Types of Tunnel Farming

Off-season Vegetable farming in tunnels is gaining popularity due to its low cost and ease of use. Plastic tunnels are transparent, allowing sunlight to reach the plants while also acting as a barrier against cold air in winter. Tunnels aid in increasing crop yield, preserving soil fertility, and maintaining temperature control. The tunnels are classified into three types based on their height:
1. High tunnel
2. Walk in tunnel
3. Low tunnel

High Tunnel:

Due to its more height and width, high tunnel provides easier access for soil preparation, spraying, and harvesting. Off-season vegetables, such as, tomatoes, hot pepper, Grapes, Bottle gourd, brinjal, sweet peppers, ridge-gourd, bitter-gourd etc., can be cultivated using high tunnel technology. The farm's estimated yield potential is greater than that of the walk-in tunnel and low tunnel. Each tunnel measures approximately 200 feet long, 10-12 feet high, and 30-32 feet wide. The pipe structure tunnel has a life span of 20-25 years, while the bamboo structure tunnel has a life span of 2-3 years.

Walk in Tunnel:

Off-season vegetable cultivation is recommended with the use of walk-in tunnel structure on the basis of its low construction cost. Walk-in tunnel technology can be used to grow off-season vegetables such as watermelon, muskmelon, pumpkin, ridge gourd, tomatoes, cucumber, sweet pepper, hot pepper, capsicum, and bitter-gourd. These are lower in height than high tunnels. Walk-in tunnels have a higher yield than low tunnels. Each tunnel is approximately 200 feet long, 5-6 feet high and 12 feet wide, and is half-moon shaped. The average life span of a pipe structure tunnel is 10-12 years.

Low Tunnel:

Low tunnels are less expensive than high tunnels, but their crop yield is lower. This tunnel is difficult for soil preparation, spraying and

Figure 1: High Tunnel

Figure 2: Walk in tunnel

Figure 3: Low Tunnel

ISSN : 3048 - 989X

picking. Cucumber, melons, watermelons, bitter gourds, squashes and snake gourds etc. can be grown in these tunnels. Low tunnels are also used to raise early seedling nursery plants and harden tissue culture plants. Each tunnel is approximately 200 feet long, 2.5 to 3 feet high and 4 feet wide. The average life span of this type of structure tunnel is 1-2 years.

Conclusion

Low Tunnel Technology for Vegetable Production is a game-changer for farmers, particularly those with limited land. By offering a controlled environment for off-season vegetable cultivation, it ensures higher yields, reduced resource use, and protection against environmental adversities. While it requires initial investment, ongoing maintenance, and skilled labour, the benefits far outweigh the challenges. This technology not only boosts productivity and profitability but also paves the way for sustainable and efficient farming practices. It's a significant leap towards meeting the year-round demand for fresh vegetables, making it an invaluable tool in modern agriculture.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Nutritional and Bioactive of Peas: A Foundation for Health Benefits and Nutraceutical Applications

Awanish Yadav, D.K. Upadhyay*, Chanchal Tiwari and Ashwani Srivastava

Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya 224 229

Corresponding Author: dhananjay.gpb2011@gmail.com

"Pea (*Pisum sativum* L.) is a nutritious pulse crop belonging to the leguminous family, and widely cultivated. In recent time, health and nutritional benefits of the pea and its by-products enriched with biomolecules, which have gained significant attention to the researchers and consumers. Peas are known for its pivotal nutritional value with high-quality proteins, dietary fibres, starch, carbohydrates and micronutrients including vitamins and minerals. It is also enriched with phytochemicals, antioxidants, flavonoids, tannins and other phenolic compounds under non nutritional category. Dietary fibre extracted from its cotyledon of the cell wall, seed coats and pods proved to accelerate the gastrointestinal activity by developing intestinal microflora. Intermediate amylose maintains blood glucose level by lowering the glycaemic index and reducing starch digestibility of peas. Pea proteins derived peptides have opportunities in nutraceuticals. Furthermore, pea-derived non-α-galactooligosaccharides could mitigate the gas production by colonic bacteria during the fermentation. Anti-acetylcholinesterase was also traced in the pea pod with some antioxidant properties. The focus of this review paper is to provide a comprehensive profiling of chemical compositions and bioactives of fresh mature peas (specifically garden or field pea seeds) and by-products of pea processing (pods and peels) that sets a foundation for assessment of their health benefits."

Introduction

Pea (Pisum sativum L.), a nutritious agricultural commodity belongs to the Leguminosae family, has potential to withstand freezing temperature which is widely cultivated across the globe (Kour *et al.*, 2020; Tulbek *et al.*, 2017). In terms of productivity, India stands as the second largest producer of green peas next to China and ranks ten among the vegetable crops. The annual global production of green pea and dry pea seeds are approximately 14.5 million tons and 22 million tons, respectively (FAOSTAT, 2019). Pea seeds are well known for its pivotal nutrients that can be differentiated in mainly soluble and insoluble fibres, proteins (tryptophan and lysine), complex carbohydrates, vitamin B, folate, minerals namely, calcium, potassium, iron but low content of saturated fat, cholesterol and sodium. Fresh green pea seeds contain 17–22g carbohydrates, 20- to 50-g starch, 14- to 26-g dietary fibre, 6.2- to 6.5-g protein, 0.4-g fat, 1.0-g ash per 100 g with 9- to 10-mg calcium, 3- to 5-mg sodium, 97- to 99-mg potassium per advance techniques like pulse electric field or ultrasonication have shown remarkable impact on the efficiency by improving nutritional quality and techno-functional properties of pea and its protein (Melchior *et al.*, 2020).

Nutritional Composition

Carbohydrates

Pea carbohydrate has unique stability to high range viscosity and temperature in contrast to tuber starch or cereals (Guillon & Champ, 2002). Glucose, galactose arabinose are present in pea's carbohydrate where stachyose and tetrasaccharide are the most abundantly found polysaccharides. Polysaccharide extraction from peapods are also reported which contain galactose, xylose and arabinose as mono saccharides (Belghith-Fendri *et al.*, 2018). Glucose is derived from similar polymers of starch. Cellulose belongs to the largest part of the carbohydrate where as other pectic polysaccharide derivatives are rhamnose, arabinose, galactose and uronic acids. Peas have 3.73% total oligosaccharides of total solids (Tosh *et al.*, 2013). Basically, starch has three forms on the basis of digestibility of glucose release and its absorption into the gastrointestinal tract. They are rapidly digestible starch (RDS), slowly digestible starch (SDS) and the third one, resistant starch (RS) (Englyst et al., 1992). After ingestion, there is a sudden hike of blood glucose quantity because of RDS fraction which is present nearly 9.2% to 10.7% and SDS fraction from 23.3% to 26.5% which gets digested completely but slowdown in small intestine. RS fraction changes its phase by fermenting itself in large intestine but still 10.1% to 14.7% does not get digested in the small intestine (Dahl *et al.*, 2012; Singh *et al.*, 2017). The fractions of starch digested in the small intestine resulting to low glycaemic index which directly impacts the metabolic rate of digestions (Guillon & Champ, 2002). Starch is also composed of a linear glucan chain of amylose and highly branched molecular chain of amylopectin. The ratio of both imparts digestibility and postprandial glucose response. As pea contains 38.% 2± 0.2% apparent amylase (Chung *et al.*, 2010), which results in reduced digestibility and low glucose release that contribute to low glycaemic index (Table 3). A natural mutation in pea seeds improves the starch assembly and glucose homeostasis (Petropoulou et al., 2020). α-Galactosides one of the oligosaccharides present in pea which may not get easily digested in the gastrointestinal tract. The high fermentability of these oligosaccharides leads to gas production which is responsible for digestive discomfort. These non-digestible oligosaccharide food components potentially to be identified as prebiotic agents and has positive impacts on consumer's health.

Protein

Peas are beneficial protein sources used as functional ingredient for many food industries. A variety of field pea contains 14.5%–28.5% protein where the range goes up to 24.4% to 27.4% (Santos *et al.*, 2019). Pea protein is labelled as a non-allergic food substance with remarkably high nutritional value without any modification in the genetic profile (Ge *et al.*, 2020). Pea protein can broadly be classified into four major groups: globulin, albumin, prolamin and glutelin where the main storage protein is globulin and albumin which accounts for 55%–65% and 18%–25%, respectively, that help in seed germination (Table 1). Globulin is divided into two types namely, legumin and vicilin. Prolamin and glutelin are present in a small amount nearly 3%–5% each (Lu *et al.*, 2020). In crude protein of pea, there are 10%–15% of non-protein nitrogen-containing materials and rest 70%–80% of crude protein are hormones, enzymes, enzyme inhibitors, storage protein and some non-storage proteins. Solubility and modification of pea protein has been reported by using industry-scale microfluidization that will promote food industry to use pea protein without involving exogenous substances (He *et al.*, 2020). Quantities of essential amino acids and its bioavailability determine the nutritional profile of protein which is digested by the organism. Pea seeds are rich in threonine, cysteine, methionine, lysine, glycine, alanine, leucin and phenylalanine amino acids (Owusu-Ansah & McCurdy, 1991). The protein content of pea seeds has a high level of lysine, leucine and phenylalanine but relatively less level of sulphur-containing amino acid namely, metheonine and cysteine (Lu *et al.*, 2020; Yi *et al.*, 2021). Total α-galactosides, verbascose, arginine, glutamic, carotenoid pigments have positive correlation with protein content (Reichert & MacKenzie, 1982). One of the proteins found in legume called lectins or phytohemagglutenin is able to agglutinate the red blood cells which is found in the pea (Owusu-Ansah & McCurdy, 1991). Recent study showed that pea protein hydrolysates can inhibit the metabolic by-product, nitric oxide which could damage the cell excessively (Lu *et al*., 2020). Pasta like sheets were developed using protein and dietary fibre fractions from yellow pea (Muneer *et al*., 2018). Mixed sumiri gels also developed by pea protein isolates through partial substitution of myofibrillar proteins (Borderías *et al*., 2020). Fermentation using co-culture of LAB and yeast may improve the sensory defects in pea protein based products (El Youssef *et al*., 2020).

Vitamins and Minerals

Peas and its peel are rich in vitamins and minerals and have numerous health benefits (Gawalko *et al*., 2009). Potassium, a most prominent major mineral element which contains 1.04% of dry and dehulled weight of peas, followed by phosphorus, magnesium and calcium which were 0.39%, 0.10% and 0.08%, respectively and also rich in vitamin B (Dahl et al., 2012; Millar et al., 2019). Various extractions were performed to isolate different types of vitamins and minerals where E group of vitamins entirely consists of β and γ tocopherols (Boschin & Arnoldi, 2011). Garden pea seeds contained ranges of potassium (97–99mg/100g), calcium (9–11mg/100g), magnesium (5–7mg/100g), sodium (3–4mg/100g) and trace amount of copper, nickel, selenium, folate and boron (Mejri *et al.*, 2019; Millar *et al*., 2019). Among them, selenium and folate may be used as preventive measures against deficiency diseases; thus, it could be used as health promoting minerals (Han & Tyler, 2003). In recent past, low phytate lines have been developed to reduce the concentration of phytate that are helpful in improving the mineral absorption (Jha & Warkentin, 2020). Biofortification is an advancing method to improve the nutritional profile of pulse crop which lacks in micro-nutrients such as iron, zinc, folic acid, β-carotene, carotenoids, folates, iodine and many more by genetic engineering, agronomic intervention and plant breeding. Thus, peas are rich in iron, zinc, manganese and naturally low phytic groups, which can be used in biofortification and can be a hidden solution for nutrient deficient hunger (Amarakoon *et al.*, 2012; Jha & Warkentin, 2020). Pea seeds reported to be used as zinc biofortification combined with selenium which enhance the bioavailability in food products, whereas phosphorous biofortification has been done to increase the soil microbiome in nutrient for higher pea production to combat micronutrient malnutrition (Powers & Thavarajah, 2019)

Dietary Fibres

Dietary fibres (DF) are compounds which restrict digestion (hydrolysis) by enzymes and consist of non-digestible carbohydrates. They are classified as soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) based on the water solubility (Table 1). Lignin, cellulose and some hemicelluloses come under the category of IDF whereas β-glucans, galactomannans, pectin, inulin and other non-starch polysaccharides are part of SDF (Maphosa & Jideani, 2016; Millar *et al*., 2019; Belghith-Fendri *et al*., 2016). Soluble fibre has excellent prebiotic and enhancer properties which have the potential to lower down the glucose absorption in small intestine and cholesterol reduction whereas the insoluble fibre is responsible for increasing faecal bulk, water absorption and intestinal regulation. Physiologically, the water absorption is more important in the body as it improves laxative effects and refines peristalsis. Mainly the insoluble fibre is derived from cereals whereas the soluble fibre is available in fruits and vegetables that is dissolved in water and fermented in the area of colon (Slavin, 2003). Pectin is an abundant water-soluble partially methylated polysaccharide which is completely digested by colonic bacteria. Pectin with its gelling property may reduce the gastric emptying by influencing small intestinal transit moments which shows its hypoglycemic properties (Bush *et al*., 1978; Khan *et al*., 2007). Investigation shows that pea contains 1.2%–1.7% pectin, 2.4% cellulose, 1.0% hemicellulose, 2.5% lignin (Dhingra *et al*., 2012). The AOAC enzymatic-gravimetric hydrolysis methods are used for the extraction process of dietary fibre in peapods. The latter have abundant glucose and xylose which is proved when the soluble sugars were processed under high performance liquid chromatography (HPLC) that resulted glucose as a prominent component. The ferric reducing antioxidant power in peapod is 25.9 µmol Trolox equivalents/g and showed scavenging effect on 2, 2-diphenyl-1-picrylhydrazyl radical as 16.0mg/ml were also measured (Mateos-Aparicio *et al*., 2012).

Anti-Nutritional Factor

Anti-nutritional compounds (ANCs) are those molecules that disrupt the digestion process. ANCs are generally non-fibrous natural substances causing negative effects on health in humans as well as in animals which affect growth along with the metabolic activity. ANCs further systematised into two categories namely, protein associated ANCs and non-protein associated ANCs. Non-protein ANCs include alkaloid, phytic acid, phenolic compounds whereas the protein associated ANCs have lectins, chymotrypsin inhibitor, trypsin inhibitors, anti-fungal peptide and ribosome-inactivating proteins. The correct proportion of anti-nutrients to nutrients can break down the negative impacts on digestibility and perform a key role in cellular operation including antioxidant and anti-inflammatory activities (Millar *et al*., 2019). Mild hydrothermal treatment has significant reduction in the level of α-galactosides, trypin inhibitors and phytic acid and enhances the digestion of pea protein utilisation (Urbano *et al*., 2003). Recent evidences have shown that there are some health benefits from protein anti-nutritional compounds present in the pea seeds like lectins and protease inhibitors which have the positive impact on immune deficiency by providing vitamins and minerals. The non-antinutritional compounds like angiotensin I-converting enzyme (ACE) inhibitor relaxes the veins and arteries to treat blood pressure. Lectins own the ability to bring down the effect of certain types of cancers by improving innate defence mechanisms and obesity. Trypsin and chymotrypsin which are protease inhibitors also showed the best result in preventing some cancers along with formidable anti-inflammatory properties. ACE inhibitor may also help in the reduction in hypertension (Roy *et al*., 2010).

Conclusion

Pea (*Pisum sativum* L.), a highly nutritious legume, holds significant promise as a functional food due to its rich profile of essential nutrients, bioactive compounds, and health-promoting properties. Beyond its macronutrient contributions, such as high-quality proteins, dietary fiber, and complex carbohydrates, peas are a valuable source of micronutrients, antioxidants, and phytochemicals. These components contribute to benefits like improved gastrointestinal health, blood glucose regulation, and potential applications in nutraceuticals. Furthermore, the by-products of pea processing, such as pods and peels, show potential for sustainable utilization in promoting health. This comprehensive profiling highlights the versatility of peas and their by-products, laying the groundwork for future research and innovation in health and nutrition.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Important Diseases of Sesamum and Its Management Practices

Bhagya Shree[1], Satyam Ranjan[2], Ashwini Yadav[3]

[1]M.Sc. Scholar, Dept. of Plant Pathology, Naini Agricultural Institute, SHUATS, Prayagraj, U.P.
[2]M.Sc. Scholar, Dept. of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, U.P.
[3]M.Sc. Scholar, Division of Environmental Sciences, ICAR IARI, New Delhi

Introduction

Sesame (*Sesamum indicum* L.) is one of the important oldest oil seed crop grown in tropical and subtropic and it is also known by queen of oil Seed in India. It belongs to family Pedaliaceae is native of India and plays an important role in the oilseed economy throughout the world. Sesame seed is a rich source of protein (20%) and edible oil (50%), and contains about 47% oleic acid and 39% linolenic acid. Nine edible oilseeds are cultivated in India and sesamum ranks fifth in production, after groundnut, rape seed, soybean and sunflower. The sesame crop suffers from many diseases like powdery mildew caused by *Erysiphe cichoracearum*, **Stem and Root rot** caused by *Macrophomina phaseolina*, Phytophthora blight (*Phytophthora parasitica* var.*sesami*), **Alternaria leaf spot** caused by *Alternaria sesame*, Cercospora leaf spot, Fusarium wilt, bacterial blight (*Xanthomonas Compestris* pv. *sesami*). Bacterial leaf spot (*Pseudomonas syringe* p.v. *sesame*) and **phyllody** caused by phytoplasma. Mycoplasma like organisms (MLOs) has been found to be associated with diseases in several hundred plant species. To control the sesamum diseases many management practices are apply like cultural, physical, biological management overcome the pathogen infection.

Major Fungal Diseases of Sesamum

Diseases	Causal organism
Alternaria leaf spot	*Alternaria sesame*
Phytophthora blight	*Phytophthora parasitica* var.*sesami*
bacterial blight	*Xanthomonas Compestris* pv. *sesami*
Stem and Root rot	*Macrophomina phaseolina*
Phyllody	*Alternaria solani*
Bacterial leaf spot	*Pseudomonas syringe* p.v. *sesame*

1. Root Rot or Stem Rot or Charcoal Rot

Causal Organism - *Rhizoctonia bataticola*

Symptoms

- The disease symptom starts as yellowing of lower leaves, drooping and at last defoliation of leaf occure.
- The stem portion near the ground level shows dark brown lesions and bark at the collar region.
- The sudden death of plants is seen in patches.
- The stem portion can be easily pulled out leaving the rotten root portion in the soil.
- The infection when spreads to pods.
- Pods open prematurely and immature seeds shriveled and become black in colour.

- No. of sclerotia (resting part) present on infected part.
- The sclerotia may also be present on the infected pods and seeds.
- The fungus interrupts the function of xylem vessels causing wilting and premature death of plant [36].

Loses due to Disease

- Murugesan et al., reported that 1.8kg/ha sesame yield losses at every one per cent increase in charcoal rot disease intensity [6]
- Maiti et al., estimated yield loss of 57% at 40% of disease incidence [10].

Favourable Conditions for Disease

- Temperature - 30℃ and above
- Prolonged drought.

Management

A. Cultural Control

- Selection of disease free seeds of chili.
- Disease crop debris should be collected and burnt.
- Early planting of chili.
- Deep plowing
- Crop rotation

B. Biological Control

- Applications of *Trichoderma* spp. effective method. It is the fungal antagonist.
- Gupta *et al*., studied the effective integrated management practice of charcoal rot in sesame by soil application of T. viride @ 2.5kg/hac [76].

C. Use of Resistant Variety

- GT-10

D. Chemical Method

- Seed treatment with carbendazim + thiram (1:1) at 2g/kg seed.
- Apply farm yard manure or green leaf manure at 10t/ha or neem cake 150 kg/ha.

Figure 1: Root Rot or Stem Rot or Charcoal Rot

2. Leaf Blight of Sesamum

Causal Organism - *Alternaria sesami*

Symptoms

- Initially small, circular, reddish brown spots (1-8mm) appear on leaves which enlarge
- Cover large area with concentric rings on leaf spots.
- The lower surface of the spots are greyish brown in colour. In severe infection defoliation occurs.
- Dark brown lesions can also be seen on petioles, stem and capsules.
- Infection of capsules results in premature splitting with shriveled seeds.

Favourable Conditions for the Disease

• Low temperature (20-25℃),
• High relative humidity and Cloudy weather

Management

A. Cultural Control

- Selection of disease free seeds of chili.
- Disease crop debris should be collected and burnt.
- Early planting of chili.
- Deep plowing
- Crop rotation

ISSN : 3048 - 989X

B. Biological Control

- Applications of *Trichoderma* spp. effective method. It is the fungal antagonist.
- The seeds treated with Trichoderma viride at 4g/kg.

C. Use of Resistant Variety

- GT-10

D. Chemical Method

- Treat the seeds with thiram or Carbendazim at 2g/kg.
- Spray Mancozeb at 2kg/ha or Iprodion 1L/ha.

3. Sesamum Phyllody

Causal Organism - Phytoplasma

Symptoms

- The disease mostly came during flowering stage.
- The into flower part transformed green leaf structure.
- Cluster of leaf present on plant
- Plant growth Plants stunted do not produce capsules (no seed formation).
- Economic loss but if capsule is formed and not produce good quality seed.

Disease Cycle: The disease transmitted by leaf hopper.

Favourable Condition for Disease

- Dry weather
- 25°C temperature
- 65% RH

Management

A. Cultural Control

- Selection of disease free seeds of chili.
- Disease crop debris should be collected and burnt.
- Early planting of chili.
- Deep plowing
- Crop rotation

B. Use of Resistant Variety

C. Chemical Method

- Application of monocrotophos 0.3% for **control of vector**.
- Application of Tetracycline 500 ppm

Figure 2: Leaf Blight of Sesamum

Figure 3: Sesamum Phyllody

Reference

Gupta GK, Chauhan GS. Symptoms identification and management of soybean diseases. Technical bulletin. 2005;10: 89-92.

Gupta KN, Naik KR, Bisen R. Status of sesame diseases and their integrated management using indigenous practices. International journal of chemical studies. 2018;6(2):1945-1952.

Maiti S, Hedge MR, Chattopadhyay SB. Handbook of Annual Oilseed Crop. Oxford and IBH Publ. Co. Pvt. Ltd., New Delhi; 1988.

Murugesan M, Shanmugam N, Menon PPV, Arokiaraj A, Dhamo KP, Kochubabu M. Statistical arrangement of yield loss of sesame due to insect pests and diseases. Madras Agriculture Journal. 1978;65: 290-295.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Hydroponics: Novel Technology for Horticultural Crops

Radha

Ph.D. Scholar
Department of Fruit Science, College of Horticulture and Forestry Acharya, Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya

Soil based cultivation is now facing difficulties due to different man-made reasons such as industrialization and urbanization. Also, sudden natural disasters, climate change and unrestricted utilization of chemicals for agriculture purposes cause the depletion of soil fertility and quality. That is why, scientists have developed a new alternative approach for cultivation system namely soil-less cultivation or hydroponics. Hydroponics is a method of growing plants in a water based, nutrient rich solution (Maharana and Koul, 2011). Through hydroponics a large number of plants and crops or vegetables can be grown. The quality of yield, taste and nutritive value of end products produced through hydroponically is generally higher than the natural soil-based cultivation. This cultivation is cost effective, disease free, eco-friendly and is gaining popularity all over the world, in both the developed and the developing countries. It has a great prospect in many countries along with high space research to fulfil the lack of arable land where proper cultivable land is not available. So, hydroponics would be a better technique to produce the different kinds of fruits, vegetables and fodder as well as meet the global nutrition demand with making advance future. In the future, hydroponics could be emerging techniques for the supplying of food to the world-wide population.

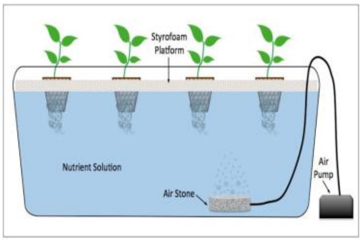
Introduction

Hydroponics is a subset of hydro culture and is a method of growing plants using mineral nutrient solutions, in water, without soil. Hydroponics is a technology of plants growing in a nutrient solution (containing water fertilizers) with or without containing of artificial medium (sand, vermiculite, perlite, gravel, rock wool, peat mass) to provide mechanical support. Utilizing this technology, the roots absorb balanced nutrient dissolved in water that meets all the plant developmental requirements. This technique is very useful for the area where environmental stress (cold, heat, dessert etc.) is a major problem. It is becoming popular because there is no chance of soil-borne disease, insect or pest infection to the crops. Crops in hydroponic system can be cultivated year-round and considered as off season. Higher yields can be obtained since the number of plants per unit is higher compared to conventional agriculture (Turner, 2008). In combination with greenhouse, it is high technology and capital intensive. Currently, demand of hydroponics cultivation has been increased in all the developing and developed countries. Holland, Germany, Australia, Japan and Brazil, USA are using hydroponics for crop production with amazing results. Various commercial crops can be grown using hydroponics including leafy vegetables, tomatoes, cucumbers, peppers, strawberries, papaya and fruit crop seedlings and many more.

Types of Hydroponic Systems in Solution Culture

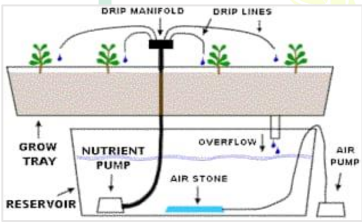
1. **Deep Water Culture**

   Deep Water Culture (DWC) systems are by far the simplest method of hydroponics. They are often used in classrooms to provide a working example of a hydroponics system. It is also not an appropriate hydroponic systemor every type of plant: Because the roots are constantly submerged in an abundance of nutrient solution, many plants will suffer from beingoverfed. Therefore, it is recommended only use this system for water-loving plants, such as lettuce.



2. **Drip system Recovery/Non-recovery**

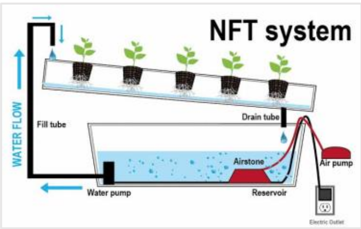
The most used hydroponics system is the drip system. The main principles behind the hydroponic drip system are relatively simple which makes them incredibly easy to use, hence their popularity. Nutrient reservoir which is kept separate from the plants.



There are two types of drip systems: the recovery drip system and the non-recovery drip system.

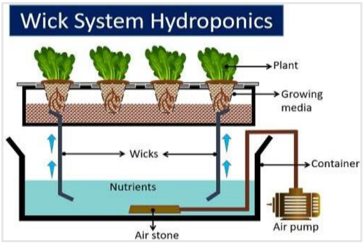
3. **N.F.T. (Nutrient film Technique)**

NFTs are often used in commercial hydroponics, particularly for short harvest crops. In India NFT technique used for vegetables and ornamentals growing. NFT system does not require a timer. The growing chamber is built with the slightest downhill decline, allowing the solution to trickle from the top end of the tray to the bottom, where it is recycled back into the nutrient reservoir. Instead of a regulated watering schedule, the plants in an NFT hydroponic system are provided with a constant flow of nutrient solution. Only a small film of nutrient solution is accessible to the plants which are suspended above with their roots hanging down - at any given point.



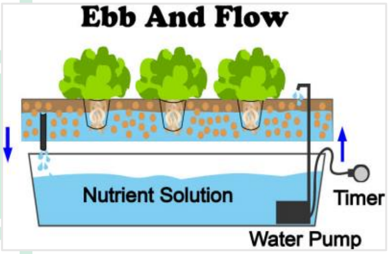
4. **Wick System or Capillary**

The wick or capillary system do not use pumps or timers. Water and nutrients are drawn up to the roots by capillary action. These systems may be important when designing a system to operate in a space station where gravity is nonexistent.



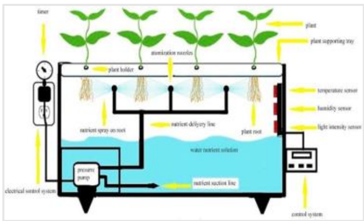
5. **Ebb and flow hydroponic system**

The ebb and flow hydroponic system (otherwise known as a flood and drain system) is also a very popular form of hydroponics. They work in a similar way to the drip system, but are actually even more simplistic to use. Use of a nutrient reservoir, keeping the water in a separate tank to the plants, which are placed in a grow tray above. A timer is set to periodically activate a pump which is kept in the nutrient reservoir. All plants in the growth tray will be flooded equally.



6. **Aeroponic system**

The aeroponic system is the most technologically advanced of all the hydroponic systems. The plants are suspended in the air, as in the NFT system, with their roots hanging down below. The nutrient solution is then pumped with a tube, where a second



ISSN : 3048 - 989X

higher pressure pump sprays the solution as a mist over the dangling roots. The reason this technology is considered essential for future food production is that it offers the possibility of a group of plants to be grown vertically, meaning less land is required to farm.

Soil Media Culture

1. **Trench or Trough Technique:** In this technique plants are grown in trenches or trough made with UV stabilized PVC/HDPE sheet, bricks, concrete or other local material. Trench or trough is filled with inert organic, inorganic or mixture of materials like coco-peat, sand, perlite, vermiculite with the depth ranging from 30-60 cm depending on the type of crops.
2. **Pot Technique:** In this technique readymade pots made of plastic in the range of 4 inch to 12-inch diameter are used for growing plants. Pots are filled with inert organic, inorganic or mixture of materials like coco-peat, sand, perlite, vermiculite etc. The volume of the container and growing media depends on type of crops and it varies from 01-10 liters.
3. **Hanging bag Technique:** In this technique thick UV stabilized polyethylene bags filled with cocopeat or coconut fiber in cylindrical shape one meter high are used to grow plants. The bags are suspended vertically and supported overhead and collecting channel is placed below for the nutrient solution. It is suitable for growing lettuce, leafy vegetables, strawberry and small flower plants.
4. **Grow Bag Technique:** In this technique grow bags made with UV stabilized polyethylene sheets of 1 meter length, 15-20 cm width and 8-10 cm height are used for growing plants. Single or paired rows can be used with the plant spacing kept at 30-60 cm depending on the type of crops. It is very common, cheap and easy technique.

Media Used in Hydroponics

- **Rockwool:** A fibrous material made from melted rock. Not biodegradable. Hazardous to health. Must be pH balanced. Excellent water retention.
- **Coco-Coir:** Has an excellent air to water ratio with great water retention.
- **Vermiculite:** Another type of expanded mineral, vermiculite is very similar to perlite, but with a higher cation-exchange capacity, allowing it to store unused minerals for release to the plants as needed at later time.
- **Perlite:** is a mineral that has been superheated so it expands into light weight pebbles that are pH neutral, porous and very absorbent.
- **Expanded Clay:** Most popular media, drain quickly and pH neutral, reusable.

Crops Grown on Soil-Less or Hydroponics Culture

It is practically feasible to grow any kinds of vegetables, fruits, fodder or crops using this technique. Flowers give a better bloom and colour when grown hydroponically. Hydroponics system might be automated, that is why it is well controlled and better for end product collection. Several plants including vegetables, fruits, flowers, medicinal crops can be grown using soil-less or hydroponics culture (Sardare and Shraddha, 2013).

Major Advantages of Hydroponics Cultivation Are as Follows:

- Cultivate greenhouse crops in poor quality soil
- Soil-borne pathogens and diseases avoidance
- Precision nutrition control in inert media
- Soil disinfection and treatment avoidance
- High yield and better quality of products
- High water and nutrient use efficiency
- Optimum control of environmental parameters
- Round the year production

ISSN : 3048 - 989X

Major Disadvantages/Limitation of Hydroponics Cultivation are as follows:

- Highly technical
- Precision surveillance
- High initial investment

Conclusion

- Hydroponics is the fastest growing sector, and it could very well dominate food production in the future. Hydroponics is one of the potential technologies for doubling farmers income.
- In the changing scenario of food habits hydroponics technology is going to play a major role for sustainable and round the year production in urban and peri-urban areas. As population increases and poor land management, people will turn to new technologies like hydroponics and aeroponics to create additional channels of crop production.
- Due to rapid urbanization crowded cities without gardens, there is no option but adopting soil-less culture to help improve the yield and quality of the produce so that we can ensure food security of our country. It can be said that hydroponic and soilless culture is “the next logical step” after traditional agriculture.

References

Maharana, L. and Koul, D.N. 2011. The emergence of Hydroponics. 55: 39-40.

Sardare, M. D. and Shraddha, V. A. 2013. A Review on Plant without SoilHydroponics. International Journal of Research in Engineering and Technology. 2(3): 299-304.

Turner, B. (2008). How Hydroponics Work. Retrieved November 18, 2008, from http://home.howstuffworks.com/hydroponics.html

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Biofortification: How It Works, Why It Matters, And What's Holding It Back

Roshin Mariam George
Ph.D. Scholar
College of Agriculture, Vellayani, Thiruvananthapuram, Kerala

Biofortification, the process of enhancing the nutritional content of crops through breeding, offers a cost-effective, sustainable, and long-term solution for combating micronutrient deficiencies. This method not only reduces the need for other interventions like supplements but also helps maintain improved nutritional status in those who benefit. It's particularly effective for reaching rural populations who may lack access to fortified foods. By focusing on enhancing nutrient levels in popular, high-yielding varieties, biofortification can reach wider markets, both rural and urban. While biofortified foods may not deliver as high a dose of micronutrients as supplements, they contribute significantly to daily intake and overall nutritional improvement across all age groups.

Essential Minerals and Vitamins: Addressing Deficiencies

Many minerals and vitamins are crucial for human health. While some are readily available in food and water, others are often lacking, especially in diets reliant on staple crops. These deficiencies are prevalent in developing countries and can lead to serious health issues.

Key Minerals

Iodine: Essential for thyroid hormone production, which regulates growth and metabolism. Deficiency leads to goiter and cretinism. India, for example, faces a significant iodine deficiency problem.

Iron: Crucial for oxygen transport and energy metabolism. Iron deficiency anemia (IDA) affects billions globally, often due to low iron levels in staple crops and the presence of absorption-inhibiting compounds.

Zinc: A vital component of numerous proteins and enzymes. Zinc deficiency, affecting nearly two billion people, can impair growth, sexual development, and cognitive function, especially in children and pregnant women.

Calcium: The most abundant mineral in the body, essential for bone health. Deficiency can lead to rickets in children and osteoporosis in adults.

Selenium: A component of selenoenzymes, acting as an antioxidant and contributing to overall health. It may also play a role in preventing cancer and heart disease.

Key Vitamins

Vitamin A: Essential for vision, immune function, and reproduction. Deficiency can cause blindness and increase the risk of disease and death, particularly in children and pregnant women. Global initiatives are underway to combat vitamin A deficiency through supplementation programs.

Folate: Critical for cell growth and development, especially during pregnancy. Deficiency can lead to neural tube defects in infants and complications during pregnancy. Fortification of wheat products is a common strategy to address folate deficiency.

Alleviating Hidden Hunger: A Multi-Pronged Approach

"Hidden hunger" refers to micronutrient deficiencies despite sufficient calorie intake. Addressing this global challenge requires diverse strategies, as many populations lack essential minerals like iron, zinc, and iodine.

Current Interventions and Their Limitations

Food Fortification: Adding micronutrients to processed foods is cost-effective in the long run, but its success in industrialized nations hasn't translated well to developing countries. This is due to limited processing and distribution infrastructure, increased cost of fortified foods, and the challenge of addressing multiple deficiencies simultaneously. While fortification with single micronutrients like iodine (in salt) has been successful, broader fortification efforts face challenges.

Industrial Fortification: Fortifying staple foods during processing can reach a large population, especially with growing global consumption of wheat flour. Organizations like the Micronutrient Initiative and the Flour Fortification Initiative are promoting these efforts. However, challenges include technical limitations with some staples, potential flavor changes, and the exclusion of populations relying on non-commercial food sources.

Dietary Diversification: Encouraging consumption of diverse foods, including fruits and vegetables, is essential. However, poverty, seasonal availability, and limited resources hinder its effectiveness. Promoting home gardens also faces challenges due to labor costs and land availability.

Food Supplementation: Providing supplements is an effective short-term solution for acute deficiencies, particularly for vitamin A and iron. However, long-term sustainability is difficult due to cost, logistical challenges in reaching vulnerable populations, and the need for consistent compliance. It's most effective when integrated with other health interventions.

Biofortification: A Sustainable Solution

Given the limitations of conventional interventions, biofortification offers a promising long-term approach. This involves enhancing the micronutrient content and bioavailability in crops through agronomic practices, breeding, or genetic engineering.

Breeding and Genetic Engineering

Both aim to develop crops with enhanced micronutrient uptake and bioavailability. Breeding relies on crossbreeding and selection, while genetic engineering allows for the introduction of genes from any source. While both are sustainable solutions requiring upfront investment, genetic engineering offers greater flexibility.

Advantages of Biofortification

This approach offers several benefits over conventional methods:

- **Sustainability:** Requires investment primarily in the research and development phase.
- **Improved Yields:** Nutrient-rich plants often exhibit increased vigor and stress tolerance.
- **Accessibility:** Bypasses infrastructure and compliance challenges associated with other interventions.
- **Natural Bioavailability:** Minerals are assimilated into organic, readily absorbable forms.
- **Cost-Effectiveness:** Offers significant long-term health and economic benefits.

Biofortification, while not a complete solution on its own, presents a powerful, complementary strategy for combating hidden hunger and improving global nutrition.

Several techniques are employed to achieve this goal.

Conventional Plant Breeding: This traditional method leverages existing genetic variation within a crop species or closely related wild relatives to enhance nutritional traits. While effective for improving traits like protein quality (e.g., QPM), it can sometimes compromise yield or other desirable characteristics. However, some cases, like iron and zinc biofortification in rice and wheat, have shown simultaneous improvements in yield and nutrition.

Mutation Breeding: This technique expands genetic diversity by inducing mutations using chemicals or radiation. While widely used for improving grain quality and yield, its application to biofortification is still emerging. This approach can create varieties acceptable for organic certification, unlike genetically engineered crops.

Molecular Breeding (Marker-Assisted Selection): This increasingly popular technique uses DNA markers to identify and track desirable genes during breeding. This significantly accelerates the breeding process by allowing early selection of seedlings with desired traits, reducing development time. Molecular breeding also facilitates "stacking" multiple desirable traits into a single variety.

Genetic Engineering (GE): This method introduces genes from any organism directly into the target crop's DNA. This allows for the incorporation of traits not found within the crop's gene pool, such as the vitamin A precursor in Golden Rice. While potentially faster than other methods, GE faces regulatory hurdles and consumer acceptance issues.

Tissue Culture: Reproducing plants from single cells allows for disease-free planting material and facilitates the use of genes from wild relatives through embryo rescue. This expands the available gene pool for breeding and has been successful in developing improved varieties like Nerica rice. It holds promise for biofortification of root and tuber crops.

Microbiological Interventions

Beyond traditional breeding and genetic modification, harnessing beneficial microorganisms offers a promising avenue for enhancing crop nutrient content.

Plant Growth-Promoting Rhizobacteria (PGPR): PGPR are beneficial bacteria that colonize plant roots, stimulating growth through various mechanisms. Their use is gaining traction as a sustainable alternative to chemical fertilizers and pesticides. PGPR can enhance nutrient uptake, particularly iron, by secreting siderophores, which bind to iron and make it more accessible to plants. They also contribute to overall plant health by suppressing diseases and improving root function. Different PGPR species exhibit varying abilities to compete with plants for micronutrients, highlighting the importance of selecting effective strains. Utilizing PGPR alongside breeding efforts offers a synergistic approach to biofortification, improving both yield and nutrient content.

Arbuscular Mycorrhizal (AM) Fungi: AM fungi form symbiotic relationships with the vast majority of plants, including major food crops. These fungi significantly enhance nutrient uptake, especially of micronutrients like copper, iron, and zinc, by extending the plant's root system with their vast network of hyphae. This fungal network effectively explores the soil and accesses nutrients that would otherwise be unavailable to the plant. AM fungi also contribute to ecosystem health by improving soil structure and nutrient cycling. Their crucial role in plant nutrition makes them a valuable target for enhancing biofortification strategies. Managing agricultural practices to promote AM fungal growth could offer a sustainable and effective way to improve crop nutrient content and combat human malnutrition.

Agronomic Interventions

Applying mineral fertilizers to soil, while a traditional agricultural practice, can also increase mineral content in grains. However, this approach depends on several factors: the soil's mineral content, the fertilizer's bioavailability, and the plant's ability to translocate the absorbed minerals to edible parts. Cost, environmental impact, and the lack of direct yield benefits for farmers pose challenges to widespread adoption. Foliar application, spraying nutrients directly onto leaves, can be more efficient in some cases, but requires sufficient leaf area and potentially multiple applications. Correct diagnosis of nutrient deficiencies is crucial for successful foliar fertilization.

Parboiled Rice: A Case Study in Fortification

Fortifying parboiled rice with iron presents a cost-effective solution to iron deficiency anemia in populations reliant on rice as a staple. The parboiling process enhances iron absorption and retention within the grain, surpassing levels achievable through conventional breeding or genetic modification. This method leverages existing parboiling infrastructure and consumer acceptance, making it a practical approach in regions with high anemia prevalence.

Biofortification of Livestock Feed

While traditionally overlooked, enhancing the nutritional value of crop residues like bran and straw is important for livestock feed. Crop management practices, breeding programs, and molecular marker techniques can improve the quality of these feed sources.

Hindrances and Limiting Factors in Biofortification

While biofortification holds immense promise, certain factors can hinder its effectiveness.

Antinutrients

Compounds like phytate and tannins inhibit the absorption of essential minerals like iron, zinc, and calcium in the human gut. Phytate, prevalent in plant seeds, binds to these minerals, making them less available for absorption. However, there's significant variation in phytate levels among different plant varieties, and low-phytate (lpa) mutants have been developed through non-transgenic methods. These lpa mutants often exhibit increased levels of iron, zinc, and magnesium, suggesting potential for breeding crops with reduced antinutrient content. While considered an antinutrient in humans, phytate plays vital roles in plant physiology, including mineral storage, stress response, and disease resistance. Therefore, reducing phytate levels must be balanced against maintaining plant health and yield.

Promoters of Nutrient Absorption

Certain organic compounds, like ascorbate (vitamin C), beta-carotene (provitamin A), and cysteine, enhance mineral absorption in humans. There's considerable variation in these compounds within plant species, offering opportunities for breeding crops with enhanced promoter content. However, the amino acid composition of different food crops is often constrained by their evolutionary history, highlighting the importance of dietary diversity for obtaining a complete range of essential amino acids.

Biofortification: Strategic Advantages

Biofortification offers several key advantages as a strategy for combating micronutrient deficiencies.

Targeting Vulnerable Populations

By focusing on staple crops, biofortification naturally targets low-income households and vulnerable populations like women and children who rely heavily on these foods. This ensures consistent daily intake of essential micronutrients.

Sustainability and Cost-Effectiveness

The initial investment in developing biofortified seeds yields long-term benefits with low recurrent costs. The ability to share germplasm internationally further amplifies its impact and cost-effectiveness. Once established, biofortified crops provide a sustainable solution, even in the absence of continuous funding or government support. They are also particularly effective in reaching remote rural populations with limited access to commercially fortified foods.

Complementary Approach

Biofortification complements commercial fortification efforts by focusing on the source of food itself. It can also enhance farm productivity by producing more vigorous, stress-resistant plants, offering a direct incentive to farmers. Nutrient-rich seeds often exhibit improved germination, seedling survival, and overall yield.

Future Challenges in Biofortification

Despite its promise, biofortification faces several challenges that require further research and development.

Enhancing Iron Biofortification

Developing crops with increased iron concentration without compromising other nutritional benefits remains a key challenge. Exploring alternative strategies beyond reducing phytate levels is crucial. Rigorous testing of iron-biofortified crops for heavy metal accumulation is essential before public release. Further research on iron compartmentalization within plants is needed.

Expanding Research on Prebiotics and Iron Absorption

Investigating the role of prebiotics in enhancing iron absorption could address the "iron paradox" where host-pathogen competition limits iron availability. Biofortifying crops with prebiotics may improve gut health and immune function, promoting better iron utilization.

Conducting Large-Scale Studies

Large-scale studies are needed to assess the effectiveness of iron-biofortified crops in reducing anemia and improving overall health outcomes. This will provide crucial evidence for supporting and scaling up biofortification initiatives.

Improving Mineral Use Efficiency in Plants

Further research is needed to improve the efficiency of mineral uptake, transport, and storage within plants. This includes enhancing mobilization of minerals in the soil, uptake by roots, transport to storage tissues, and accumulation in bioavailable forms without hindering plant growth. Reducing antinutrient levels while maintaining plant health and yield remains another important challenge.

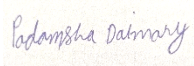
INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Agri-Entrepreneurship Development Through Bee Keeping

D. Sharmah, H. Rabha, A. Khound, B. Nagaria and P. Bora

Krishi Vigyan Kendra (AAU), Udalguri, BTC, Assam, India

The present finding is of a successful farmer Mr. Padamsha Daimary from the Udalguri district, BTC, Assam. Involvement of activities like awareness creation and need base Training on Scientific Bee Keeping technology, regular monitoring of his apiary unit and determination are the main pivotal point behind his achievement to become a successful Bee keeper in his area. Mr. Daimary, at present, is earning an average net income of Rs. 5,05,000/- only per year from his honey bee enterprise. Undoubtedly, the present net income earned by Mr. Daimary is a big achievement for him as compared to his previous income as traditional bee keeper from where is used to get Rs. 8000/- to Rs.10,000/- per year only.



Key words: Honey Bee, Honey, Bee colony, Income and Rural youth

Introduction

Mr. Padamsha Daimary (age 27 Years), a Schedule Tribe (ST) rural youth belongs to Sijonguri village, No.5 Dhanshiri under Udalguri district, BTC, Assam, Basically, he is a rural unemployed youth up to 2018. He started Honey Bee production traditionally in last part of 2018 with one colony. In search of income opportunity, he considered apiculture as a way but he was in confusion to start the bee keeping without any scientific Knowledge in bee keeping. Even he started rearing with local honey bee species from where he was able to harvest only 4-5 kg honey per colony per year which solves only home consumption. His intension was to go for commercial and quality honey production but due to lack of knowledge on Scientific production technology of Honey, in search of that he was introduced with KVK, Udalguri in the end part of 2018. Accordingly, one fine morning he visited to KVK, Udalguri for a better way of earning as well as to become a commercial Entrepreneur on Honey bee production and management leading to have a better life.

Impact of Intervention Made by KVK

The Scientist of KVK, Udalguri interacted with him regarding his problem, resources availability, cultivable land area with him etc. After thorough discussion with him, Subject experts of KVK visited his area and formulated a plan of action on site selection, placing of Box and colony management strategies. According to the plan, Expert of KVK sequentially conducted series of programme starting from Awareness creation, Training, Demonstration on Bee keeping technology to make his farm a model unit. Under the complete guidance, his farm is now become a Model of Good bee keeping Enterprise in that area. Moreover, he became one of the champion farmer in this sector in Udalguri district and encourage other farmers to start this enterprise. Presently he is rearing both the species namely *Apis cerena indica and* Apis *mellifera* in his apiary.

Innovative Ideas Used

He has developed a Honey Box, where he had placed empty bottle in place of the frames in the Honey chamber of the bee box. By using this technique, the honey along with the wax is

Apiary Unit of Mr. Daimary

collected in the bottles and no need to extract the honey separately. Customers are also preferring this honey for the quality of fresh honey produced in the bottles.

Significant Achievement

a. Conventionally, he is a traditional bee keeper from where is used to get Rs. 8000/- – Rs.10,000/- per year only from two bee colonies), he shifted his traditional Bee keeping to modern and scientific Honey producer with incorporation of new scientific technology in entire management of the colony to have a quality produce.

b. Presently he is earning on an average Rs. 505,000/- per year from his Bee keeping enterprises with limited land resources. Probably, this net income is a big issue for him as compared to his previous income as traditional Bee keeper (Rs. 8,000–10,000/- per year only). His maximum income was started from 2019 after being established his apiary in a scientific way. Presently he has 150 numbers of bee colonies producing 1.5 q to 2 q honey per year. Average annual income from Honey production is Rs. 1,20,000/- to Rs. 1,60,0000/- (average selling price @ Rs.800/-kg). He is receiving Rs. 1,50,000/- to Rs. 2,25,000.00 annually by selling bee colony (average selling price @ Rs. 1500/- per colonies). Additionally, he uses to sale bee box also and earning an average income of Rs. 1,00,000/- to 1,20,000/- per year (@ Rs. 2000/- per Box)

c. His annual net income is increasing day by day leading to a happy life

d. He utilises his income in developing his farm due to which now he has one Tower tiller, one Tractor in group, motor for irrigation and other small farm implements.

e. Now, he is a Champion farmer in this area and other fellow farmers using to follow him.

f. Presently he is working as a Master Trainer and disseminating his gained knowledge to other fellow farmers so that they can also start a apiary scientifically.

Market Linkage:

As preference for the raw honey is high among the local customers therefore, he could fulfil the demand of local retail market of the

KVK, Udalguri Officials visit to Daimary's Apiary unit

district as well as the BTR area of Assam. Apart from the home state, the honey colonies are also sold in the northeastern region including Meghalaya, Nagaland and Tripura. The tendering parties collect the colonies from his residence.

Conclusion

The combined action on awareness creation, Training on Scientific Bee keeping, frequent monitoring of his bee keeping activities and strong willpower are the main focal point behind the achievement to establish a successful Apiary unit in his farm. Rural youth like Mr. Padamsha Daimary at present, he is earning on an average Rs. 5,05,000/- per year from his Apiary with 150 numbers of bee colonies. Undoubtedly, the present net income earned by Mr. Daimary is a big achievement for him as compared to his previous income as traditional bee keeper from where is used to get Rs. 8000/- – Rs.10,000/- per year only (from two bee colonies). Thereby Scientific management and rearing of Honey bee can also boost up the income of a farmer with limited land holdings.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Advancements in Gene Editing: Homologous Recombination to Nuclease-Based Techniques

Neha Saini, Vindhya Bundela, Ajay Veer Singh

Department of Microbiology, G.B. Pant University of Agriculture & Technology, Pantnagar 263 145, Uttarakhand, India

Introduction

Gene editing is revolutionizing modern science, enabling precise genetic modifications that were once unimaginable. Two key approaches to gene editing—homologous recombination (HR)-based techniques and nuclease-based technologies—have paved the way for groundbreaking advancements. Here's a closer look at how these methods work and their significance in genetic research.

1. Homologous Recombination-Based Gene Editing

Homologous recombination (HR)-based systems represent the earliest advancements in gene editing, offering precision in genetic modifications by utilizing site-specific recombinases. These systems aim to introduce foreign DNA into recipient cells, replacing or modifying specific target genes. Notable HR-based systems include the Lambda-red system, Cre-loxP, and FLP-FRT, each contributing uniquely to gene editing.

1.1. Lambda-Red System

First introduced in 1998, the Lambda-red system is specific to *Escherichia coli*. It uses three bacteriophage-derived proteins—Exo, Gam, and Beta—for gene modification. Exo creates single-stranded DNA (ssDNA) fragments, Gam protects linear DNA from nucleases, and Beta facilitates the annealing of ssDNA to complementary sequences. This system has shown adaptability for other organisms, including fungi, and has been successfully integrated with CRISPR technologies for broader applications.

1.2. Cre-loxP System

Originating from P1 bacteriophages, the Cre-loxP system uses the Cre recombinase enzyme to modify DNA at loxP sites. It enables deletions, inversions, and cassette exchanges, making it versatile for genome engineering in organisms such as *Saccharomyces cerevisiae*, *Aspergillus*, and *Trichoderma*. This system is particularly effective for multigene manipulations and large gene fragment integrations.

1.3. FLP-FRT System

Derived from *Saccharomyces cerevisiae*, the FLP-FRT system utilizes flippase (FLP) to recognize specific FRT sequences for gene editing. It is widely used in yeast, filamentous fungi, plants, and mammals. Although effective, these HR-based systems rely on specific recombinase recognition sequences, which may limit their versatility.

2. Nuclease-Based Gene Editing Technologies

In contrast to HR techniques, nuclease-based methods offer precision by targeting specific DNA sequences using engineered nucleases. These systems create double-strand breaks (DSBs) in DNA, triggering repair mechanisms that enable targeted gene modifications (Sakuma, T. 2022). Key players in this category include Zinc Finger Nucleases (ZFNs), Transcription Activator-Like Effector

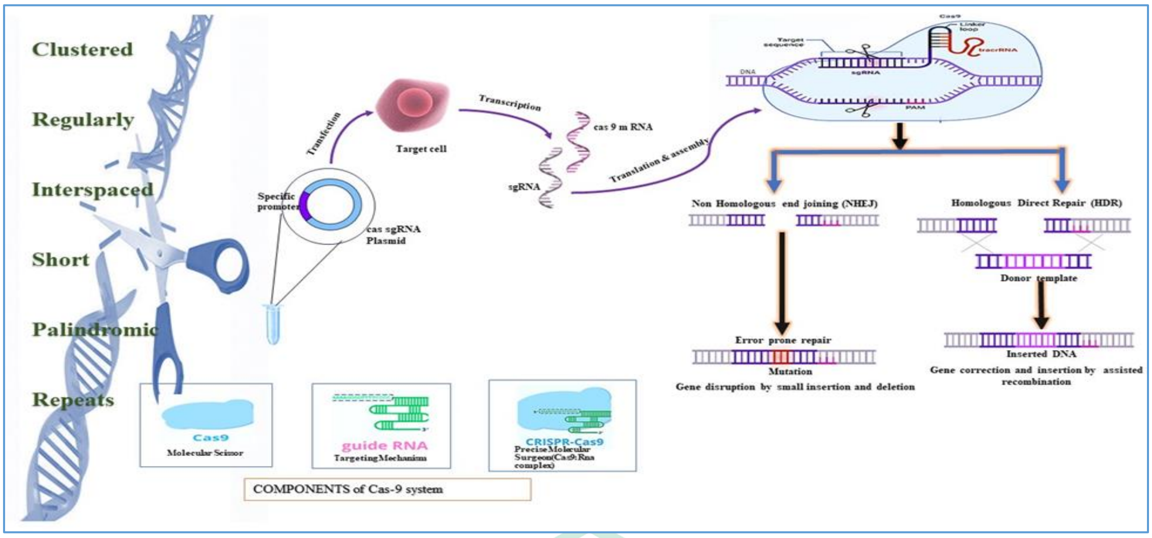


Figure 1: Schematic Representation of the CRISPR-Cas9 Mechanism in Microbial Genetic Engineering (Saini et al., 2024)

Nucleases (TALENs), and CRISPR-Cas systems.

2.1. Zinc Finger Nucleases (ZFNs)

ZFNs are engineered proteins that combine zinc finger DNA-binding domains with the FokI endonuclease catalytic domain. Each zinc finger domain recognizes a specific DNA triplet, allowing ZFNs to target sequences 9–18 base pairs in length. Despite their precision, ZFNs require complex engineering, making them less accessible for widespread use.

2.2. Transcription Activator-Like Effector Nucleases (TALENs)

TALENs consist of a FokI nuclease domain and a TALE-derived DNA-binding domain. These domains recognize single nucleotides, offering greater design flexibility compared to ZFNs. TALENs have been used successfully in organisms such as *A. oryzae*, zebrafish, and *Arabidopsis thaliana*. However, their construction is labor-intensive, limiting their scalability (Grau J et al., 2013).

2.3. CRISPR-Cas Systems

CRISPR-Cas systems have emerged as the most versatile and efficient tools for genome editing. Guided by short RNA molecules, these systems introduce precise cuts at target DNA sites, enabling modifications through repair mechanisms like non-homologous end joining (NHEJ) or homology-directed repair (HDR) (Mushtaq et al., 2021). The CRISPR-Cas9 system, in particular, is widely used for its simplicity and specificity. It employs the Cas9 protein to create double-strand breaks at specific genetic sites, guided by a single-guide RNA (sgRNA). Additionally, systems like Cas12a and Cas13 expand the range of applications by targeting RNA and enabling multiplexed editing. CRISPR-Cas9 editing begins with the formation of a crRNA-tracrRNA-Cas9 complex (Nguyen et al., 2022). This complex recognizes a protospacer adjacent motif (PAM) near the target DNA and cleaves it with precision (Ishino et al., 2018). Repair via non-homologous end joining disrupts genes, while homology-directed repair enables sequence insertion or correction. Its simplicity and versatility make CRISPR-Cas9 a powerful genome-editing tool.

3. Revolutionizing Genetic Engineering

From the foundational Lambda-red system to the groundbreaking CRISPR-Cas technologies, gene editing methods have

TABLE 1: Difference between ZFN, TALEN and CRISPR/Cas9 (Saini *et al.*, 2024)

Characteristics	ZFN	TALEN	CRISPR/Cas9
Abbreviation	Zinc finger nucleases	Transcription activator-like nucleases	Clustered Regulatory Interspaced Short Palindromic Repeats
Composition	Zinc finger domain and Fok1 endonuclease	TALE protein (Bacterial) and Fok1 endonuclease	Two RNAs (trans-activating crRNA and a single guide RNA) and Cas proteins
Precision	Moderate	Higher	Higher
Length of target DNA sequence	9–36 bp	30–40 bp	22 bp and PAM sequence
Mechanism of action (Breakdown of DNA)	Targeted protein-DNA and Double strand break	Targeted protein-DNA and double strand break	Targeted RNA-DNA and single or double strand break
Advantages	Less than 1 Kb protein size permit packing in a single AAV	Precise recognition by 1 bp Rather simple target recognition region	Modify DNA with higher precision. Permit multiplexing

significantly advanced our ability to manipulate genetic material. Each system has unique strengths and challenges, contributing to diverse applications across fields like medicine, agriculture, and biotechnology. As research progresses, these tools are expected to unlock new possibilities in understanding and treating genetic diseases, improving crop resilience, and exploring microbial functions.

Conclusion

Recent discoveries of microorganisms and enzymes offer promising solutions, with genetic engineering playing a pivotal role in enhancing enzyme efficiency and stability. However, the limited natural capabilities of these microorganisms necessitate advancements in enzyme production and activity for targeted biodegradation. Metabolic engineering, supported by tools like CRISPR-Cas9, ZFNs, and TALENs, holds great potential for precise genetic modifications to improve plastic degradation processes. Leveraging genomic, proteomic, and metabolomic data further enhances our ability to design effective biodegradation strategies, addressing this global challenge efficiently.

References

Grau J, Boch J, Posch S (2013) TALENoffer: genome-wide TALEN off-target prediction. Bioinform 29(22):2931-2932.

Sakuma, T. (2022). From nuclease-based gene knock-in to prime editing–promising technologies of precision gene engineering. *Gene and Genome Editing*, *3*, 100017.

Mushtaq, M., Ahmad Dar, A., Skalicky, M., Tyagi, A., Bhagat, N., Basu, U., ... & EL Sabagh, A. (2021). CRISPR-based genome editing tools: Insights into technological breakthroughs and future challenges. *Genes*, *12*(6), 797.

Saini, N., Bharti, D., Singh, S., Banoo, R., Bundela, V., Nain, P., & Sahgal, M. (2024). Genetically Engineered Plastic Munching Microbes: Recent Advancements and Perspectives. In *Advanced Strategies for Biodegradation of Plastic Polymers* (pp. 193-224). Cham: Springer Nature Switzerland.

Sakuma, T., & Woltjen, K. (2014). Nuclease-mediated genome editing: At the front-line of functional genomics technology. *Development, growth & differentiation*, *56*(1), 2-13.

Nguyen, G. T., Dhingra, Y., & Sashital, D. G. (2022). Miniature CRISPR-Cas12 endonucleases–Programmed DNA targeting in a smaller package. *Current opinion in structural biology*, *77*, 102466.

Ishino, Y., Krupovic, M., & Forterre, P. (2018). History of CRISPR-Cas from encounter with a mysterious repeated sequence to genome editing technology. *Journal of bacteriology*, *200*(7), 10-1128.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

The Interaction of Biochar with Soil Nutrients: Implications for Sustainable Agriculture

Monika Kumari*, Gurdev Chand, Jyotsana Kalsi, B.K. Sinha, Sapalika Dogra, Farzana Kouser and Marvi Sharma

Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha 180 009, Jammu & Kashmir, India

Biochar, a carbon-rich material derived from biomass pyrolysis, has garnered significant attention for its potential to enhance soil fertility and sustainability. This article explores the interaction of biochar with soil nutrients, focusing on its effects on nutrient availability, retention, and cycling. The implications for sustainable agriculture, including improved crop yields and reduced environmental impacts, are discussed. Biochar influences soil biological characteristics by enhancing microbial populations, boosting enzyme activities, increasing soil respiration, and raising microbial biomass. Additionally, the application of biochar improves nutrient uptake and use efficiency, making it a valuable nutrient source for plants. Consequently, biochar serves as an effective soil amendment to enhance overall soil quality. Recent advancements and future research directions are also highlighted.

Introduction

Sustainable agriculture aims to balance productivity with environmental conservation. Soil health, a cornerstone of sustainability, is increasingly threatened by intensive farming practices and climate change. Biochar, produced from agricultural and forestry residues, offers a promising solution. Its porous structure and high cation exchange capacity (CEC) make it an effective soil amendment. This review examines the mechanisms through which biochar interacts with soil nutrients and evaluates its potential in sustainable agricultural systems. The diverse nature of biochar, combined with the complexity of its physiological, biochemical characteristics and the microbiological processes influencing its effects, results in varied responses under different conditions (Joseph *et al.*, 2021). This highlights the importance of understanding soil and plant reactions to various biochars produced under diverse conditions with distinct properties, particularly in the context of changing climates (Kavitha *et al.*, 2018). Such insights could clarify the mechanisms governing plant responses to biochar application and aid in optimizing the biochar production process, including the selection of feedstock, application dose, method, and its suitability for specific crops and soil types.

Biochar can be categorized into three main groups according to its ash composition and associated properties (Joseph and Taylor, 2014).

i) Biochar derived from biomass with low ash content (< 3–5%), such as wood, nut shells, bamboo, and certain seeds like apricots. These biochar's are characterized by high porosity, a large surface area (SA), and superior water retention compared to other biochar types.

ii) Biochar made from biomass with moderate ash content (5–13%), which includes most agricultural residues, bark, and high-quality green waste (i.e., minimally contaminated with plastics, soil, or metals).

iii) Biochar produced from biomass with high ash content (> 13%), such as manure, sludge, wastepaper, municipal waste, and rice husks.

Biochar Properties and Nutrient Interactions

Biochar's chemical and physical properties, including its high surface area, porosity, and functional groups, facilitate its interaction with

ISSN : 3048 - 989X

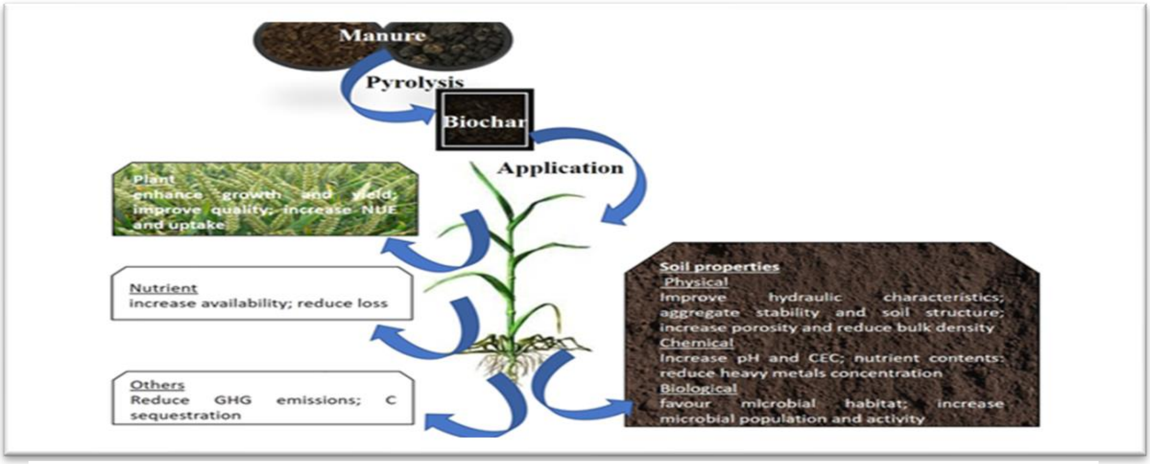


Fig. 1. Conceptual framework for impact of biochar on soils and plants (Hossain et al., 2020)

soil nutrients. Biochar's physiochemical properties can directly and indirectly affect the soil attributes. Key interactions include:

1. Nutrient Retention: Biochar enhances nutrient retention by adsorbing ions onto its surface. For example, studies show that biochar improves the retention of ammonium (NH^{4+}) and nitrate (NO^{3-}) ions, reducing nutrient leaching (Lehmann *et al*., 2011).
2. Nutrient Availability: Biochar can modify soil pH, influencing nutrient solubility. In acidic soils, biochar raises pH levels, improving the availability of phosphorus (P) and potassium (K) (Glaser *et al*., 2002).
3. Microbial Activity: Biochar provides habitats for soil microorganisms, which play critical roles in nutrient cycling. For instance, mycorrhizal fungi, supported by biochar, enhance phosphorus uptake (Warnock *et al*., 2007).

Implications for Sustainable Agriculture

1. Enhanced Fertilizer Efficiency: By reducing nutrient losses through leaching and volatilization, biochar improves fertilizer use efficiency. Studies report yield increases of up to 30% in crops such as maize and rice (Jeffery *et al*., 2011).
2. Soil Health Improvement: Biochar enhances soil organic matter, water-holding capacity, and aeration, creating a conducive environment for plant growth (Novak *et al*., 2009).
3. Environmental Benefits: Biochar reduces greenhouse gas emissions, particularly nitrous oxide (N_2O) and methane (CH_4), from

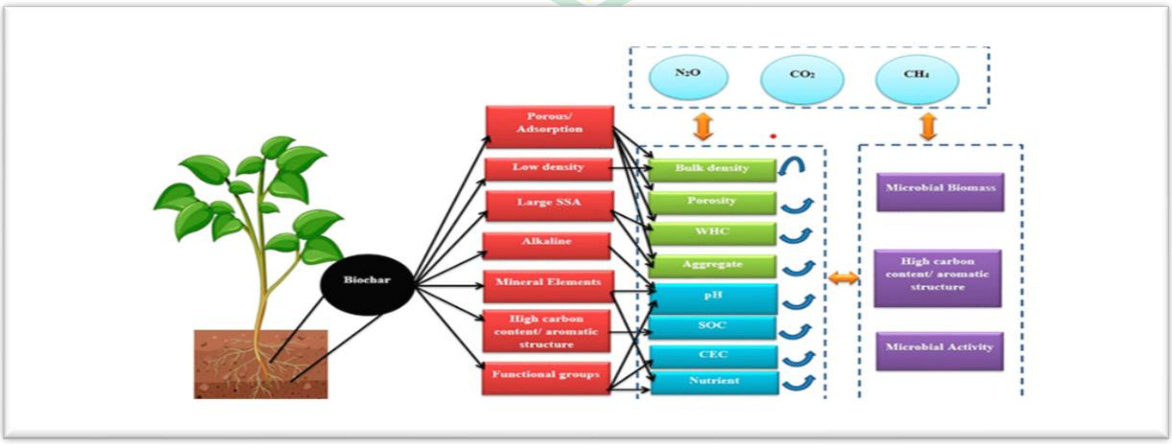


Fig 2: Effect of biochar application on soil physicochemical and biological properties (Murtaza et al., 2023)

agricultural soils. Its role in carbon sequestration further supports climate change mitigation (Woolf *et al*., 2010).

Challenges and Considerations

Despite its benefits, biochar application faces challenges. These include variability in biochar properties based on feedstock and production conditions, economic constraints, and potential negative effects such as nutrient immobilization in the short term. Tailoring biochar applications to specific soil types and cropping systems is essential.

Future Research Directions

1. Long-Term Studies: Evaluating the long-term effects of biochar on soil nutrient dynamics and crop productivity.
2. Feedstock Optimization: Identifying optimal feedstocks and pyrolysis conditions for specific agricultural goals.
3. Integration with Other Amendments: Exploring synergistic effects of biochar with compost, manure, or synthetic fertilizers.

Conclusion

Biochar's interaction with soil nutrients underscores its potential as a sustainable agricultural tool. By enhancing nutrient retention, availability, and cycling, biochar contributes to improved soil health and productivity while mitigating environmental impacts. Further research and tailored applications are essential to fully harness its benefits.

References

Glaser, B., Lehmann, J., & Zech, W. (2002). Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal – A review. *Biology and Fertility of Soils*, *35*(4), 219-230.

Hossain, M.Z., Bahar, M.M., Sarkar, B., Donne, S.W., Ok, Y.S., Palansooriya, K.N., Kirkham, M.B., Chowdhury, S. and Bolan, N. 2020. Biochar and its importance on nutrient dynamics in soil and plant. *Biochar*, **2**: 379-420.

Jeffery, S., Verheijen, F. G. A., van der Velde, M., & Bastos, A. C. (2011). A quantitative review of the effects of biochar application to soils on crop productivity using meta-analysis. *Agriculture, Ecosystems & Environment, 144*(1), 175-187.

Joseph, S. and Taylor, P. 2014. The production and application of biochar in soils. In: Waldron K (ed) Advances in biorefineries: biomass and waste supply chain exploitation. *Cambridge*, 525–555.

Joseph, S., Cowie, A. L., Van Zwieten, L., Bolan, N., Budai, A. and Buss, W. 2021. How biochar works, and when it doesn't: A review of mechanisms controlling soil and plant responses to biochar. *GCB Bioenerg*, 13: 1731–1764.

Kavitha, B., Reddy, P. V. L., Kim, B., Lee, S. S., Pandey, S. K. and Kim, K. H. 2018. Benefits and limitations of biochar amendment in agricultural soils. *Journal of Environment Management*, 227: 146–154.

Lehmann, J., & Joseph, S. (Eds.). (2011). *Biochar for Environmental Management: Science and Technology*. Earthscan.

Murtaza, G., Ahmed, Z., Eldin, S.M., Ali, B., Bawazeer, S., Usman, M., Iqbal, R., Neupane, D., Ullah, A., Khan, A. and Hassan, M.U. 2023. Biochar-Soil-Plant interactions: A cross talk for sustainable agriculture under changing climate. *Frontiers in Environmental Science*, **11**: 1059449.

Novak, J. M., Busscher, W. J., Laird, D. A., Ahmedna, M., Watts, D. W., & Niandou, M. A. S. (2009). Impact of biochar amendment on fertility of a southeastern coastal plain soil. *Soil Science*, *174*(2), 105-112.

Warnock, D. D., Lehmann, J., Kuyper, T. W., & Rillig, M. C. (2007). Mycorrhizal responses to biochar in soil – Concepts and mechanisms. *Plant and Soil*, *300*(1-2), 9-20. Woolf, D., Amonette, J. E., Street-Perrott, F. A., Lehmann, J., & Joseph, S. (2010). Sustainable biochar to mitigate global climate change. *Nature Communications*, *1*(56),

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Impact of Crop Residue Management on Soil Health

Dilbag Singh[1] and Shweta Sharma[2*]

[1]School of Agricultural Sciences, Galgotias University, Greater Noida, Uttar Pradesh 203 201, India

[2]Department of Zoology, CCS Haryana Agricultural University, Hisar, Haryana 125 004, India

*Corresponding author: shwetasaraswat@hau.ac.in

Introduction

In terms of biomass production of lignocellulose, India is second largest country in world. Almost 686 million tons crop residue is produced per year. The main crops responsible for residue production are (Figure 1):

Composition of crop residue: Crop residues mainly consist of cellulose, hemicellulose, lignin, and micro-nutrients including, nitrogen, phosphorus, potassium, silica, sulphur etc.

As the population of India is increasing day by day, to fulfil the basic food requirements, the use of high yielding varieties of crops is also increasing. And these high yield varieties of crops use all the important micro and macro-nutrients from soil. To restore the concentration of micronutrients (N,P,K) in soil, fertilizers are commonly used but other important nutrients e.g. organic carbon, zinc, calcium, magnesium, sulphur, manganese etc remains unintended, due to which degradation of soil health increasing day by day.

Hence, proper management of crop residual should be done which will help in restoring the health of soil.

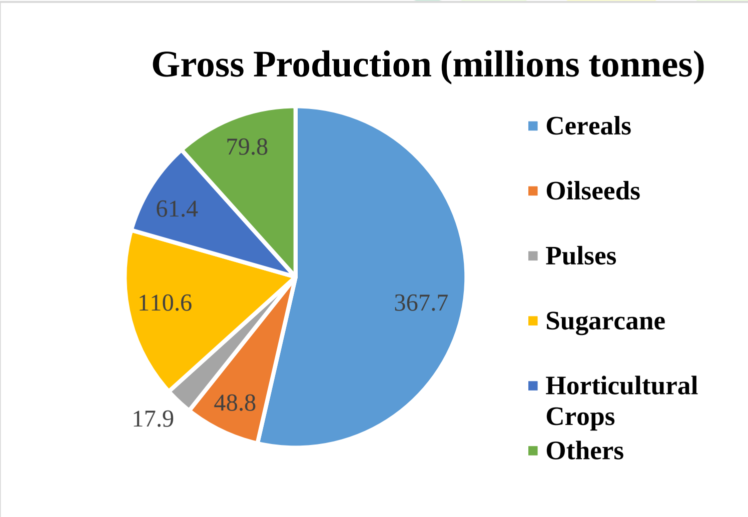


Figure 1: The crops Responsible for Production of Residue

Different Methods of Crop Residue Management:

1. **In-situ:** The management happens on the site or in the field. This includes

A. Crop burning is the most effortless and cheapest method to clear the field within a very short interval of time. Undoubtedly it is easiest way to get rid of residue but simultaneously harm the soil health and also cause environment pollution (e.g. one ton rice after burning produce 1460 kg CO_2, 199 kg Ash, 60 kg CO, 3 kg particulate matter and 2 kg SO_2), increase evaporation rate and reduce micro, micronutrients in soil.

B. Happy Seeder: To reduce air pollution and use of burning, TATA trust RGR cell has developed a technology named as happy seeder. This machine sows seeds (scatter evenly throughout the field) of new crop and remove residue of old crop at the same time. This technique helps in retaining moisture and ultimately helps in seed germination. The residue naturally decomposes over time and also enriching the soil. Studies have validated the benefits of this technique. Since the machine is expensive but state government offers

50% subsidy to individual farmers and upto 75% to a group of farmers.

C. Biodegradable Mulch: Biodegradable Mulch are crop residue loose covering of material placed on the surface of soil. Mulches can be applied to bare soil to cover the soil surface, retain soil moisture, reduce transpiration, suppress weeds, improve soil fertility, structure, water holding capacity, encourage beneficial soil organisms.

Straw, defined here as the stalks and other residues left after harvest of a mature grain, is similar to hay in texture, potential for soil protection and moisture conservation, weed suppression, and application methods. Straw differs from hay in that it:

- Has higher carbon to nitrogen (C:N ratio).
- Provides a cleaner, more persistent mulch that is slower to decompose, and more effective in keeping the fruit of pumpkin and other vine crops clean.
- May carry seeds of the grain crop itself, but is less likely to carry other weed seeds.
- Has somewhat lower K levels and slower K release.
- Is lighter colored and more reflective, hence it may cool soil more than hay.

Because straw is so much less likely to introduce serious new weed problems than hay, organic horticultural farmers located in or near grain-producing regions where straw is available and affordable often prefer straw over hay. The high C:N ratio of straw precludes much release of N from mulch to the current year's crop, but usually does not lead to tie-up of soil N, as long as the mulch lies on top of the soil and is not tilled in.

The dramatic soil cooling under straw can delay crop growth; however it can be beneficial for cool weather crops like potato, in which tuber growth is inhibited by soil temperatures above 70°F; and for other crops during hot summer weather. For example, tomato shows optimal nutrient uptake and production at root zone temperatures of 70–85°F, and becomes stressed at higher temperatures; thus, it often performs better in organic than in plastic mulches during the heat of summer. Bright, reflective straw can intensify heating of crop foliage under a row cover, resulting in crop damage, and may also increase damage from frosts.

D. PUSA Decomposer: The PUSA Decomposer, developed by the Indian Agricultural Research Institute (IARI), is an innovative and eco-friendly solution for managing crop residues in situ. This microbial-based technology comprises a consortium of fungal strains that produce enzymes to decompose paddy straw and other crop residues efficiently. By accelerating the breakdown process, the PUSA Decomposer converts residues into organic mulch within 20-25 days, enriching the soil with nutrients and organic matter.

Process:

- The decomposer is prepared as a liquid formulation by fermenting the microbial solution for 4-5 days.
- The prepared solution is sprayed onto crop residues uniformly in the fields.
- The treated residues decompose rapidly, eliminating the need for burning.

Benefits:

- Prevents air pollution caused by stubble burning, a significant issue in northern India.
- Improves soil health by increasing organic carbon content and nutrient availability.
- Reduces dependency on chemical fertilizers.
- Cost-effective and easy to use for farmers.

Field trials by IARI have demonstrated the effectiveness of the PUSA Decomposer across various agro-climatic zones. This technology has been widely promoted by the Government of India as part of sustainable agricultural practices to combat pollution and enhance soil fertility.

2. **Ex Situ Management of Crop Residue:** Crop residues are a valuable resource when managed effectively. Ex situ management involves utilizing these residues outside the

fields for various purposes, reducing environmental pollution and adding economic value. Below are five major strategies for ex situ management of crop residues:

A. Biocompost: Biocomposting transforms crop residues into nutrient-rich organic fertilizers through microbial degradation. This process enhances soil fertility, promotes sustainable agriculture, and reduces dependence on chemical fertilizers. Crop residues like wheat straw, rice straw, and sugarcane bagasse are shredded and mixed with animal dung, green waste, and microbial inoculants to accelerate decomposition.

Key Steps:

- Collection and shredding of residues.
- Mixing residues with cow dung and microbial inoculants.
- Piling in layers and maintaining moisture levels.
- Periodic turning to ensure aeration.

Advantages:

- Enhances soil organic matter.
- Reduces greenhouse gas emissions from residue burning.
- Offers a cost-effective method for residue disposal.

B. Cattle Feed: Crop residues such as paddy straw, wheat straw, and maize stalks serve as valuable livestock feed. These residues can be processed into silage or enriched with nutrients to improve digestibility and nutritional value. This strategy addresses both the issue of residue management and the shortage of cattle feed in rural areas.

Methods of Utilization:

- Chopping residues and mixing them with molasses or urea for enrichment.
- Ensiling residues to preserve them for offseason feeding.

Advantages:

- Provides an affordable feed alternative for livestock.
- Converts low-quality residues into high-value products.

C. Roofing Material in Rural Areas: Crop residues like paddy straw, wheat straw, and sugarcane leaves are widely used as roofing materials in rural areas. These residues are bundled and arranged on wooden frames to create eco-friendly and cost-effective roofs.

Benefits:

- Provides natural insulation against heat and cold.
- Uses locally available materials, reducing costs.
- Biodegradable and renewable resource.

Challenges:

- Requires regular maintenance and periodic replacement.
- Susceptible to fire and pests.

D. Biomass Energy: Crop residues are an excellent source of biomass energy. Technologies like briquetting, pelletization, and direct combustion convert residues into energy-dense products for use in power generation and household cooking.

Technologies:

- **Briquetting:** Compressing residues into solid blocks for fuel.
- **Pelletization:** Creating uniform pellets for industrial boilers and household stoves.
- **Direct Combustion:** Using residues directly in biomass power plants.

Advantages:

- Reduces reliance on fossil fuels.
- Provides a renewable energy source.
- Generates employment in rural areas.

E. Packing Material: Crop residues, especially wheat straw and rice husks, can be converted into eco-friendly packing materials. These materials are biodegradable and offer a sustainable alternative to plastic packaging.

Applications:

- Production of molded pulp products like trays and containers.
- Use as cushioning material for fragile goods.

Advantages:

- Reduces plastic waste.
- Biodegradable and compostable.

- Adds economic value to agricultural by-products.

Conclusion:

Effective crop residue management is essential for maintaining and enhancing soil health while addressing environmental concerns. Both in situ and ex situ methods, such as the use of the PUSA Decomposer, biocomposting, and biomass energy generation, offer sustainable, eco-friendly solutions. These approaches enrich the soil with organic matter, improve nutrient availability, and reduce dependency on chemical inputs. Additionally, ex situ strategies add economic value, offering alternative uses for residues in livestock feed, rural infrastructure, and renewable energy. Widespread adoption of these practices can revolutionize agricultural residue management, ensuring soil fertility and environmental sustainability.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Integrated Insect Pests Management in Vegetable Crop: Bottle Gourd (*Lagenaria siceraria*)

Vikas Kumar*, Dr. Ajay Kumar and Dr. D.S. Srivastava

*Ph.D. Scholar, Department of Entomology, Banda University of Agriculture & Technology, Banda, 210001, Uttar Pradesh, India
Ch. Charan Singh University, Meerut, 250001, Uttar Pradesh, India
Krishi Vigyan Kendra, Sitapur II, Uttar Pradesh, India

The present investigation entitled integrated insect pests management in vegetable crop bottle gourd (*Lagenaria siceraria*). The fruits can be used as vegetable or for making sweets. As a vegetable, it is easily digestible even by patients. The fruits contain 0.2% protein, 2.9% carbohydrates, 0.5% fat and 11 mg of vitamin C per 100g fresh weight (Aykroyd 1963). The seasonal incidence of major insect pests such as Red pumpkin beetles (*Aulacophora foveicollis*), Fruit Fly (*Bactrocera cucurbitae*) and Thrips palmi was studied. Therefore, there is a dire need to focus on integrated management practices of the insect vectors as a part of sustainable agriculture. Pests are a serious menace to our agricultural and horticultural crops and damage the plants' aerial and underground parts. From past century many researchers were trying to find economically viable plant protection strategies and recently they were succeeded in finding out an ecofriendly safe strategy i.e. Integrated Pest Management (IPM), which is potentially an effective tool for pest management. This is inexpensive, socially accepted, environmentally safe and economically viable, which make it truly sustainable. Successful integrated Pest Management modules are always socially as well as economically viable, environmentally safe and mainly focused on ecological aspects of pest management strategies. But with the progress of time there is development in agricultural technologies, newly developed Information and communication tools, end client interest, enhanced sustainability awareness and globalization. So, there is a strong need to revisit the Integrated Pest Management paradigm shift in present time.

Introduction

Bottle gourd (*Lagenaria siceraria*) belonging to the family Cucurbitaceae, is a climbing perennial plant widely cultivated round the year as a vegetable crop across the country. It is grown in warmer regions of the world nowadays, it is becoming popular for several health benefits. The fruits can be used as vegetable or for making sweets. As a vegetable, it is easily digestible even by patients. It is gaining importance due to its high yield. potential, steady market price throughout the season. The fruits contain 0.2% protein, 2.9% carbohydrates, 0.5% fat and 11 mg of vitamin C per 100 g fresh weight (Aykroyd 1963). The present investigation was carried out during the kharif season of 2019 to study the incidence of prevailing four insect pests of bottle gourd in relation to weather. The seasonal incidence of major insect pests such as among them, red pumpkin beetle, *Aulacophora foveicollis* (Lucas) (Chrysomelidae, Coleoptera) and fruit flies (*Bactrocera* spp.), *Aulacophora foveicollis Lucas, Bactrocera cucurbitae Coquillett, Aphis gossypii Glover* and *Bemicia tabaci Gennadius* was studied.

Identification of Important Pest

1. **Red Pumpkin Beetles** (*Aulacophora foveicollis*): Brownish elongate eggs are laid in the soil and each female may lay about 150 to 300 eggs singly or in groups of 8-9 near the base

ISSN : 3048 - 989X


Red Pumpkin Beetles

Egg Laying by Adult Fruit Fly

Fruit Fly Eggs Beneath the Skin of Fruit

Adult of Thrips

Thrips Damage Symptoms

of plants. Egg period is 5-8 days. Grubs are creamy white with darker oval shield at back. Grub period is 13-25 days. Pupation takes place in an earthen cocoon. Pupal period is 7-17 days. *Raphidopalpa foveicollis* has reddish brown elytra; A. intermedia has blue black elytra; and A. cincta has grey elytra with black border. Total life cycle takes 26-27 days. Beetles are more destructive. They bite holes on leaves and also feed on flowers. There are 5 to 8 generations/year.

2. Fruit Fly (*Bactrocera cucurbitae*): Eggs lay singly in clusters on fruits. Larva is dirty white apodous maggot and they pupate in soil. Fruit fly maggots feed on the internal tissues of the fruit causing premature fruit drop, yellowing and rotting of the affected fruits. This fruit fly is difficult to control because its maggots feed inside the fruits, protected from direct contact with insecticides.

3. Thrips (*Thrips palmi*): Adults are pale yellow or whitish in color, but with numerous dark setae on the body. A black line, resulting from the juncture of the wings, runs along the back of the body. The slender fringed wings are pale. The hairs or fringe on the anterior edge of the wing are considerably shorter that those on the posterior edge. They measure 0.8 to 1.0 mm in body length, with females averaging slightly larger than males. Unlike the larval stage, the adults tend to feed on young growth, and so are found on new leaves. Adult longevity is 10 to 30 days for females and seven to 20 days for males. Females produce up to about 200 eggs, but averaging about 50 per female. Both mated and virgin females deposit eggs.

Integrated Pest Management Strategies

Integrated pest management (IPM) is a strategy that uses a combination of methods to control pests while minimizing environmental disruption. IPM strategies include the five steps of IPM are:

1. Prevention: Organisms are kept from becoming problems by planning and managing ecosystems.

2. Identification: Pests and beneficial organisms are identified.

3. Monitoring: Pest and beneficial organism's populations are watched, as well as pest damage, and the environment.

4. Injury and Action Decision: Injury and action thresholds are used to know when to treat pests.

5. Evaluation: The effectiveness of pest management plans are considered.

Integrated Pest Management Tools

Cultural Control: Uses farm management strategies and resistant plant varieties to minimize the impact of pests. For example, rotating corn production with other crops to prevent corn rootworm.

Biological Control: Uses natural enemies, such as predators, parasites, pathogens, and competitors, to control pests.

Mechanical Control: These are based on the knowledge of pest behaviour. Hand picking, installation of bird perches, mulching and installation of traps are a few examples.

Pest Resistant Varieties: Breeding for pest resistance is a continuous process. These are bred and selected when available in order to protect against key pests.

Chemical Control: Uses pesticides to manage pests, but only when biological and cultural control have not been enough. Selective insecticides are chosen to target the pest while leaving beneficial populations unharmed.

IPM brings together into a workable combination the best strategies of all control methods that apply to a given problem created by the activities of pests. IPM has been defined in various ways but a more scientific definition describes it as, "the practical manipulation of pest populations using sound ecological principles to keep pest populations below a level causing economic injury". The emphasis here is "practical" and "ecological". There are many ways of controlling insect pests but only a few are practical, and fewer are ecologically sound, such that an undesirable citation is created.

Conclusion

Integrated Pest Management (IPM) for bottle gourds (*Lagenaria siceraria*) involves monitoring and using a combination of practices to control pests. IPM is an environmentally friendly approach that uses information about pests and their interactions with the environment.

Reference

Anonymous 2021. Area, Production and Productivity of Vegetables in India.

Bhowmik S & Saha S. 2017. Study on the pest complex of bottle gourd in the gangetic plains of West Bengal. Journal of Entomology and Zoology Studies, 5: 725–727.

Common Sense Pest Control. 1991. W. Olkowski, S. Daar and H. Olkowski. The Taunton Press.715 pp. Bio-Integral Resource Center, P.O. Box 7414, Berkeley, CA 94707 Tel: 510-524-2567 Fax: 510-524-1758 www.birc.org.

IPM Practitioner. Bio-Integral Resource Center, P.O. Box 7414, Berkeley, CA 94707 Tel: 510-524-2567 Fax: 510-524-1758 www.birc.org.

GLASS, E.H. (ed.) 1975. Integrated Pest Management, Rationale, Potential Needs and Implementation. Entom. Soc. Amer. Spec. PubI. 75-12,141 pp.

Nath, P., and Velu, S.., (2006). Cucurbitaceous Crops in Asia, Hort Science, July 2006 vol 41 no. 4 1016 Himalayan Resources Institute, New-Baneshwor, Kathmandu, Nepal. 77 -100.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Probiotics and Probiotic Foods: A Path to Better Health

Dr. M. Deepa, Dr. M. Yugandhar Kumar, Dr. M. Ganga Devi, Dr. Ch. Anil Kumar, Dr. R.K. Soujanya

Krishi Vigyan Kendra, SVVU, Guntur

Probiotics are live microorganisms, often referred to as "good" or "friendly" bacteria, that provide a wide range of health benefits when consumed in adequate amounts. These beneficial microbes naturally exist in the human gut and play an essential role in maintaining a healthy digestive system and overall well-being. While the term "bacteria" may often be associated with disease, probiotics serve as the opposite—helping to restore balance in the body's microbiome and combating harmful pathogens.

Probiotics offer numerous health benefits, particularly for digestive health. They enhance the breakdown of food, improve nutrient absorption, and reduce issues like bloating, constipation, and diarrhea. One of their significant applications is in combating antibiotic-associated diarrhea, where antibiotics disrupt the balance of gut flora. Probiotics can help replenish beneficial bacteria, restoring harmony to the digestive tract. Additionally, these microorganisms are known to strengthen the immune system, helping the body fight off infections more effectively. Emerging research has also linked probiotics to mental health benefits. Through the gut-brain axis, a healthy gut can influence mood and cognitive function, potentially reducing symptoms of anxiety and depression. Furthermore, probiotics contribute to skin health, support the management of conditions like irritable bowel syndrome (IBS) and inflammatory bowel diseases (IBD), and even alleviate allergies.

Incorporating probiotic-rich foods into the diet is a natural and effective way to reap their benefits. Fermented dairy products like yogurt, kefir, and buttermilk are among the most well-known sources, as they contain strains of *Lactobacillus* and *Bifidobacterium*. These strains are essential for gut health and have been extensively studied for their positive effects. For those who prefer non-dairy options, fermented vegetables such as sauerkraut and kimchi are excellent choices. These foods are not only rich in probiotics but also packed with vitamins, minerals, and antioxidants. Kombucha, a fermented tea, and miso, a fermented soybean paste commonly used in Japanese cuisine, are other popular options. Soy-based foods like tempeh and natto also provide probiotics while catering to vegan and vegetarian dietary needs.

When choosing probiotic foods, it is crucial to pay attention to the label. Look for products that mention "live and active cultures," as this ensures the presence of viable probiotics. Storage conditions are equally important; for example, yogurt and other fermented products often require refrigeration to maintain their efficacy. It is also wise to select products with minimal added sugars and artificial ingredients to maximize their health benefits. For individuals with specific health concerns, consulting a healthcare professional can help identify the most suitable probiotic strains for their needs.

Incorporating probiotics into daily meals can be simple and enjoyable. A bowl of yogurt with fresh fruits and nuts can serve as a nutritious breakfast. Add a spoonful of sauerkraut or kimchi as a side dish to your lunch or dinner for a tangy, probiotic-rich boost.

Sauerkraut is a traditional fermented cabbage dish that originated in Europe. It is made by finely shredding cabbage and allowing it to ferment in its natural juices with the addition of salt. The fermentation process encourages the growth of beneficial lactic acid bacteria, which gives sauerkraut its tangy flavor and makes it a rich source of probiotics. Sauerkraut is also packed with dietary fiber, vitamins C and K, and other essential nutrients. To prepare sauerkraut, cabbage is shredded, salted, and tightly packed into a jar or container. It is then left to ferment at room temperature for several days to weeks, depending on the desired level of tanginess.

Kimchi, on the other hand, is a staple in Korean cuisine and is also a fermented vegetable dish, primarily made from napa cabbage and radishes. It is seasoned with a mix of spices, including red chili flakes, garlic, ginger, and fish sauce or fermented shrimp, which gives it a spicy and savory flavor profile. Like sauerkraut, kimchi undergoes fermentation that enhances its probiotic content, along with its richness in vitamins A, B, and C, and antioxidants. To prepare kimchi, napa cabbage is salted and rinsed, then mixed with a spicy paste made from chili powder, garlic, ginger, and other ingredients. The mixture is packed into jars and allowed to ferment for several days to weeks, depending on taste preferences.

Sipping on kombucha or including miso soup in your diet can also be refreshing ways to introduce probiotics. **Kombucha** is a fermented tea beverage made by fermenting sweetened black or green tea with a symbiotic culture of bacteria and yeast (commonly referred to as SCOBY). During fermentation, the sugars in the tea are broken down, resulting in a tangy, fizzy drink that is rich in probiotics, organic acids, and antioxidants. Kombucha is known for its refreshing taste and potential health benefits, including improved digestion, detoxification, and immune support. To prepare kombucha at home, sweetened tea is brewed and combined with a SCOBY, then left to ferment at room temperature for one to two weeks. The fermentation process can be adjusted to achieve the desired level of sweetness or tanginess.

Miso soup is a traditional Japanese soup made using miso, a fermented soybean paste. Miso is prepared by fermenting soybeans with salt and a mold called *koji*. It is available in different varieties, ranging from mild white miso to stronger red or brown miso, depending on the fermentation period. Miso soup typically consists of a broth made by dissolving miso paste in hot water, often accompanied by ingredients like tofu, seaweed, and green onions. The fermentation process in miso enriches it with probiotics, which support gut health and immunity. Miso soup is not only a comforting dish but also a quick and easy way to incorporate probiotics into daily meals.

Indian Probiotic Foods and Cultures

India has a rich tradition of probiotic foods, deeply rooted in its culinary and cultural practices. Some popular Indian probiotic foods include:

1. Curd (Dahi): A staple in Indian households, curd is made by fermenting milk with a bacterial culture. It is an excellent source of probiotics, particularly *Lactobacillus* strains, and is often consumed with meals to aid digestion and enhance gut health.

2. Lassi and Chass: Lassi is a sweetened yogurt-based drink, while chaas (buttermilk) is a spiced version. Both are traditional probiotic drinks that help cool the body and improve digestion, especially during the summer months.

3. Idli and Dosa Batter: These South Indian breakfast staples are made by fermenting a mixture of rice and urad dal (black gram). The natural fermentation process develops beneficial bacteria, making the batter probiotic-rich.

4. Kanji: A fermented drink made from black carrots or beets, kanji is a traditional North Indian probiotic beverage. It is tangy and mildly spicy, known for its digestive benefits.

5. Pickles: Indian pickles made through natural fermentation, particularly lime or mango pickles, are a rich source of probiotics. The salt brine encourages the growth of lactic acid bacteria, which enhances gut health.

6. Appam and Panta Bhaat: Appam, a fermented rice pancake from Kerala, and panta bhaat, fermented rice water from Bengal, are regional dishes with probiotic benefits. They are often consumed with coconut milk or lightly spiced curries.

7. Fermented Bamboo Shoots: Consumed in the northeastern states of India, fermented bamboo shoots are a rich source of probiotics and are used in various dishes.

These foods not only contribute to gut health but are also integral to India's diverse culinary heritage. They are prepared using traditional fermentation methods, often passed down through generations, highlighting the importance of probiotics in Indian diets.

For people who find it challenging to include probiotic foods in their diet, supplements are available; however, natural food sources are often more sustainable and provide additional nutrients.

Probiotics are more than just a health trend; they are a cornerstone of maintaining a balanced and healthy lifestyle. From digestive health to immune support and mental well-being, the benefits of these microorganisms are vast and well-documented. By consciously incorporating probiotic-rich foods into your diet, you can take a simple yet impactful step toward improving your overall health and vitality.

INNOVATIVE AGRICULTURE
www.innovativeagriculture.in
ISSN : 3048 - 989X

Medicinal Properties of Physalis minima (Cut Leaf Ground Cherry)

[1]Dr. V. Manimaran and [2]Mr. K. Selvakumar

[1]Assistant Professor (Forestry) and [2]Assisatnt Professor (AGR)

J.K.K. Munirajah College of Agricultural Sciences, T.N. Palayam, Erode District

Introduction

Physalis minima, commonly known as the wild gooseberry, little gooseberry, or sunberry, belongs to the Solanaceae family. This small herbaceous plant is widely distributed in tropical and subtropical regions, thriving in fields, roadsides, and waste lands. Traditionally, various parts of this plant have been utilized in indigenous medicinal systems, particularly in Ayurveda, Unani, and traditional Chinese medicine. It has been recognized for its extensive pharmacological benefits, ranging from anti-inflammatory and antimicrobial properties to its potential role in managing chronic diseases like diabetes and cancer.

Phytochemical Composition

The medicinal properties of *Physalis minima* are attributed to its rich phytochemical profile, including:

- **Withanolides**: Bioactive compounds with anti-cancer, anti-inflammatory, and immunomodulatory effects.
- **Flavonoids**: Potent antioxidants that help combat oxidative stress and inflammation.
- **Alkaloids**: Exhibit antimicrobial and analgesic properties.
- **Sterols**: Important for anti-inflammatory and cardioprotective actions.
- **Tannins**: Known for their astringent, antimicrobial, and anti-diarrheal properties.
- **Saponins**: Support immune function and show antiviral activity.

Medicinal Benefits

1. Anti-Inflammatory and Analgesic Properties

Physalis minima has demonstrated significant anti-inflammatory effects, which

make it useful in treating conditions such as arthritis and muscle pain. Its bioactive compounds, particularly withanolides and flavonoids, help reduce inflammation by inhibiting pro-inflammatory enzymes like cyclooxygenase (COX) and lipoxygenase (LOX).

2. Antimicrobial Activity

The plant exhibits strong antimicrobial activity against various bacterial and fungal pathogens. Its alkaloids and flavonoids have shown effectiveness against *Escherichia coli*, *Staphylococcus aureus*, *Candida albicans*, and *Aspergillus* species, making it a promising natural antibiotic alternative.

3. Antioxidant Potential

Due to its high flavonoid and polyphenol content, *Physalis minima* acts as a powerful antioxidant. It helps neutralize free radicals, thereby protecting cells from oxidative damage, which is linked to aging, cardiovascular diseases, and neurodegenerative disorders.

4. Anti-Diabetic Effects

Extracts of *Physalis minima* have been studied for their hypoglycemic properties. The plant's bioactive compounds help regulate blood sugar levels by enhancing insulin sensitivity and inhibiting glucose absorption in the intestine, making it beneficial for diabetes management.

5. Anti-Cancer Properties

Withanolides, present in *Physalis minima*, have been reported to exhibit anti-cancer activity by inducing apoptosis (programmed cell death) and inhibiting the proliferation of cancer cells. Research suggests potential effectiveness against breast, lung, and colon cancers.

6. Hepatoprotective Effects

The plant's phytochemicals protect the liver against toxic damage caused by excessive alcohol, drugs, and environmental toxins. It enhances liver enzyme function and reduces oxidative stress, supporting liver health.

7. Cardioprotective Properties

Saponins and sterols in *Physalis minima* contribute to heart health by reducing cholesterol levels, preventing lipid peroxidation, and improving overall cardiovascular function. The plant's antioxidant properties also help in maintaining healthy blood vessels.

8. Diuretic and Kidney Health Support

Traditionally, *Physalis minima* has been used as a natural diuretic, helping in the removal of excess fluids and toxins from the body. This makes it beneficial for managing kidney stones, urinary tract infections, and fluid retention issues.

9. Immune System Modulation

The plant enhances immune function by stimulating white blood cell activity and providing resistance against infections. Its antiviral properties have also been explored, particularly in the treatment of viral fevers and respiratory infections.

10. Wound Healing and Dermatological Benefits

Topical application of *Physalis minima* extracts has been found useful in wound healing due to its antimicrobial and anti-inflammatory effects. It is also beneficial for skin conditions like eczema, psoriasis, and acne.

Traditional Uses and Applications

- **Decoction** of leaves is used to treat fevers and respiratory ailments.
- **Paste** of leaves and stems is applied to wounds and skin infections.
- **Fruit consumption** is believed to enhance immunity and improve digestion.
- **Root extracts** are used in traditional medicine to alleviate jaundice and liver disorders.
- **Infusion** of the plant is used for kidney disorders and as a diuretic.

Conclusion

Physalis minima is a promising medicinal plant with diverse therapeutic properties. Its rich phytochemical composition supports its traditional uses in treating inflammatory conditions, microbial infections, diabetes, cancer, and liver diseases. While traditional knowledge strongly supports its medicinal applications, further scientific studies and clinical trials are necessary to fully understand its potential and ensure safe therapeutic use. Integrating *Physalis minima* into modern medicine could provide natural alternatives for managing various health conditions, emphasizing the need for continued research and conservation of this valuable plant species.