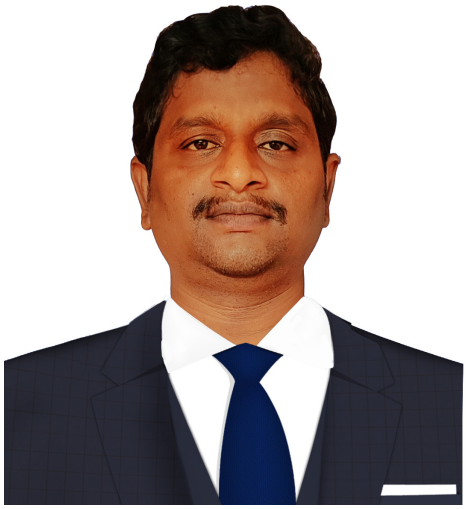
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From the Desk of Editor-in-Chief



With immense humbleness and anticipation, I seek it's my pleasure to launch the September 2026 issue of the **"Krishi Netra"** a monthly e-Magazine subtitled "Invisible Vision on Farming" published by **GRN Creatives**. On behalf of the Krishi Netra Editorial Team, I would like to take this opportunity to thank our authors, editors, reviewers and all of them who have volunteered to contribute to the successful release of the first (December) issue of the e-Magazine.

The magazine aims to provide a common platform for the scientific community, research scholars and other readers to publish their ideas, new inventions, research findings etc., to provide the invisible insights for betterment of the farming community. Krishi Netra magazine is primarily focused on the areas of Agriculture, Horticulture, Precision Farming, Fisheries & Animal Sciences, Agriculture Engineering, Agribusiness Management, Food & Dairy Technology, Bio-Sciences/ Life-Sciences, Biotechnology & Biochemistry, Environmental Science &Forestry, Organic Farming, Sericulture and Home Science.

As we turn the pages of Krishi Netra, let us celebrate the unsung heroes, the farmers, the agri-entrepreneurs, the scientists, and the agri scholars. Together, we delve into the realms of sustainable practices, agro ecology, and the transformative power of technology, ensuring that the seeds we sow today yield a bountiful harvest for generations to come.

May this magazine be a source of inspiration, knowledge, and appreciation for the remarkable journey from seed to harvest. Join us on this exploration of the fields that bind us all, as we cultivate a deeper understanding and appreciation for the intricate dance of life on the farm.

I warmly welcome the authors with their contributions that can meet the practical appliances with an integrated/ convergent approach. I wish, with all your support I could see a very bright prospects for Krishi Netra magazine as an eye opener in serving the needs of the farming community.

We look forward for your valuable feedback!
For any questions/ suggestions/ concerns, please contact us: krishinetra@gmail.com
Thank you.

Editor-in-Chief
Gangisetty Srikanth Kumar

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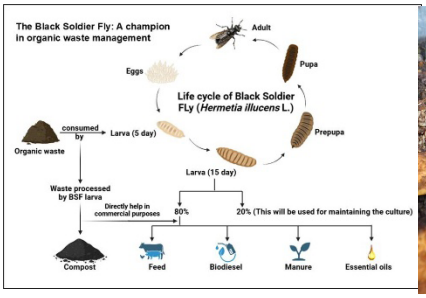
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Black Soldier Fly Frass: From Organic Waste to a New Generation of Fertilizer

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How an unlikely insect is helping turn organic waste into a valuable resource for farmers







Agriculture faces two major challenges at the same time: managing growing quantities of organic waste and maintaining healthy, productive soils. An unusual insect may offer part of the solution.

The black soldier fly (BSF), *Hermetia illucens*, is attracting increasing attention because its larvae can process suitable organic materials and convert them into useful products. One of the most interesting products is frass, the residue left after the larvae feed.

Frass contains insect excreta, shed material and undigested feed residues. Rather than treating this material simply as waste, researchers are investigating it as an organic fertilizer and soil amendment. Recent reviews report promising effects on nutrient availability, soil health and plant growth, while also emphasizing that frass composition varies according to the material fed to the larvae and how the frass is processed.

The insect behind the idea

Black soldier flies are very different from the common housefly. It is their **larval stage** that has attracted agricultural and waste-management researchers.

BSF larvae can process a variety of suitable organic substrates, including food residues, agricultural by-products and some animal-derived materials. During this process, part of the substrate becomes larval biomass, while another portion remains as frass.

This creates an interesting biological conversion system:









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Organic waste → BSF larvae → Larval biomass + frass → Agricultural products

Researchers see this as an example of the circular economy, in which materials that might otherwise be discarded are converted into useful resources

What exactly is BSF frass?

The word *frass* is commonly used for the material associated with insect rearing. In BSF production, it can contain larval excreta, shed exoskeleton material and residual feed substrate.

Its composition is not identical from one production system to another. The substrate given to the larvae can substantially affect the resulting frass.

Studies have found that BSF frass can contain important plant nutrients, including nitrogen, phosphorus and potassium, together with organic matter and other biologically active components.

That combination is what makes frass interesting as a potential fertilizer.

More than just NPK

The potential value of frass goes beyond its basic nutrient content.

Soil is a living system containing microorganisms, organic matter, plant roots, minerals and water. A good soil amendment therefore does more than simply supply nitrogen.

Research has investigated compounds such as chitin, organic matter and microorganisms associated with BSF frass. These components may influence microbial activity, nutrient cycling and plant responses. A 2025 review concluded that BSF frass has promising physicochemical and biological properties for restoring degraded soils.

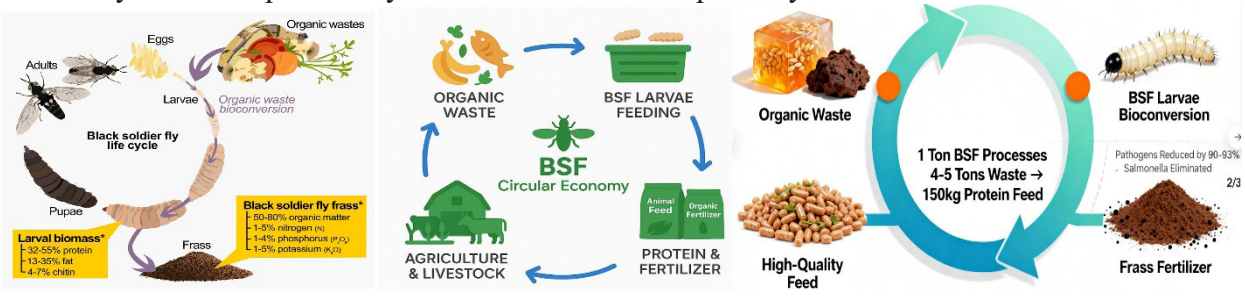
However, these effects depend strongly on the frass product and its application conditions.

From waste to soil: closing the nutrient loop

Perhaps the most important story about BSF frass is not the insect itself but the nutrient cycle it can help create.

Instead of following a linear pattern—**produce → consume → discard**

BSF systems can potentially create a more circular pathway:



Organic residues → insect production → frass → soil → crops → new organic residues

Does frass improve crop growth?

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Research so far is encouraging.

A 2021 study examining BSF frass as an organic fertilizer for perennial ryegrass found increased plant production with increasing frass application under the experimental conditions. The researchers also observed increases in soil organic matter, phosphorus and potassium and changes in soil enzyme activity.

Research on tomato has also examined BSF frass in relation to plant growth, nutrient uptake and beneficial mycorrhizal fungi. A 2025 study found that frass has significant potential as a nutrient-rich organic fertilizer, while also identifying nutrient imbalances that could limit its effectiveness in some circumstances.

These studies suggest that frass can be agriculturally useful—but they also demonstrate why it should be evaluated as a fertilizer product with specific characteristics, rather than if all frasses will perform identically.

What does frass look like?

Processed frass generally has a dark brown, soil-like appearance. Its texture varies according to the production and processing system.

Its appearance, however, cannot tell a farmer everything about its fertilizer value. Laboratory analysis is much more useful for determining nutrient concentration, moisture, pH, electrical conductivity and other characteristics.



Frass is not a “magic manure”

The growing enthusiasm around BSF frass should be accompanied by some caution.

Not all frass is the same.

Its properties depend on the larvae’s feed substrate, insect-rearing conditions, processing method and storage. A 2024 review specifically highlighted differences in nutrient composition, pH, organic matter and other properties among frass products produced from different substrates.

This means that farmers should not assume that one application rate will work for every frass product, crop or soil.

The maturity and stability of the material also matter. Researchers have identified cases in which excessive or insufficiently stabilized frass negatively affected plant growth. The critical review literature therefore emphasizes the importance of post-processing and biological stabilization.

Could frass replace chemical fertilizer?

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Probably not in every situation—and that may not be the right question.

Instead, BSF frass could become one component of **integrated nutrient management**.

Mineral fertilizers provide concentrated, predictable quantities of nutrients. Organic amendments can contribute nutrients together with organic matter and other biological components.

Using the right combination for a particular crop and soil could potentially provide both immediate nutrient availability and longer-term soil benefits.

The scientific literature increasingly points toward this type of integrated approach rather than treating frass as a universal substitute for conventional fertilizers.

The importance of quality control

For BSF frass to become a mainstream agricultural input, farmers need to know exactly what they are buying.

Important characteristics include:

- nutrient concentrations.
- moisture content.
- pH and electrical conductivity.
- organic matter content.
- stability and maturity.
- possible contaminants.
- microbial safety; and
- consistency between batches.

Standardization is therefore one of the major challenges for the emerging frass industry. Recent research reviews have specifically identified feedstock variability and the lack of consistent standards as important areas requiring further work.

A promising future for sustainable agriculture

The real promise of black soldier fly frass lies in its ability to connect several environmental and agricultural goals.

Organic residues can become inputs for insect production. The insects can generate valuable biomass, while the remaining frass can potentially return nutrients and organic matter to agricultural soils.

This does not mean that BSF frass will solve every agricultural problem. More long-term field research is needed, particularly across different crops, climates and soil types.

But the research already available provides a compelling reason to take the technology seriously.

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The humble black soldier fly may ultimately become more than an insect used to process organic residues. It could become part of a new generation of circular agriculture, in which waste is transformed into nutrients and nutrients are returned to the food-production system.

The future of fertilizer may not simply be about producing more nutrients—it may be about learning how to recycle the nutrients we already have.

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Role of Extension Scientists In Krishi Vigyan Kendras: Bridging Science, Farmers and Sustainable Agriculture

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ABSTRACT

Agriculture is continuously evolving in response to climate change, emerging technologies, changing market demands, natural resource constraints and the growing need for sustainable food production. In this dynamic situation, Krishi Vigyan Kendras (KVKs) play a vital role in connecting agricultural research institutions with farming communities. Extension Scientists working in KVKs serve as an important link between scientific knowledge and farmers' field-level requirements. Their role extends beyond conventional technology transfer to include need assessment, technology validation, capacity building, entrepreneurship development, digital extension, natural resource management, climate-resilient agriculture and strengthening farmer institutions.

Extension Scientists identify location-specific agricultural problems, conduct On-Farm Testing (OFTs) and Frontline Demonstrations (FLDs), organize farmer trainings, method demonstrations, field days, exposure visits and awareness programmes and provide timely technical advisories. They also facilitate the adoption of improved varieties, farm mechanization, integrated pest and nutrient management, protected cultivation, livestock and fisheries technologies, post-harvest management and value addition. By working closely with farmers, Farmer Producer Organizations (FPOs), Self-Help Groups (SHGs), rural youth, women farmers and line departments, Extension Scientists contribute significantly to improving farm productivity, profitability and livelihood security.

Thus, the Extension Scientist in a KVK is not merely a communicator of technology but a facilitator, problem solver, educator, innovator and catalyst for rural transformation. Strengthening extension systems and enhancing the professional capacity of Extension Scientists will be crucial for achieving resilient, profitable and sustainable agriculture.

Keywords: Krishi Vigyan Kendra, Extension Scientist, Technology Transfer, Farmer Training, OFT, FLD, Capacity Building, Sustainable Agriculture, Climate Resilience, Agricultural Extension

Introduction:

Indian agriculture supports the livelihood of a large section of the population and plays a central role in ensuring food and nutritional security. However, farmers today face several challenges, including climate variability, erratic rainfall, declining soil fertility, pest and disease outbreaks, increasing input costs, labour shortages, fragmented landholdings, market uncertainties and limited access to modern technologies.

Agricultural research institutions continuously develop improved technologies to address these challenges. However, the availability of a technology does not automatically ensure its adoption at the farm level. Farmers need technologies that are *location-specific, economically viable, technically feasible and

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socially acceptable*. This is where agricultural extension assumes critical importance.

The *Krishi Vigyan Kendra (KVK) system* was established with the objective of providing vocational training and practical agricultural knowledge to farming communities. Over the years, KVKs have evolved into important frontline extension institutions that demonstrate improved agricultural technologies under real field conditions.

Extension Scientists are at the heart of this process. They work directly with farmers and simultaneously interact with agricultural universities, ICAR institutions, line departments, NGOs, FPOs and other stakeholders. Their work enables the conversion of scientific knowledge into practical solutions for farmers.

2. KVKs as the Bridge Between Research and Farmers

The success of agricultural research ultimately depends on its effective application in farmers' fields. KVKs provide a platform where technologies developed by research institutions can be demonstrated, evaluated and refined according to local conditions.

Extension Scientists facilitate this process through a *research–extension–farmer linkage*.

The linkage can broadly be represented as:

Research Institutions → KVKs → Extension Scientists → Farmers → Field Feedback → Research Institutions

This is not a one-way process. Modern agricultural extension follows a *two-way knowledge flow*, where farmers are also recognized as important sources of knowledge and innovation. Their field experiences, indigenous practices and practical difficulties provide valuable feedback for researchers.

Extension Scientists therefore act as a bridge connecting:

* Agricultural research with farming communities

* Universities with rural development agencies

* Scientists with farmers

* Technologies with field-level needs

* Government schemes with eligible beneficiaries

* Farmers with markets and institutions

* Traditional knowledge with modern scientific practices

3. Major Roles of Extension Scientists in KVKs

3.1 Identification of Farmers' Problems

One of the most important responsibilities of an Extension Scientist is to identify the actual problems faced by farmers. Regular interaction with farmers through village visits, farmer meetings, diagnostic visits, field days and group discussions helps scientists understand:

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* Crop production constraints

* Pest and disease problems

* Soil and nutrient-related issues

* Water management difficulties

* Labour and mechanization constraints

* Post-harvest losses

* Marketing problems

* Livestock and fisheries-related challenges

* Climate-related risks

* Lack of knowledge and skill gaps

This information helps KVKs prioritize technologies and interventions according to local needs.

3.2 On-Farm Testing and Technology Assessment

Technologies developed under research conditions may perform differently under farmers' field conditions. Extension Scientists therefore play an important role in conducting *On-Farm Testing (OFT)*. OFTs help evaluate the suitability of technologies under diverse agro-climatic, socio-economic and farming situations.

Extension Scientists:

1. Identify suitable locations and farmers.

2. Select technologies based on identified problems.

3. Develop appropriate treatment and comparison protocols.

4. Monitor field performance.

5. Record farmer observations and feedback.

6. Analyze the results.

7. Document successful technologies.

8. Recommend suitable technologies for wider dissemination.

3.3 Frontline Demonstrations for Technology Dissemination

Frontline Demonstrations (FLDs) are among the most effective tools used by KVKs for showcasing improved agricultural technologies. An Extension Scientist demonstrates the difference between existing farmer practices and recommended technologies under actual field conditions. Such demonstrations create

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confidence among farmers because they can directly observe the results.

FLDs may cover areas such as:

* Improved crop varieties
* Integrated nutrient management
* Integrated pest management
* Farm mechanization
* Water-saving technologies
* Climate-resilient practices
* Natural farming
* Integrated farming systems
* Oilseed and pulse production
* Horticultural technologies
* Livestock management

The *“Seeing is Believing”* principle makes frontline demonstrations particularly powerful in agricultural extension.

4. Capacity Building and Farmer Training : Knowledge and skills are essential for technology adoption. Extension Scientists organize training programmes based on the needs of different target groups.

Training programmes may be conducted for:

* Farmers
* Farm women
* Rural youth
* Agricultural entrepreneurs
* SHG members
* FPO members
* Input dealers
* Para-extension workers
* Agricultural officers
* Village-level extension personnel

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The training methodology is increasingly becoming practical and participatory. Instead of merely delivering lectures, scientists use *method demonstrations, practical sessions, field visits, videos, interactive discussions and problem-solving exercises*.

The objective is not simply to provide information but to develop the capacity of participants to independently apply the technology.

5. Empowering Women and Rural Youth : Women and rural youth are increasingly becoming important stakeholders in agricultural development.

Extension Scientists support farm women through programmes on:

* Nutrition gardens
* Value addition
* Food processing
* Mushroom cultivation
* Backyard poultry
* Dairy and goat rearing
* Millet-based products
* Post-harvest management
* Entrepreneurship
* Small-scale enterprises

Similarly, rural youth can be trained in agricultural enterprises such as custom hiring services, nursery raising, beekeeping, mushroom production, protected cultivation, seed production, food processing and digital agricultural services.

Such interventions help create *employment opportunities within rural communities* and reduce dependence on traditional crop production alone.

6. Promoting Climate-Resilient Agriculture

Climate change has emerged as one of the major challenges to agricultural production. Rising temperatures, delayed monsoons, prolonged dry spells, intense rainfall and extreme weather events can significantly affect farm productivity.

Extension Scientists play a key role in promoting climate-resilient technologies such as:

* Drought-tolerant crop varieties
* Short-duration varieties
* Water-saving irrigation methods

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* Mulching
* Soil moisture conservation
* Integrated farming systems
* Crop diversification
* Weather-based advisories
* Contingency crop planning
* Conservation agriculture
* Farm mechanization

KVKs also conduct awareness programmes and demonstrations on climate risk management so that farmers can make informed decisions.

7. Digital Agricultural Extension : The rapid growth of digital technology has transformed agricultural extension. Extension Scientists now use digital platforms to reach a larger number of farmers in less time.

Important digital extension tools include:

* WhatsApp groups
* Mobile-based advisories
* Social media
* Online training programmes
* Video demonstrations
* Digital photographs for pest and disease diagnosis
* Weather information services
* Online farmer databases
* Webinars and virtual meetings

Digital extension does not replace personal interaction but complements conventional extension methods. A combination of *digital and physical extension* can significantly improve the speed and reach of agricultural information.

8. Entrepreneurship, Value Addition and Market Linkages

Increasing farm income requires more than increasing crop productivity. Farmers must also be supported in reducing post-harvest losses, processing agricultural produce and accessing better markets.

Extension Scientists play a growing role in promoting:

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* Food processing
* Packaging
* Branding
* Labelling
* Value addition
* Enterprise development
* FPO formation and strengthening
* Market-oriented production
* Agri-startups
* Rural entrepreneurship

9. Strengthening Farmer Institutions : Individual farmers often face difficulties in accessing inputs, machinery, technology and markets. Collective action can help overcome many of these constraints.

Extension Scientists facilitate linkages with:

* Farmer Producer Organizations
* Self-Help Groups
* Farmer Interest Groups
* Commodity groups
* Cooperatives
* Rural youth groups

Capacity building of these institutions can improve collective input procurement, value addition, processing, branding and marketing. Strong farmer institutions can transform farmers from individual producers into *organized agribusiness stakeholders*.

11. Coordination with Line Departments and Stakeholders : Agricultural development involves several departments and organizations. Extension Scientists coordinate with:

* Department of Agriculture
* Horticulture Department
* Animal Husbandry Department
* Fisheries Department
* Rural Development agencies

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* Agricultural Universities

* ICAR Institutes

* NGOs

* FPOs

* Banks and financial institutions

* Private sector organizations

KVKs can serve as a *knowledge and coordination platform* at the district level, bringing different stakeholders together for farmer-oriented programmes.

12. Documentation of Success Stories and Innovations : Successful technologies and innovative farmers provide powerful learning resources.

Extension Scientists document:

* Successful farmers

* Best management practices

* Innovative farming practices

* Entrepreneurial activities

* Technology adoption stories

* Impact of demonstrations

* Income enhancement models

* Women-led enterprises

* Youth entrepreneurship

A well-documented success story can motivate other farmers more effectively than a conventional lecture. The Extension Scientist therefore has an important role as a *knowledge documenter and knowledge manager*.

13. Feedback from Farmers to Research Institutions : Extension is incomplete without feedback.

Farmers frequently identify practical problems that may not be visible under controlled research conditions. Extension Scientists communicate these issues to researchers and subject matter specialists.

For example, farmers may report:

* Difficulty in operating a machine

* High input requirements

* Poor availability of seed

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* Variety preference issues

* Labour-related constraints

* Processing difficulties

* Market limitations

* Local pest and disease problems

Such feedback helps researchers modify technologies and develop more farmer-friendly solutions. Thus, Extension Scientists ensure that agricultural research remains *farmer-centred and demand-driven.

14. Extension Scientist as a Multi-Dimensional Professional : The responsibilities of an Extension Scientist have expanded considerably. The modern Extension Scientist is expected to perform multiple roles:

Teacher + Trainer + Facilitator + Demonstrator + Problem Solver + Communicator + Innovator + Entrepreneurial Mentor + Digital Communicator + Farmer Advocate

This requires continuous professional development.

Extension Scientists should keep themselves updated in emerging areas such as:

* Artificial intelligence in agriculture

* Precision agriculture

* Remote sensing and GIS

* Climate-smart agriculture

* Natural farming

* Digital agriculture

* Agri-business

* Food processing

* Entrepreneurship development

* Market intelligence

* Participatory extension approaches

Continuous learning is essential for delivering relevant and credible services to farmers.

15. Challenges Faced by Extension Scientists : Despite their important role, Extension Scientists face several challenges:

1. Large geographical areas and diverse farming situations.

2. Limited human resources and infrastructure.

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3. Increasing demand for real-time technical advisories.

4. Climate variability and emerging pest problems.

5. Rapid changes in agricultural technologies.

6. Limited digital literacy among some farmers.

7. Difficulty in ensuring sustained technology adoption.

8. Market-related constraints.

9. Need for greater convergence among stakeholders.

10. Increasing expectations for measurable impact.

Addressing these challenges requires institutional support, adequate resources, capacity building and stronger coordination between research, extension and development agencies.

16. Future Directions for KVK Extension

The future of agricultural extension will increasingly move from technology transfer to knowledge facilitation and innovation management.

KVK Extension Scientists should focus on:

* Demand-driven extension

* Farmer-led innovation

* Digital advisory services

* Climate-smart agriculture

* Entrepreneurship development

* Value addition and processing

* FPO strengthening

* Youth engagement

* Women-led enterprises

* Precision agriculture

* Integrated farming systems

* Sustainable natural resource management

The emphasis should shift from simply asking “How many programmes were conducted?” to asking “What measurable change occurred in farmers’ lives?”

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Impact-oriented extension will be the key to strengthening the relevance of KVKs in the future.

Conclusion

Krishi Vigyan Kendras are an important institutional mechanism for translating agricultural research into practical field-level solutions. Extension Scientists are central to this mission. Their role encompasses problem identification, technology assessment, frontline demonstrations, capacity building, advisory services, entrepreneurship development, digital extension, climate-resilient agriculture, farmer institution building and impact documentation.

The modern Extension Scientist is no longer merely a transmitter of information. He or she is a facilitator of innovation, a bridge between science and society, a mentor for farmers and a catalyst for rural development. Therefore, strengthening the capacity, resources and professional development of Extension Scientists in KVKs is essential for building a knowledge-driven, climate-resilient, profitable and sustainable agricultural sector.

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Success story

Small Farm, Big Harvest: How Karunakar, a Vegetable Grower in Orugonda, Beat the Odds

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1. Introduction

Odela Karunakar is a progressive and hardworking farmer from Orugonda village, Damera Mandal, Hanumakonda district, Telangana. His story illustrates the grit and flexibility that small farmers across rural India bring to their work. A graduate, he has built a sound working knowledge of agriculture through hands-on practice, close observation and a readiness to try new methods. His holding of three acres (1.21 ha) places him among small farmers, who contend with scarce resources, rising input costs and unpredictable market prices. Instead of depending only on conventional field crops, he has concentrated on vegetables, with cabbage, tomato and okra as his principal crops. Such vegetables sell steadily in local markets and, if well managed, bring regular income. In the monsoon he adds sweet corn to the rotation, which puts the season to good use and spreads his earnings over several crops.

Most of the work on the farm is done by his own family; his wife and parents help in the field, which lessens his need for outside labour. Marketing matters just as much to him, and he owns a vehicle for carrying his produce. With his own transport he can take vegetables to market soon after harvest, cut losses caused by delays, save on hiring charges and choose whichever market pays best. Altogether, family labour, hired workers brought in at the right time, efficient irrigation, a varied crop mix and independent transport add up to an organised and practical way of farming.

1.1 Cropping system and cropping intensity



Fig 1. Mr Odela Karunakar in his field with a harvested cabbage.

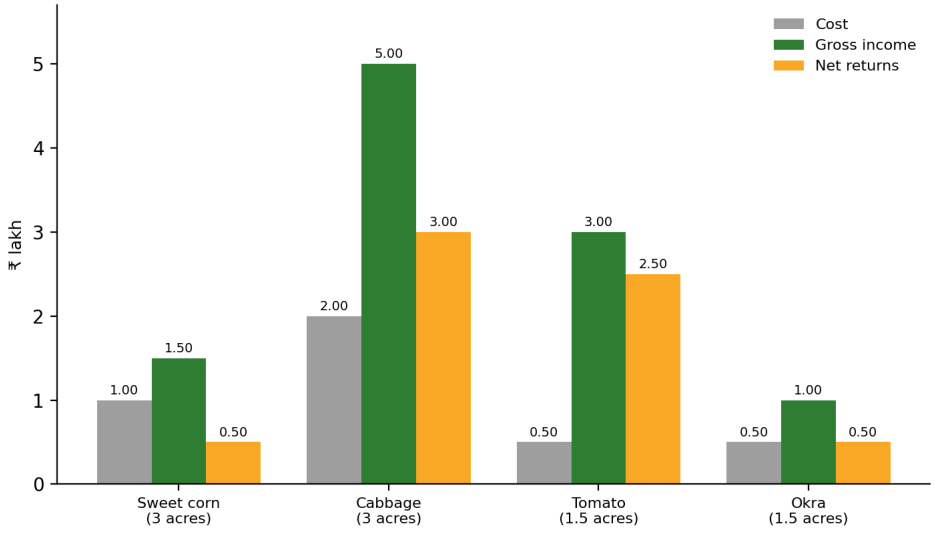
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The farm follows a cropping sequence with three stages (Table 1; Figure 1). Sweet corn is grown on all three acres during the monsoon. Once it is harvested, the same area is put under cabbage. After cabbage, the land is split into two equal plots of 1 acre 20 guntas (1.5 acres): one is sown with tomato and the other with okra. As a result, the land carries a crop almost all year, with each stage following the last and no long fallow in between.

Table 1. Cropping sequence followed on the farm by the farmer

Stage	Crop	Position in the sequence	Area (acres)	Area (ha)
1	Sweet corn	Monsoon season	3.0	1.21
2	Cabbage	After sweet corn	3.0	1.21
3a	Tomato	After cabbage	1.5	0.61
3b	Okra	After cabbage	1.5	0.61
Gross cropped area			**9.0**	**3.64**
Net sown area			**3.0**	**1.21**
Cropping intensity (%)			**300**	

Over this sequence, a net sown area of three acres yields a gross cropped area of nine acres, which is a cropping intensity of 300 per cent. This is possible because the crops differ in duration and belong to different botanical groups: sweet corn (a cereal-type crop), cabbage (a cole crop), tomato (a solanaceous crop) and okra (a malvaceous crop). Rotating crops from different families is a widely recommended agronomic practice, since it checks the build-up of pests and diseases specific to one crop and lets the roots draw on different soil layers.



1.2 Costs and returns

Table 2 sets out the costs and returns reported for each crop. Across the four crops, the total cost of cultivation was ₹4,00,000 against a gross income of ₹10,50,000, which leaves net returns of ₹6,50,000 and an overall BCR of 2.63. Spread over the three acres of land, the system earned net returns of ₹2,16,667 per acre.

Table 2. Reported costs and returns of the cropping system (₹)

Crop	Area (acres)	Cost of cultivation	Gross income	Net returns	BCR	Net returns per acre of crop
Sweet corn	3.0	1,00,000	1,50,000	50,000	1.50	16,667

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Cabbage	3.0	2,00,000	5,00,000	3,00,000	2.50	1,00,000
Tomato	1.5	50,000	3,00,000	2,50,000	6.00	1,66,667
Okra	1.5	50,000	1,00,000	50,000	2.00	33,333
Total	**9.0**	**4,00,000**	**10,50,000**	**6,50,000**	**2.63**	**72,222**

Figure 2. Cost of cultivation, gross income and net returns of each crop (₹ lakh).

Cabbage made the biggest contribution. Its cultivation cost was the highest, at ₹2,00,000 (₹66,667 per acre), but it brought in ₹5,00,000 gross and ₹3,00,000 net, a BCR of 2.50 and net returns of ₹1,00,000 per acre. The farmer credits this result to careful crop management, fertilisers and pesticides applied on time, a prior estimate of market demand and prompt delivery to the market.

Tomato, on 1.5 acres, gave the best BCR (6.00) and the highest net returns per acre (₹1,66,667). A reported cost of ₹50,000 against a gross income of ₹3,00,000 is an unusually favourable ratio. Factors that probably helped include the residual fertility left by the preceding cabbage crop, low seedling and irrigation costs, and efficient use of family labour.

Okra, also on 1.5 acres, earned a gross income of ₹1,00,000 on a cost of ₹50,000 (BCR 2.00), or net returns of ₹33,333 per acre. Sweet corn, grown on all three acres, was the least profitable crop: it cost ₹1,00,000 and earned ₹1,50,000, leaving net returns of ₹50,000 (BCR 1.50, or ₹16,667 per acre).

1.3 Water management and drip irrigation

Mr Karunakar saves water by using drip irrigation along with other modern cultivation practices, while still obtaining good yields. Drip suits widely spaced row crops such as cabbage, tomato and okra, which make up most of the farm's gross cropped area. What stands out is that he treats drip irrigation as one part of his production system and not as a subsidy-driven installation in its own right: he uses it on the crops where precise watering counts most and where each unit of water earns the most.

1.4 Marketing and transport



Fig 3. Vegetable crops on the farm, photographed during the field visit.

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The transport decision is the most distinctive feature of this case. In the early years Mr Karunakar relied on hired vehicles to carry his produce to market. That brought two problems: transport was expensive, and the produce arrived late, so he missed out on good prices. Solving it took both confidence and money. He set aside some savings, took a bank loan and bought a small goods vehicle. Now he delivers his own produce, the cost per trip has dropped, and he reaches the market at the right time and gets a better price.

1.5 Family labour and hired labour

The farmer believes that the family working together raises yields. This agrees with the finding that timeliness of operations is among the most important determinants of vegetable productivity. Two hired workers supplement the family's labour. The arrangement also raises a question of sustainability, since it depends on family members continuing to take part in field work.



Fig 4. Students and faculty of the Agricultural College, Warangal, at the farm during the field visit.

1.6 Factors contributing to success

Table 3 Factors contributing to the performance of the farm

Factor	Evidence from the case
Seasonal crop sequence	Sweet corn, then cabbage, then tomato and okra; cropping intensity of 300%
Crop management and demand estimation	Timely fertiliser and pesticide use; market demand anticipated; cabbage net returns of ₹3,00,000
Drip irrigation	Water saved and good yields reported by the farmer
Farm-owned vehicle	Lower transport cost; timely arrival at market; better price
Family and hired labour	Wife and parents in the field; two hired workers
Income spread across crops	Four crops; positive net returns even if cabbage earns nothing

1.7 Implications for extension and policy

Several implications follow for extension agencies, universities and policy-makers. First, demonstrations should show whole crop sequences instead of single crops. Farmers judge their land over the full year, so an account of how a monsoon cereal-type crop is followed by a high-value cole crop and then by two short-duration vegetables, with costs and returns at each stage, is more convincing and more useful than a package of practices for one crop.

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Second, support for micro-irrigation should be tied to crop choice. Benefits are greatest where the crop is of high value, is planted in rows and the farmer has the skill to run the system. Extension programmes that pair subsidy with training in scheduling, fertigation and maintenance are therefore more likely to succeed than those that stop at installation.

Third, credit for market logistics deserves attention. Here, a loan for a small goods vehicle seems to have mattered as much as any production input, because it gave the farmer control over the cost and timing of marketing. Fourth, assessing market demand and price trends are teachable skills. His habit of estimating demand in advance appears to have contributed to his profit from cabbage. Short training modules on price trends, arrival patterns and planting calendars, offered through the same channels as agronomic advice, could help other growers avoid the periodic gluts that depress vegetable incomes and increase post-harvest losses.

1.8 Conclusion

Mr Odela Karunakar's experience shows that a three-acre farm in Orugonda village, Telangana, can earn a substantial income from vegetables and sweet corn when crops are sequenced well, water is applied precisely, labour is drawn mainly from the household and the farmer controls his own marketing. Growing four crops in sequence gave a cropping intensity of 300 per cent, reported net returns of ₹6.50 lakh on a cost of ₹4.00 lakh, and an overall BCR of 2.63. Cabbage and tomato together accounted for about 85 per cent of net returns, while sweet corn and okra added smaller but positive returns and kept the land in use through the year. The system would stay profitable even if the leading crop earned nothing. His choice to buy a small goods vehicle with savings and bank credit, so that he could take his produce to market on time and at lower cost, shows that marketing constraints can matter as much as production constraints for small vegetable growers.

These findings are in line with evidence that diversifying into high-value crops, adopting micro-irrigation and improving market access raise farm incomes, with small farmers gaining the most.

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The Hidden Garden Within: Plant EndophyticMicrobiomes as a Reservoir for Next-Generation Biocontrol

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Abstract

All healthy plants have within their own tissues a community of endophytic bacteria and fungi which live in the roots, stems, and leaves without causing disease. This article looks at the growing body of evidence showing that this internal microbiome represents a significant and still underused source of biocontrol agents capable of combating fungal plant pathogens. The paper examines the mechanisms by which endophytic fungi and bacteria counteract pathogens namely competitive exclusion, the production of secondary metabolites, mycoparasitism, and the induction of systemic resistance and gives a summary of field evidence regarding disease suppression, such as the reported decrease of over fifty per cent in the severity of Fusarium wilt after treatment with endophytes. It is claimed that the endophytic compartment, since it is located inside the plant tissue and thus spatially protected, provides a level of biocontrol that is both persistent and consistent which is generally missing in microbial products applied to the surface, and the article describes the metagenomic and metabolomic tools currently being used to systematically exploit this reservoir rather than merely taking advantage of it.

Keywords: endophytic microbiome, biocontrol, plant pathogens, fungal endophytes, bacterial endophytes, sustainable agriculture

1. Introduction: Life within the leaf

Almost all of the plants that have far been studied contain endophytic microorganisms bacteria and fungi which live in the root stem and leaf tissues for part or all of their lives without causing any visible disease. This association has in the past been termed an antagonism: the microorganism obtains nutrients from the plant while the host either endures it or actively attracts the organism in return for advantages such as promotion of growth increased tolerance to stress and more recently identified as crucial protection against pathogens that would otherwise invade (Afzal et al., 2019). Since these organisms are already present in the plant's environments, they are in a position to stop invading pathogens before those pathogens can set up an infection, a kind of spatial advantage which cannot be achieved by externally applied biocontrol sprays (Latz et al., 2018; Fadiji & Babalola, 2020).

The need to carry out research in this field is practical because of the limitations of chemical fungicides; after decades of using synthetic chemicals, resistant strains of pathogens have appeared and biodiversity has been lost, which has led to a search for biological alternatives that can be used on the same scale and with the same reliability as the existing.

2. The mechanisms by which endophytes exert biocontrol

Endophytic fungi such as Trichoderma and endophytic bacteria such as Bacillus and Pseudomonas use a number

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of overlapping methods to combat fungal plant pathogens. This direct antagonism involves the production of secondary metabolites and lytic enzymes which break down the fungal cell walls, as well as mycoparasitism in which the endophyte physically parasitizes the hyphae of the pathogen. With regard to exclusion the effect is more indirect in that the endophytes take up the same intercellular spaces and nutrient sources that a pathogen would otherwise make use of thus preventing the invading fungi from gaining the ecological advantage they need to establish an infection (Latz et al., 2018; Afzal et al., 2019; Fadiji & Babalola, 2020).

There is also a mechanism, induced systemic resistance, which has no requirement for the endophyte to come into contact with the pathogen. When beneficial endophytes colonize the plant, they can prepare the hosts defense signaling pathways typically involving crosstalk between jasmonic acid and salicylic acid so that a faster and more vigorous response is mounted when the plant is later attacked thus effectively vaccinating the tissue before infection occurs (Afzal et al., 2019; Fadiji & Babalola, 2020).

3. Evidence obtained in the field

Field-scale studies are now increasingly consistent with the mechanisms that were first identified in controlled laboratory tests. Multi-season field trials which compared endophyte-derived treatments with Fusarium wilt found disease severity reductions of fifty-five per cent when compared to untreated controls a level of effectiveness generally similar to that reported for several conventional fungicide programmes although it was achieved using a self-replicating biological agent instead of a chemical product that needs to be applied repeatedly (Latz et al., 2018; Grabka et al., 2022).

Reviews covering research carried out from 1980 to 2023 have listed over twenty fungal genera. Such as Trichoderma, Penicillium and the volatile-organic-compound specialist Muscodor. That has shown antagonistic activity towards fungal pathogens of important food crops based on evidence from more than two hundred individual studies (Grabka et al., 2022; Latz et al., 2018).

A review covering a twenty-year period on the subject of endophyte identification and their applications shows how the combination of metagenomics, metatranscriptomics and metabolomics is now enabling the discovery of unculturable endophyte diversity and the metabolic pathways responsible for its biocontrol activity thus taking the field past the traditional bottleneck associated with culture-dependent methods (Ahmed et al., 2024; Carrión et al., 2019).

4. A shift from discovery to systematic mining

In the past useful endophytes have usually been found by chance. They were isolated from a healthy plant that was growing in a field susceptible to disease and then tested for their ability to counteract a pathogen that was present in the same area. The new approach however is systematic and based on omics data: it involves sequencing the endophytic community of a crop in a number of different genotypes and environments linking the makeup of the community to the disease symptoms that are observed and then focusing on the taxa that are most closely associated with disease suppression for isolation and functional verification. When this method is used with genome mining for both known and newly identified biosynthetic gene clusters it enables researchers to select their candidates beforehand rather than having to carry out the time-consuming greenhouse and field trials (Ahmed et al., 2024).

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5. Conclusion

The microbiome living within the plant acts as a source of control and is already present in the plant already adapted to the conditions inside the plant and already the product of evolutionary selection for compatibility with its host features which make it an exceptionally promising supplement to and perhaps even a partial substitute, for synthetic fungicides. If this resource is to be turned into an agricultural product it will be necessary to keep combining multi-omics discovery procedures with thorough multi-site field tests in order to ensure that the antagonistic effect demonstrated in the laboratory leads to consistent suppression of disease under actual production conditions.

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Polyploids: Their Origin, Behavior, Study and Role in Crop Improvement

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Abstract

Polyploids are organisms that contain more than two sets of genomes or chromosomes and this condition is known as polyploidy. Polyploidy is quite common in case of plants and made a significant role in their evolution. Polyploids originate through many mechanisms such as polyspermy, gametic non-reduction and somatic doubling during mitosis. Polyploids are mainly of three types *viz.* autopolyploids, allopolyploids and segmental allopolyploids. Autopolyploids show completely different meiotic, genetic and breeding behavior though allopolyploids show behavior similar to diploids. Polyploids show complex genetic ratios and due to this they need unique tools and approaches for their analysis. Polyploidy has been involved in increasing crop yield, improving agronomic traits, enhancing tolerance to various stresses and producing entirely new crop species. Polyploidy breeding faces some challenges such as seed sterility, low seed germination, complex genetic ratios, and difficulty in handling sequence data of polyploids. Many techniques and methods are being developed to overcome these challenges such as genetic analysis on diploid parents of polyploids, use of CRISPR/Cas9 to target sterility related genes, backcrossing with diploid parents. Overall, we will discuss origin of polyploids, their meiotic, genetic and breeding behavior, unique tools and approaches for their study, their role in crop improvement, challenges in polyploidy breeding and prospects for use of polyploidy breeding in crop improvement.

Keywords: Polyploidy, autopolyploids, allopolyploids, multivalent, crop improvement.

Introduction

Most of the eukaryotic organisms contain two sets of genomes or chromosomes in their somatic cells, whereby, one is contributed by male parent and another by female parent. These organisms are referred as diploid organisms and this condition is called as diploidy. Most of the laws and procedures in genetics and breeding assume organism to be diploid, however the question arises that are all eukaryotes diploids and if not, will it affect results of such laws? Answer for this question is no, there are eukaryotic organisms that are not diploids but they show polyploidy or they are polyploids. Polyploids are organisms that have more than two sets of genomes or chromosomes. They are classified into three types viz. autopolyploids, allopolyploids, and segmental allopolyploids, wherein, autopolyploids are the ones that contain more than two sets of genomes or chromosomes originated from same species, allopolyploids contain multiple sets of genomes or chromosomes from different species and segmental allopolyploids are intermediates between autopolyploids and allopolyploids, whereby, they contain more than two partially differentiated genomes so that recombination can occur between genomes. Polyploidy contributed significantly towards evolution of many organisms and it is widely prevalent in plant species. According to Wood et al., (2009) almost 35% of angiosperms are polyploids. In this article we will discuss origin of polyploids, meiotic, genetic and breeding behavior of polyploids, unique tools

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and approaches used in polyploid studies, and role of polyploids in crop improvement.

Origin of polyploids

Polyploids can originate due to various methods such as polyspermy, gametic non-reduction and somatic doubling during mitosis. Wherein, polyspermy is the condition where egg cell gets fertilized by more than one sperm, gametic non-reduction is the phenomenon whereby, gamete contains somatic chromosome numbers and somatic doubling during mitosis occurs in a zygote or young embryo to give complete or chimeric polyploids. Once unreduced gametes are formed they can unite with normal gametes or with each other to give different kinds of polyploidy (Fig. 1). It can give rise to autopolyploids or allopolyploids, depending upon if uniting gametes are coming from same or different species.

Meiotic, genetic and breeding behavior of polyploids

Autopolyploids generally shows multivalent formation during meiosis due to presence of more than two sets of homologous chromosomes from same species, whereas, allopolyploids usually show bivalent formation due to the fact that chromosomes tend to pair with its homologous counterpart from the same species instead of pairing with homeologous chromosome from different species. During meiosis autopolyploids behave differently from diploid organisms, whereas, allopolyploids behave same as diploids. Autopolyploids show different inheritance ratios than diploids mainly due to the presence of more than two chromosomes sets that lead to formation of multivalent and movement of chromosomes is unpredictable during anaphase-I. Additionally, these ratios also get modified by important phenomenon called double reduction, whereby, sister chromatids pass to same pole in both meiotic divisions. Moreover, possible number of heterozygotes also increases in autopolyploids as in case autotetraploid for one gene we can have five genotypes viz. AAAA, AAAa, AAaa, Aaaa and aaaa where three are heterozygotes. Due to the formation of multivalents, autopolyploids show different breeding behavior. They generally show aneuploids in their progeny particularly in case odd genome ploidy such as triploidy. Allopolyploids on the other hand show normal breeding behavior in general.

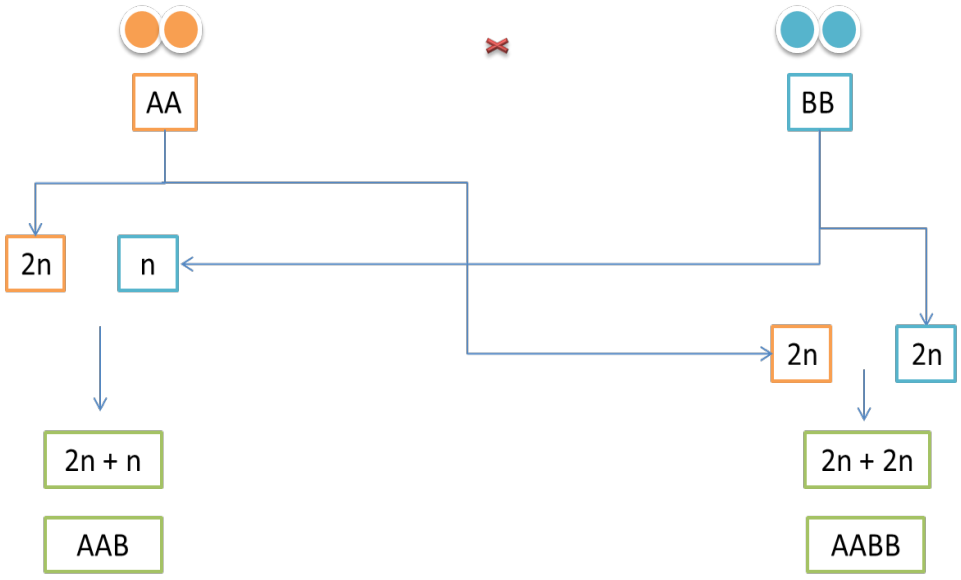


Figure 1: Illustration of formation of allotriploids and allotetraploids due to union of non-reduced and reduced gametes in different combinations

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Unique tools and approaches used in polyploid studies

In polyploids, genotyping is done using dosage based markers that can easily identify copies of each allele (dosage) in an individual. This dosage information can distinguish various heterozygous genotypes (AAAa, AAaa, Aaaa) from each other. Commonly used dosage based markers are based on microarray technology and DNA sequencing at higher sequencing depths. Due to complexity of polysomic ratios, mapping and genome sequencing studies are often performed on diploid parents of polyploids. Additionally, in some cases studies are performed on haploids of polyploids to reduce the complexity in trait segregation. Some dedicated tools and software programs are also available for polyploid breeding such as fitTetra (Voorrips et al., 2011) is used for genotyping in polyploids and tetraploidMap (Hackett and Luo, 2003) is used for linkage mapping.

Role of polyploids in crop improvement

Main effect of polyploidy is cell enlargement that increases size of leaves, seeds and fruits and this phenomenon called gigas effect is observed in polyploid species such as alfalfa (*Medicago sativa*) resulting in higher biomass and yield (Adhikari et al., 2019). There are many reports where polyploidy contributed directly towards enhancement of various agronomic traits. In one such study, polyploidy led to increased yield per plant, spike length and plant height in rice mainly by modifying expression of genes related to these traits (Yang et al., 2024). In another study, polyploidy improved embryo development, growth kinetics and seed traits in cumin (*Cuminum cyminum* L.) (Sanaei-Hoveida and Mortazavian, 2025). Polyploidy also enhances tolerance to various biotic and abiotic stresses in crop species (Tossi et al., 2022). One of the reasons for development of stress tolerance due to polyploidy is redundancy of stress-related genes that in turn increase their buffering capacity. Apart from these, polyploidy can also generate genetic diversity and novel traits that can be used in crop improvement. Main reason for generation of such genetic diversity is duplication of entire genomes that give opportunities for producing genes with entirely new function. In addition to its role in improving different traits in crops, polyploidy can also lead to synthesis of entirely new species. Triticale is one such species that was created by crossing wheat (*Triticum aestivum*) and rye (*Secale cereale*), combining beneficial traits of both the parents and resultant species is being grown in various parts of the world.

Challenges in polyploidy breeding

In polyploids, multiple sets of homologous or homeologous chromosomes lead to complex genetic ratios that in turn make their genetic analysis very complex. Additionally, handling of sequencing data is difficult in case of polyploids mainly during genome assembly and annotation process that needs special software and long computational time. Due to multivalent formation, seed sterility and low germination is often seen in polyploid species, this issue being more prominent in newly synthesized polyploids. Moreover, newly synthesized polyploid species may undergo genome restructuring during successive generations resulting in changed chromosome number, gene content and ploidy levels.

Conclusion and perspectives

Polyploid organisms are the ones that contain more than two sets of genomes or chromosomes and this condition is known as polyploidy. They can originate due to various methods such as polyspermy, gametic non-reduction and somatic doubling during mitosis. Autopolyploids show multivalent formation during meiosis leading to unpredictable movement of chromosomes during anaphase. Multivalent formation and double re-

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duction gives modified inheritance ratios. Additionally, autopolyploids also show aneuploids in their progeny. However, allopolyploids show no such changes at meiotic, genetic or breeding level. Due to complex nature of polyploids, genetic analysis is often performed on their diploid parents to later extend these results to polyploids. Additionally, some dedicated software programs are also used for genetic analysis. Polyploids are often genotyped using dosage based markers. Polyploidy has been seen to be associated with enhancement of various agronomic traits such as yield, plant height, seed traits, tolerance to various kinds of stresses and in creation of new crop species. Polyploidy breeding face some challenges also, such as difficulty in genetic analysis due to complex inheritance ratios, difficulty in handling of sequence information, seed sterility, low seed germination and genomic instability of newly formed polyploids. Although, some of these challenges are being addressed such as carrying genetic studies on diploid parents of polyploids, selection of genes providing meiotic stability and increased fertility, backcrossing with diploid parents, use of CRISPR/Cas9 to target genes that are related to sterility. Though, polyploidy breeding is quite challenging, but due to widespread occurrence of polyploidy among plant species it is an urgent need to focus more towards its development. We need to develop more software programs that can handle complex genetic ratios associated with polyploids. Moreover, with the assistance of above mentioned methods to tackle challenges in polyploidy breeding, it is possible to exploit polyploidy to produce varieties with enhanced yield, better agronomic traits and more importantly with higher tolerance to various stresses that is the current need to fight changing climate.

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Impact Of Plant Growth Regulators on Mulberry Host Plant

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Introduction

Sericulture is one of the important agro-based rural industries in India, providing employment and livelihood opportunities to a large number of rural households. The term *sericulture* is derived from the Greek word *sericos*, meaning silk and *culture*, meaning rearing (Ganga and Chetty, 1997). Silk, often described as the "queen of textiles", is valued for its exceptional strength, natural lustre, softness, purity and attractive appearance. Sericulture is not limited to silkworm rearing alone; it includes a series of interconnected activities such as cultivation of host plants, silkworm rearing, cocoon production and post-cocoon processing.

India is the second-largest producer of raw silk in the world after China and has the unique distinction of producing all the commercially important varieties of silk. The major silk-producing insects include the mulberry silkworm (*Bombyx mori* Linnaeus), eri silkworm (*Samia ricini* Donovan), muga silkworm (*Antheraea assamensis* Helfer), temperate tasar (*Antheraea proylei* Jolly) and tropical tasar (*Antheraea mylitta* Drury). According to recent production estimates, India produced about 30,614 MT of raw silk, of which mulberry silk contributed approximately 75.55% (23,131 MT), followed by eri silk with 20.32% (6,217 MT), tasar with 3.52% (1,079 MT) and muga with 0.61% (187 MT) (Anon., 2025). These figures clearly indicate the dominant contribution of mulberry sericulture to India's silk industry.

Importance of Mulberry in Sericulture

The mulberry silkworm, *Bombyx mori*, is a monophagous insect and feeds almost exclusively on mulberry (*Morus* spp.) leaves. The quality and quantity of mulberry leaves directly influence larval growth, cocoon formation and ultimately the quantity and quality of silk produced. Although numerous mulberry species, varieties and cultivars are available, only a limited number are commercially suitable for silkworm rearing. Major mulberry silk-producing states include Andhra Pradesh, Karnataka, Tamil Nadu, Uttar Pradesh, West Bengal, Maharashtra, Telangana and Jammu and Kashmir, which together account for a major share of India's mulberry silk production (Gadge *et al.,* 2024).

Based on the number of generations completed in a year, *B. mori* is broadly classified into three categories: univoltine, bivoltine and multivoltine. The choice of silkworm breed or hybrid is closely associated with the climatic conditions of the region, as temperature, humidity and seasonal variations influence the voltinism and performance of the silkworm.

Mulberry leaves form the primary nutritional base of the silkworm and supply the nutrients required for larval growth and silk protein synthesis. Therefore, maintaining a healthy mulberry plantation with adequate leaf production throughout the year is one of the most important requirements for successful sericulture

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as mulberry growth and productivity have a direct influence on silk yield and quality (Ananya *et al*., 2015).

Leaf Senescence and Its Significance

Leaf senescence is a natural stage of plant development in which leaves gradually lose their physiological activity and eventually die. It is a common biological phenomenon and represents the final stage of leaf development (Hughes and Reynolds, 2005). During senescence, chlorophyll degradation results in visible colour changes, while important cellular components such as proteins, nucleic acids, lipids and pigments undergo degradation. The nutrients released during this process are subsequently redistributed to developing plant parts. Although senescence is a natural and essential process, premature senescence can adversely affect crop productivity. In mulberry, early ageing and deterioration of leaves can reduce the availability of nutritious foliage for silkworm feeding. The process of senescence is influenced by several factors, including leaf age, plant hormones, nutritional status, temperature, drought, salinity, light conditions, disease and other environmental stresses. Among these, leaf age is considered one of the major factors governing natural senescence. Both biotic and abiotic stresses can accelerate leaf ageing and consequently reduce plant biomass and productivity. The availability of good-quality mulberry leaves throughout the year remains one of the major challenges in sericulture. Climate variability, water scarcity, poor soil fertility, pest and disease incidence and limited availability of cultivable land can affect mulberry growth and leaf production. Reduction in leaf availability ultimately affects larval health, cocoon characteristics and silk yield. Hence, improving mulberry growth, leaf production and tolerance to environmental stress is essential for maintaining stable silk production.

Role of Plant Growth Regulators

Plant growth regulators (PGRs) are organic compounds that influence plant growth and development even when applied in very small quantities. They regulate several physiological and biochemical processes and can be broadly classified into growth-promoting and growth-inhibiting groups. Important plant hormones and regulators include auxins, cytokinins, gibberellins, abscisic acid and ethylene. Their effects depend considerably on the concentration applied, environmental conditions and genetic characteristics of the plant.

In mulberry cultivation, PGRs have attracted considerable attention because of their potential to improve leaf production, plant growth, physiological efficiency and stress tolerance. Appropriate application of PGRs can influence processes such as cell division, cell elongation, root initiation, shoot development, leaf expansion and chlorophyll maintenance. They can also affect the movement and utilisation of nutrients within the plant, thereby supporting the production of healthy and nutritious foliage. Growth-promoting substances can stimulate sprouting, leaf expansion and vegetative growth under favourable conditions. On the other hand, growth-retarding or stress-associated hormonal responses can help plants cope with adverse environmental conditions by influencing transpiration, water balance and other physiological processes (Saranya, 2024). Thus, PGRs have potential as an important component of improved mulberry production practices.

Among the different PGRs, auxins and cytokinins have been widely studied for their role in improving vegetative growth and leaf quality. Indole-3-butyric acid (IBA), an auxin, is particularly associated with root initiation and successful establishment of stem cuttings. It promotes rooting and can therefore contribute to better vegetative propagation of mulberry. Kinetin, a cytokinin, promotes cell division and is associated with shoot development, chlorophyll maintenance and delayed leaf senescence. The combined or individual use of such regulators may therefore improve plant establishment, growth and leaf quality.

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However, the response of mulberry to PGR application is not uniform. It may vary depending on the concentration of the regulator, method and time of application, prevailing environmental conditions and the genetic constitution of the cultivar. Therefore, determining the optimum concentration and suitable application method is essential before recommending PGRs for commercial mulberry cultivation.

S-1635: A Promising Mulberry Cultivar

Among the high-yielding mulberry cultivars, S-1635 is an important triploid variety widely cultivated in Eastern and Northeastern India. It is considered suitable for irrigated conditions and is recognised for its vigorous growth, good branching and strong sprouting ability (Ganga and Chetty, 1997). The cultivar is often regarded as a unique and valuable variety because of its stable performance and high leaf-producing capacity.

The leaves of S-1635 are large, unlobed, succulent and dark green, with desirable nutritional characteristics for silkworm rearing. Its vigorous growth and abundant branching contribute to greater leaf biomass production. The cultivar also possesses good rooting ability from stem cuttings, making it suitable for rapid vegetative multiplication and nursery establishment.

Under recommended agronomic practices and proper irrigation management, S-1635 can produce approximately 40–45 tonnes of leaves per hectare per year (Rajanna *et al*., 2005). Apart from its high productivity, the cultivar possesses considerable tolerance to drought and shows resistance or moderate resistance to certain important pests and diseases. It is reported to be resistant to leaf spot disease and moderately resistant to mealy bug and leaf rust. These characteristics make S-1635 a suitable cultivar for sustainable mulberry cultivation, particularly in regions where environmental conditions may fluctuate.

Scope of IBA and Kinetin Application in Mulberry

Improving the productivity and quality of mulberry leaves is directly linked with better silkworm performance and silk production. In this context, the application of PGRs such as IBA and kinetin offers a promising approach for enhancing the physiological efficiency of mulberry plants.

IBA can play an important role in root initiation and vegetative propagation, which is particularly useful for the rapid multiplication and establishment of mulberry plants. A well-developed root system can improve water and nutrient uptake and thereby support better plant growth. Kinetin, on the other hand, can promote cell division, shoot development and chlorophyll retention and may delay premature senescence. Improved chlorophyll content and prolonged maintenance of physiologically active leaves can contribute to greater availability of nutritious foliage for silkworms. The use of PGRs should, however, be approached scientifically, as excessive or inappropriate concentrations may produce undesirable effects. The optimum dose should be determined based on the cultivar, environmental conditions and intended objective. Therefore, cultivar-specific studies are necessary to identify suitable PGR concentrations that can improve plant growth without adversely affecting leaf quality.

Conclusion

Mulberry is the foundation of successful sericulture, and the availability of healthy, nutritious leaves throughout the year is essential for maintaining silkworm growth and cocoon productivity. Although leaf senescence is a natural process, premature ageing and environmental stresses can reduce the availability and

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quality of mulberry foliage. Plant growth regulators provide a potential means of managing plant growth, improving leaf production and maintaining physiological activity under different growing conditions. As such, S-1635, with its high leaf-yielding potential, vigorous growth, good sprouting capacity and adaptability, offers considerable scope for productivity enhancement through appropriate agronomic management. The use of IBA and kinetin may further improve root development, vegetative growth, chlorophyll retention and leaf quality. Therefore, systematic evaluation of these PGRs under suitable concentrations and application schedules can contribute to developing an efficient and sustainable production strategy for S-1635.

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Wastelands In India - Occurrence, Distribution and Causes

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Abstract

Wastelands in India represent degraded or underutilized lands that are unable to achieve their full productive potential due to natural constraints and human-induced activities. The National Wastelands Development Board defines wasteland as land that remains unutilized because of various constraints, while other definitions emphasize degradation and the potential for rehabilitation through appropriate soil and water management practices. Wastelands are broadly classified into culturable and unculturable categories based on their potential for vegetative development. Major types include gullied and ravinous lands, uplands with or without scrub, waterlogged and marshy lands, saline and alkaline soils, areas affected by shifting cultivation, sandy areas, degraded forest and grazing lands, mining and industrial wastelands, barren rocky areas, steep slopes, and snow-covered or glacial regions. The formation of wastelands is mainly attributed to soil erosion, overgrazing, deforestation, indiscriminate exploitation of forest resources, faulty irrigation and drainage, mining, industrial pollution, and unscientific land-use practices. These lands adversely affect agricultural productivity, soil fertility, biodiversity, water resources, and rural livelihoods. Their occurrence and distribution vary according to climatic conditions, topography, geological characteristics, and land-use patterns across different regions of India. Effective reclamation strategies, including afforestation, agroforestry, watershed management, soil and water conservation, drainage improvement, and sustainable grazing practices, are essential for restoring degraded lands. Scientific assessment and region-specific management of wastelands are crucial for enhancing land productivity, conserving natural resources, and promoting sustainable agricultural development in India.

Keywords: Wastelands, land degradation, soil erosion, salinity and alkalinity, waterlogging, shifting cultivation, agroforestry, wasteland reclamation, sustainable land management.

INTRODUCTION

National wastelands development board defines the wasteland as a land which is presently lying unutilized due to different constraints ICAR has defined wastelands as lands which due to neglect or due to degradation are not being utilized to their full potential. These result from inherent or imposed disabilities or both, such as location, environment, chemical and physical properties, and even suffer from management conditions. Integrated Wasteland Development Programme has defined wasteland as a degraded land which can be brought under vegetative cover, with reasonable effort, which is currently underutilized , land which is deteriorating for lack of appropriate water and soil management or on account of natural causes.

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CATEGORIES OF WASTELAND

- ✓ **Culturable Wasteland**

The land which is has potential for the development of vegetative cover and is not being used due to different constraints of varying degrees, such as erosion, water logging, salinity etc. is called cultural waste-land

- ✓ **Unculturable Wasteland**

The land that cannot be developed for vegetative cover, for instance the barren rocky areas and snow covered glacier areas.

CAUSES OF FORMATION OF WASTELANDS

The major causes include the indiscriminate and excessive utilization of forest resources, which leads to deforestation, habitat destruction, and the depletion of natural resources. Overgrazing by livestock reduces vegetation cover, exposes the soil to erosion, and affects the natural regeneration of plants. Development projects such as the construction of dams, roads, industries, and urban settlements can result in the destruction of forests, displacement of wildlife, and degradation of natural ecosystems. The misuse of land and unscientific land management practices, including improper cultivation, excessive use of chemicals, and unsuitable irrigation methods, can lead to soil degradation, loss of soil fertility, and water pollution. These activities disturb the ecological balance, reduce biodiversity, and threaten the long-term sustainability of natural resources. Therefore, scientific land management, controlled grazing, sustainable utilization of forest resources, and environmentally responsible development practices are essential to conserve natural resources and maintain ecological stability.

CATEGORIES OF WASTELAND IN INDIA

- ✓ Gullied and/or ravine land
- ✓ Upland with or without scrub
- ✓ Water-logged and marshy land
- ✓ Land affected by salinity/alkalinity (coastal or inland)
- ✓ Areas of shifting cultivation
- ✓ Sandy areas (desert or coastal)
- ✓ Mining industrial wasteland
- ✓ Under-utilized/degraded notified forest land (forests under the control of the state government's forest department)
- ✓ Degraded pastures/grazing land
- ✓ Degraded land under plantation crops

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- ✓ Barren rocky wastes and sheet-rock areas
- ✓ Steeply-sloping areas and
- ✓ Snow covered and/or glacial areas.

The distribution pattern of these categories of wastelands as identified by the government.

Wasteland class Area	(in M ha)	Percentage
Gullied/ravinous land	2.06	0.65
Land with/without scrub	19.40	6.13
Waterlogged/marshy land	1.66	0.52
Land affected by salinity	2.04	0.65
Shifting cultivation area	3.51	1.11
Degraded notified forest land	14.07	4.44
Degraded pastures/grazing land	2.60	0.82
Degraded land under plantation	0.58	0.18
Sandy area	5.00	1.58
Mining/industrial wasteland	0.12	0.04
Barren rock y/stony/sheet rock	6.46	2.04
Steep sloping area	0.77	0.24
Snow covered/glacial area	5.58	1.76
Total	**63.85**	**20.16**

GULLIES : hey are formed as a result of localised surface run off affecting the friable unconsolidated material. It results in the formation of channels resulting in undulating terrain. Gullies are the first stage of excessive land dissection.

RAVINES : The networking leads to the development of ravenous land. It is usually associated not with an isolated gully but a network of gullies. It is formed generally in deep alluvium and entering nearby river flowing much lower than the surrounding table lands. Ravines are extensive systems of gullies developed along river courses.

In India, about 0.02 m. sq.Km of land comes under this category. Madhya Pradesh and Rajasthan are the states having more ravine lands, followed by Uttar Pradesh.

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UPLAND WITH OR WITHOUT SCRUB : These land occupies topographically high locations in the respective systems and excludes hilly and mountainous terrain. The land with or without scrub is generally prone to deterioration due to erosion.Erosion is more active on elevated portions of land.

This category covers a maximum of 0.194000 m. sq.km. About 19% of this type exists in Madhya Pradesh followed by Maharashtra, Gujarat has about 11%.

WATERLOGGED LAND : This is the land where water table is at /or near the surface and water stands for most of the year. Waterlogging occurs due to the rise of sub-soil water-table and this happens in almost all the over-irrigated areas.This problem is generally seen in the areas of canal irrigation where due to the seepage of water from canals, the sub-soil becomes saturated with water and also in the areas of defective drainage often liable to inundation either due to bank flow of river water or lake water or sea water etc. Waterlogging is the result of the rising trend in the sub-soil water either due to over-irrigation or accumulation of water inhibiting the growth of plants.

Effects

- ✓ Creation of Anaerobic Condition in the Crop Root-Zone
- ✓ Impossibility of Tillage Operations
- ✓ Accumulation of Harmful Salts
- ✓ Lowering of Soil Temperature
- ✓ Reduction in Time of Maturity

MARSHY LAND : Marsh is the land which permanentIy or periodically is inundated by water and is characterized by vegetation that includes grasses and reeds. Marshes are classified into salt, brackish and fresh water categories depending on the salinity of water.

DEGRADES PASTURES : Overgrazing occurs when plants are exposed to intensive grazing for extended periods of time, or without sufficient recovery periods. It can be caused by either livestock in poorly managed agricultural applications, game reserves, or nature reserves. It can also be caused by immobile, travel restricted populations of native or non-native wild animals. The main causes are poor irrigation methods in arid and semi-arid areas overstocking, improper land use.The acts of compaction and erosion as a result of overgrazing can cause tremendous land degradation and soil erosion

AREAS OF SHIFTING CULTIVATION

Land of shifting cultivation is the result of cyclical land use practiced with felling of trees and burning of forests for growing crops. This leads to land degradation and extinction of flora and fauna. Clearing of jungles is the pre-requisite of shifting. The felling of trees and clearing of bushes, however, accelerate soil erosion and accentuate variability of rainfall which may lead either to droughts or floods. The overall impact is the decline in soil fertility.The ecosystems lose their resilience characteristics.

This accounts for about 0.03514 m.sq.km. The situation exists in Manipur, Assam, Nagaland and Mizoram.

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UNDER-UTILIZED/DEGRADED NOTIFIED FOREST LAND

Certain areas are notified under forest act to be designated as protected areas.Those lands with various types of forest cover- vegetative cover is< 20%. In protected forests, all the activities are permitted.Overuse of these forests may lead to degradation.

SALINE & ALKALINE SOILS

Land of soil salinity or alkalinity severely affects the growth of plants due to excessive salts or exchangeable sodium.Land has adverse effects on growth of most of the plants due to the action or presence of excess soluble salts or excess exchangeable sodium.Saline soils have more of soluble salts with EC more than 4 dsm^{-1}.Alkali land has an ESP of > 15 which is generally considered as the limit between normal and alkali soils. Predominant salts are carbonates and bicarbonates of sodium Soil salinity is a controlling factor of agriculture. About 0.020 m.sq.km has come under this category. Gujarat, Uttar Pradesh and Tamil Nadu are the states mainly having this problem.

SANDY AREAS

Sandy areas are expected along the coasts, riverine areas and in deserts. Stabilized accumulation of sand or alluvium may affect the plains or coasts. About 0.05 M. sq.km of land is covered by this category. Rajasthan is the main state followed by Assam.

MINING INDUSTRIAL WASTELANDS

Sometimes, useful land areas become wastelands due to mining and industrial activities. Dumping of mine wastes and release of effluents over adjacent areas create a land unsuitable for any purpose. In India, about 0.0012 M.sq.km of land belongs to this category. Bihar, Madhya Pradesh, Rajasthan and Tamil Nadu are the states having such wasteland.

Mining leads to loss of biodiversity due to forest land diversion, economic, and livelihood loss due to displacement and encroachment of agricultural land, loss of local water resource due to reduction in catchment area, and destruction of streams. Some of the land-related impacts such as water pollution, loss of agricultural productivity, depletion of ground water, and siltation of river are more pronounced at the operational stage.

BARREN LANDS EXPOSED WITH ROCKS AND STONES

Barren lands exposed with rocks and stones need more attention for development.They cannot be used as such for any kind of land use. In India about 0.065 M. sq.km of land are Barren lands.States like Jammu & Kashmir, Andhra Pradesh and Rajasthan have more Barren lands.

LAND OF STEEP SLOPES

Land of Steep Slopes are unstable for any human use. Frequent occurrence of landslides may not allow the land for appropriate use. Grading of slopes may help in planting tropical crops. Nearly 0.008 M.sq.km of land comes under steep slopes. It is a problem in Jammu & Kashmir, Himachal Pradesh, Maharashtra and Uttar Pradesh.

SNOW COVERED LAND : The land which cannot be used directly is the snow covered land. Glaciers are

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extreme environments.The land will be covered by snow and the soil will be freezed thus rendering it unfit for agriculture or any other use. About 0.05 M.sq.km of land in India are snow covered. Jammu and Kashmir, Uttar Pradesh, Himachal Pradesh and Arunachal Pradesh have these types of lands.

CONCLUSION

Wastelands in India are a major concern for sustainable land use, agricultural productivity, and environmental conservation. Their formation is primarily associated with natural factors and human activities such as soil erosion, deforestation, overgrazing, improper irrigation, mining, and unscientific land management. The occurrence and distribution of wastelands vary across regions depending on soil characteristics, climate, topography, and land-use practices. Proper identification, classification, and scientific assessment of these lands are essential for effective reclamation. Measures such as afforestation, agroforestry, watershed development, soil and water conservation, improved drainage, and sustainable grazing management can help restore degraded lands and improve their productive potential. Therefore, integrated and region-specific wasteland development strategies are essential for conserving natural resources, enhancing rural livelihoods, and achieving sustainable agricultural development in India.

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Noni: The Unusual Tropical Fruit With Remarkable Nutritional Potential

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Introduction

In the tropical regions of Asia and the Pacific, a peculiar-looking fruit with a strong odor and bitter taste has been used for centuries in traditional cultures. This fruit, known as noni (*Morinda citrifolia* L.), is commonly called Indian mulberry or cheese fruit. Although its appearance and smell may discourage some consumers, noni has attracted considerable scientific attention because of its rich nutritional profile and diverse bioactive compounds.

Noni belongs to the Rubiaceae family and is widely distributed in India, Southeast Asia, Polynesia, Australia and other tropical regions. Traditionally, different parts of the plant, including its fruits, leaves, roots, bark and flowers, have been utilized for food and folk remedies. Today, noni is available as juice, powders, fermented beverages, capsules and extracts, making it an important ingredient in the growing functional food and nutraceutical industries.

Nutritional and phytochemical composition

Noni contains a variety of nutrients and bioactive compounds that contribute to its scientific and commercial interest. The fruit provides carbohydrates, dietary components, vitamins and minerals such as potassium, magnesium, folate and vitamin C. The most remarkable feature of noni is its rich phytochemical composition. Researchers have identified several important compounds, including:

- Iridoids (asperulosidic acid and deacetylasperulosidic acid)
- Phenolic compounds
- Flavonoids
- Coumarins
- Lignans
- Polysaccharides
- Anthraquinones

These phytochemicals are being investigated for their antioxidant and health-promoting properties. The concentration of these compounds varies depending on fruit maturity, geographical location, processing techniques and storage conditions.

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Potential health benefits:

Antioxidant properties: Oxidative stress results from an imbalance between free radicals and the body's antioxidant defense system. Excessive oxidative stress may contribute to ageing and several chronic diseases. Noni contains iridoids, phenolics, flavonoids and vitamin C, all of which have demonstrated antioxidant activity in laboratory studies. These compounds help neutralize free radicals and may contribute to cellular protection.

Anti-inflammatory effects: Inflammation is a natural defense mechanism, but long-term inflammation is associated with many chronic disorders. Several studies have reported that noni phytochemicals can influence inflammatory pathways. These findings suggest potential anti-inflammatory properties, although more human studies are needed to confirm these effects.

Immune support: Researchers have explored the role of noni polysaccharides and other bioactive constituents in regulating immune responses. Preliminary studies indicate that some compounds may enhance immune-related activities, making noni a promising subject for future nutritional research.

Cardiovascular health: Some experimental studies suggest that noni may help improve lipid profiles and support cardiovascular function. However, most of the available evidence comes from laboratory and animal studies and further clinical research is required before definitive conclusions can be drawn.

Anticancer research: One of the most exciting areas of noni research involves its potential anticancer properties. Laboratory investigations have shown that certain noni compounds may influence cancer-related cellular processes. However, these studies do not prove that noni can prevent or cure cancer in humans. Rigorous clinical trials are necessary before such claims can be supported.

Applications in food and industry: The unique composition of noni has led to its incorporation into a variety of commercial products.

Noni juice: Noni juice is the most widely marketed product. Because of its strong taste and odour, it is often blended with other fruit juices to improve palatability.

Fermented beverages: Fermentation has been explored to develop noni beverages with improved flavor and enhanced shelf life.

Dried powders and extracts: Drying converts noni into powders that can be incorporated into functional foods, dietary supplements and nutraceutical products.

Cosmetic applications: Noni extracts are increasingly used in cosmetic and skincare products because of their antioxidant-rich composition. The utilization of noni and its by-products offers opportunities for developing innovative food, pharmaceutical and cosmetic products with added economic value.

Safety considerations: Although noni has a long history of traditional use, consumers should be aware of certain safety concerns. As with any functional food, moderation and informed consumption are important.

- Noni juice contains relatively high levels of potassium, which may not be suitable for individuals with kidney disorders.

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- Some reports have suggested possible liver-related adverse effects associated with excessive consumption.
- Noni products may interact with medications affecting blood pressure, potassium levels, or liver function.
- Pregnant and breastfeeding women should consult healthcare professionals before consuming concentrated noni supplements.

Conclusion: Noni is a fascinating tropical fruit that combines a rich nutritional profile with an impressive diversity of bioactive compounds. Research has highlighted its antioxidant, anti-inflammatory, immune-supportive and potential health-promoting properties. In addition, noni has emerging applications in beverages, functional foods, nutraceuticals and cosmetic products. Despite its promise, most evidence regarding noni's health benefits comes from laboratory and animal studies. Human clinical research remains limited and stronger scientific evidence is needed to establish specific therapeutic effects. Therefore, noni should be regarded as a promising functional fruit rather than a miracle cure. Continued research will help unlock its full potential for nutrition, health and industrial applications.



Mature noni fruit



Noni juice



Noni fermented beverage



Noni powder