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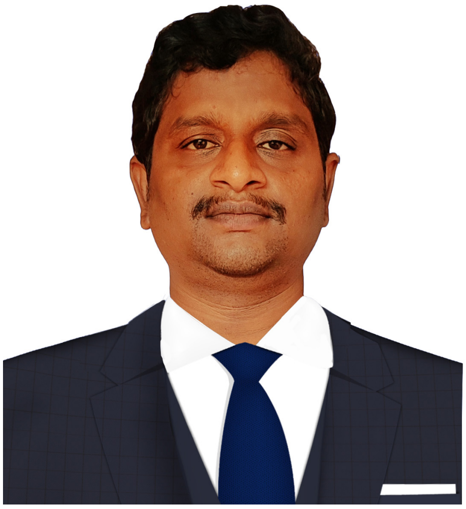
From the Desk of Editor-in-Chief



With immense humbleness and anticipation, I seek it's my pleasure to launch the April 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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Protected Cultivation of the Cucumber (Cucumis sativus L)

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Abstract

Protected cultivation of cucumber (*Cucumis sativus* L.) has emerged as a viable strategy to enhance productivity, quality, and profitability under shrinking land resources and changing climatic conditions in India. The technology enables year-round production through controlled microclimate, efficient water and nutrient management, and reduced pest and disease incidence. The use of gynoecious and parthenocarpic hybrids under polyhouse conditions ensures higher fruit set and uniform yield even in the absence of pollinators. Standardized packages of practices involving soil or soilless media, fertigation, training systems, and intercultural operations further optimize crop performance. Protected cultivation also supports export-oriented and pharmaceutical-grade cucumber production by ensuring superior quality. Overall, this approach offers a sustainable solution for intensifying cucumber cultivation and improving farmers' income under diverse agro-climatic conditions.

Keywords: Cucumber, Gynoecious lines , Protected cultivation, Parthenocarpic hybrids, Polyhouse technology.

India is the world's most populous country, with a population of about 1.4 billion, projected to reach nearly 1.6 billion by 2048. Land degradation, rapid urbanization and climate change pose major threats to sustainable agricultural production (Sharma et al., 2026). Since the pre-independence period, the average agricultural landholding size in India has been declining at a rate of approximately 0.06–0.07 ha per year. To meet the increasing food demand and to cope with erratic seasonal patterns and irregular rainfall, efficient utilization of land resources is essential. Consequently, agricultural practices such as vertical farming, protected cultivation, adoption of high-yielding and climate-resilient hybrids/varieties and biofortified crops have gained prominence. Protected cultivation harnesses the greenhouse effect to enhance productivity within limited land areas and enables year-round cultivation of high-quality, disease-free crops. In India, protected cultivation is predominantly practiced for high-value vegetables such as parthenocarpic cucumber, coloured capsicum, indeterminate and cherry tomato, gynoecious muskmelon and bitter gourd and different lettuce types used in salads. The adoption of protected cultivation has increased significantly due to changing food habits and greater nutritional awareness among consumers. Andhra Pradesh, Karnataka and Chhattisgarh lead in protected cucumber cultivation, while West Bengal ranks first in cucumber area and production (Sheeba et al., 2025).

The expansion of protected cucumber cultivation is driven by high domestic demand, export potential and its increasing utilization in pharmaceutical industries. Conventionally, cucumber is cultivated mainly during the

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summer season in tropical, sub-tropical and temperate regions (Kalloo et al., 1994). Being a thermosensitive crop, cucumber requires specific climatic conditions, particularly during seed germination and female flower induction, with optimal growth occurring at temperatures of 25–30 °C. Regions characterized by heavy snowfall, excessive rainfall and unsuitable soils (acidic or alkaline) pose significant challenges for open-field cucumber cultivation. In such environments, protected cultivation offers great potential through the use of hi-tech polyhouse with controlled environmental conditions, precise use of water and nutrients and grow bags containing suitable growing media.

Protected cultivation plays a crucial role in the production of cucumber and gherkin for export-oriented and pharmaceutical purposes, as it ensures superior quality produce with minimal incidence of pests and diseases. Gynoecious and parthenocarpic cucumber hybrids are specifically developed for cultivation under protected environments (Devi et al., 2023), where pollinators are scarce or absent. Therefore, protected cultivation of cucumber serves as a significant boon for farmers by enhancing productivity, quality and profitability.

Cucumber: Ideotypes and Breeding Objectives for Protected Cultivation

1. Node to first female flower – 1^{st} to 5^{th} node female flower anthesis
2. Days to first female flower -25-30 days after the germination
3. Mulipistilate flowering habit – 3-4 clustered female flower anthesis, preferably in gynoecious-parthenocarpic cucumbers
4. Parthenocarpic and gynoecious based hybrids for protected cultivation
5. Short internodal length – 5- 10 cm internodal length
6. Higher female: male sex ratio- 1: 25-30
7. More flesh thicknesses
8. Dark green colour without spines.
9. Proper fruit shape and length (10-15 cm) as per local preference without crooked neck.
10. Less or negligible cucurbitacin content.
11. Thermosensitive intolerance, earliness and uniformity of fruiting.
12. Highest heterosis for horticultural traits
13. Resistance to biotic (Nematodes, TLNDV, Downy mildew, Powdery mildew, White fly resistant) and abiotic stress (Heat and frost tolerance).
14. Stable gynoecious lines at high temperature and suitable for tropical and subtropical regions of the India.
15. Extended shelf life, tolerance to de-greening and long field staying characters without fruit shrinkage/ shrivelling and spongy flesh formation.

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16. High yielding and productivity (Pradeepkumara et al., 2025)

Table 1. Public-Sector: Cucumber Hybrids Suitable for Protected Cultivation in India.

Research centre	Hybrid / Variety (name)	Key characters (gynoecy / parthenocarpy + agronomic/market traits)	Year of release / recommendation	Source
ICAR-IARI, New Delhi	Pusa Seedless Cucumber-6 (Pusa Parthenocarpic Cucumber-6)	Extra-early, parthenocarpic & gynoecious, seedless fruits, suitable for protected cultivation (protected/polyhouse).	2017	(IARI annual report)
ICAR-IARI, New Delhi	Pusa Gynoecious Cucumber Hybrid-18 (DGCH-18)	Gynoecy-based hybrid, early (≈45 DAS), high yielding; recommended for specific zones; suited to spring–summer / protected conditions.	2019–2021 (AICRP / IARI	(Indian Agricultural Research Journals)
ICAR-IARI, New Delhi	Pusa Parthenocarpic Cucumber Hybrid-1 (DPaCH-07 / Pusa Parthenocarpic Cucumber Hybrid-1)	Parthenocarpic gynoecious F_1 hybrid, developed for protected cultivation (seedless fruit set in absence of pollinators).	2023–2024	(IARI)
ICAR-IARI, New Delhi	Pusa Gynoecious Cucumber Hybrid-1301	Parthenocarpic gynoecious F_1 hybrid, developed for protected cultivation (seedless fruit set in absence of pollinators).	2024-25	IARI, Vegetable Science reports
Kerala Agricultural University (KAU)	KPCH-1 (KAU Parthenocarpic Cucumber Hybrid / KPCH-1)	Parthenocarpic, gynoecious-based hybrid; early, long dark green fruits; suitable for polyhouse/protected cultivation; moderate resistance to downy mildew.	2010.	(Cohvka)
G.B. Pant Univ. of Ag. & Tech., Pantnagar	Pant Parthenocarpic series (Pant Parthenocarpic Cucumber-1 / 2 / 3)	Parthenocarpic / gynoecious parental lines and selections used to develop parthenocarpic hybrids; suitable for protected cultivation; evaluated for polyhouse performance.	2010s–2020s; Pant Parthenocarpic-3 discussed in Pantnagar trials (2021–2024).	(gbpuat.res.in)
Punjab Agricultural University (PAU), Ludhiana	Punjab Kheera Hybrid-11 (PKH-11) (earlier Punjab Kheera-1)	Parthenocarpic gynoecious hybrid developed for poly-net / protected cultivation; high yield in polyhouse; described in PAU publications.	2021	(ISVS Veg Sci)
MPKV (Dr. Punjabrao Deshmukh Krishi Vidyapeeth), Rahuri	Parthenocarpic khira-3	Parthenocarpic type recommended for polyhouse cultivation; reported female-flower rich habit and high yield potential under protected conditions.	-	(Tamil Nadu Agricultural University)

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Gynoecious and parthenocarpic hybrids for protected cultivation

Gynoecious and parthenocarpic cucumber hybrids are highly preferred for polyhouse cultivation because of their superior yield and productivity compared with conventional monoecious or mixed-sex hybrids. Several studies have reported that gynoecious–parthenocarpic hybrids consistently outperform traditional varieties under protected conditions, primarily due to their ability to set fruits without the intervention of pollinators (Kalloo, 1994; Jat et al., 2017). This trait is particularly advantageous in polyhouse, where natural pollinator activity is limited or absent. Compared with conventional hybrids, gynoecious and parthenocarpic cucumbers exhibit a higher number of fruits per plant, attributed to their Mulipistilate flowering habit and the presence of female flowers at nearly every node (Pradeepkumara et al., 2025). Research findings indicate that this floral biology significantly enhances fruit set, uniformity, and overall yield under controlled environments (Devi et al., 2023). Furthermore, protected cultivation structures not only facilitate higher yields and better fruit quality, but also provide an ideal environment for the hybrid seed production of gynoecious (Gynoecious x gynoecious, Gynoecious x monoecious, Gynoecious x hermaphrodite) and parthenocarpic cucumbers through controlled pollination techniques, Maintainace . Studies suggest that regulated temperature, humidity, and isolation conditions inside polyhouse improve genetic purity and seed quality, making protected cultivation a preferred system for both commercial production and hybrid seed multiplication.

Package of practices for protected cultivation of cucumber

Soil and Growing Media

The soil should be sandy loam to loam, well-drained, and rich in organic matter. An optimal soil pH of 6.0–6.8 (slightly acidic to neutral) is ideal for crop growth. Under polyhouse conditions, cultivation is preferably carried out on raised beds or in grow bags using a growing medium composed of cocopeat: vermicompost: perlite (3:1:1) or a properly sterilized soil mixture. The soil or growing media must be free from soil-borne pathogens to ensure healthy plant establishment and growth.

Climate Requirements under Protected Cultivation

The optimum day temperature for cultivation is 25–30 °C, while the night temperature should be maintained at 18–22 °C. Relative humidity (RH) should be kept within the range of 60–75%. Proper ventilation must be ensured to prevent the buildup of excess humidity and to reduce the incidence of diseases. Adequate light intensity is essential for healthy growth; therefore, 30–50% shading may be provided during summer, if required, to avoid heat stress.

Manures and Fertilizer Application

Farmyard manure (FYM) or organic manure should be applied at 20–25 t/ha (2–3 kg per m²) during bed preparation to promote better crop growth. The FYM must be well-decomposed and properly dried to minimize the risk of secondary infection in the crop. Under protected cultivation, the recommended NPK dose is 150 : 100 : 200 kg/ha (N : P_2O_5 : K_2O); however, the exact fertilizer requirement may vary depending on soil type and the nature of the variety or hybrid. A fertilizer schedule based on fertigation is preferred. The basal application should consist of the entire dose of phosphorus along with 25% nitrogen and 25% potassium. The remaining nitrogen and potassium should be supplied through drip fertigation at weekly intervals. Micronutrients such

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as zinc (Zn), boron (B), and iron (Fe) should be applied through foliar sprays whenever deficiency symptoms are observed.

Seed Rate and Nursery Management

The recommended seed rate is 0.8–1.0 kg/ha (approximately 8–10 g per 1000 m²). Only certified gynoecious–parthenocarpic hybrids should be used to ensure uniform growth and high productivity. Seedlings should be raised in protrays (98-cell trays) using a sterilized growing medium. Healthy seedlings should be transplanted at the 2–3 true leaf stage, when they are about 15–18 days old, to ensure better establishment and early vigor.

Spacing and Training System

Spacing: Row × plant: 45–60 cm × 40–45 cm

Training system: Single-stem training on vertical trellis / overhead wire system. Remove side shoots up to 6–7 nodes. Allow fruiting on upper nodes. Regular tying with plastic twine is essential (Jat et al., 2017).

Intercultural Operations

Removal of basal leaves touching the soil is recommended, as it reduces the incidence of soil-borne foliar fungal diseases. Timely pruning of excess side shoots helps maintain proper plant architecture and improves aeration, ensuring better air circulation and light penetration, which in turn supports a favorable female-to-male flower ratio. Mulching, preferably with plastic mulch, should be practiced for effective moisture conservation and weed control. Proper irrigation through a drip system must be ensured to maintain uniform soil moisture and optimum crop growth.

Harvesting and After-Care

The first harvest is usually carried out 30–35 days after transplanting. Subsequent harvesting should be done at intervals of 2–3 days. Fruits should be harvested gently to avoid injury to the vines. Continuous and timely harvesting promotes enhanced fruiting and results in higher overall yield. Adequate nutrient and water supply must be maintained throughout the cropping period to sustain productivity. For fresh consumption, fruits should be harvested at the appropriate maturity stage, when they attain a uniform green colour. The optimum fruit length is generally 18–22 cm, depending on the specific hybrid. At harvest, the flesh should be firm and tender, with seedless fruits or only soft, undeveloped seeds. Over-mature fruits should be avoided, as they adversely affect both yield and quality.

Table 2. Major Pest and Diseases of the protected cultivation of the cucumber.

Category	Pest / Disease	Chemical / Management Measure	Dosage
Major Pests	Aphids / Whiteflies / Thrips	Imidacloprid 17.8 SL	0.3 ml per litre of water
		Thiamethoxam 25 WG (alternative)	0.25 g per litre of water
	Spider mites	Abamectin 1.9 EC	0.5 ml per litre of water
	Pumpkin beetles	Imidacloprid 17.8 SL	0.33 ml/L
Major Diseases	Powdery mildew	Wettable sulphur	2 g per litre of water
	Downey Mildew	Metalaxyl + Mancozeb @ 2 g/l	1.5 g per liter of the water

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Future Thrust Areas in Protected Cultivation of Cucumber

Protected cultivation of cucumber offers significant potential to enhance productivity, quality, and year-round availability. Future efforts should focus on the development of climate-resilient gynoecious and parthenocarpic hybrids suited to diverse agro-climatic conditions. Precision fertigation and sensor-based irrigation systems can improve resource-use efficiency and reduce production costs. Integration of IPM and IDM strategies will help minimize pesticide use and residue issues. Development of the hybrid's resistance to the Downey mildew, powdery mildew and TLNDV, Anthracnose and Nematodes, Advances in soilless cultivation and biodegradable growing media are promising for sustainable production. Adoption of automation and digital monitoring for microclimate control can optimize crop performance. Strengthening post-harvest handling, grading, and cold-chain infrastructure is essential to reduce post-harvest losses. Finally, capacity building and technology dissemination among farmers will accelerate adoption of protected cucumber cultivation.

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ICT Pathways: Empowering Livestock Farmers with Innovative Knowledge Delivery

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Abstract

Information and Communication Technology (ICT) serves as a pivotal tool for generating, storing, managing, and disseminating knowledge in animal husbandry, particularly in India's livestock sector. Encompassing computers, internet, software, and peripherals, ICT enhances decision-making, disease control, dairy management, and market access amid rising demand for animal products. This review explores ICT's transformative impact on rural livestock farmers, entrepreneurs and livestock systems, emphasizing tailored solutions for linguistic and geographical diversity.

Introduction

The livestock sector in India has undergone a significant transformation, transitioning from a subsidiary component of agriculture to a vital source of livelihood in various regions across the country. The livestock sector is a significant source of income and employment for millions of individuals (Nirmala et al., 2016). Livestock keeping offers an additional advantage in terms of household nutritional outcomes. It is common practice in India to rear livestock within mixed farming systems, wherein animals typically serve diverse functions. Livestock activities are typically incorporated within established farming systems, wherein animals can graze on fallow land and browse on hedges. Additionally, they use crop residues as feed sources, generate milk, egg and meat products, and manure for biogas production and power for traction purposes. The importance of information and knowledge has significantly increased in the livestock sector. This changing environment necessitates the utilisation of information and knowledge as crucial factors for making effective decisions (Adhiguru et al., 2009).

Information Needs of Livestock Farmers

The exponential expansion of Information and Communications Technology (ICT) has transformed the landscape of livestock-related information distribution to farmers. This has led to the development of livestock machinery and techniques, providing comprehensive information on government initiatives aimed at animal husbandry and rural development. Weather forecasting, post-harvest technology, input prices and availability, livestock insurance, and market information are essential for farmers to make informed decisions about where to sell their produce. Collaboration between multiple departments and experts in animal husbandry is crucial to address these information needs effectively. Establishing an online network with multiple stakeholders within the livestock value chain is essential to effectively address the information requirements of farmers, both present and future. ICT-enabled systems are better suited to meet the information requirements of various client groups (Nagesh and Saravanan, 2019).

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Role Of Ict In Animal Husbandry

ICTs play a vital role in promoting communication and knowledge exchange among animal husbandry researchers, extension agents, and farmers, leading to improved livestock production. They also facilitate environmentally sustainable farming practices, disaster management, market access, food safety, traceability, financial inclusion, and community expansion. ICTs also facilitate financial services for rural communities, enabling individuals to safeguard savings, obtain affordable insurance, and manage risks effectively. Furthermore, ICTs facilitate the implementation of regulatory mechanisms and policies, providing frameworks for monitoring and evaluating progress (FAO, 2017).

Information and Communication Technology (ICT) concept and impact

Information and Communication Technology (ICT) is a crucial technological instrument that facilitates the generation, storage, management and dissemination of information via electronic methods. It encompasses various technologies, such as desktop and laptop computers, software applications, peripheral devices, and internet access. ICTs play a vital role in enhancing access to knowledge, information, and communication, making them increasingly vital in contemporary economic and social interactions.

In India's livestock, agriculture, and rural artisans, adopting ICT tools can significantly impact the economic landscape. The livestock industry should focus on developing computer software and electronic materials tailored to specific requirements, geographical contexts, and linguistic diversity. This will help in controlling of livestock diseases, manage dairy herds, production and market livestock products. ICT integration in the livestock industry holds significant promise for enhancing decision-making processes and improving the quality of livestock farming systems. The importance of information is growing in developing countries due to the expansion of livestock production systems and increasing market demand for animal-based products. The potential of livestock innovations to drive progress depends on farmers embracing and effectively disseminating them through appropriate channels (Laurantine 2011). ICTs are the fundamental building blocks of the emerging global economy, which heavily relies on information. The capacity and immediacy of information sharing at a minimal cost are highlighted in the literature (Tiwari et al. 2010).

Radio

Community radio is a valuable communication tool for rural farming communities, providing affordable and easily accessible platforms for disseminating information. It is adaptable, timely, and serves diverse needs, with All India Radio operating 96 stations and its Kisanvani program. In India, 126 operational community radio stations are currently broadcasting their programs. Radio plays a crucial role in developing communication and targeting rural audiences, enhancing group interaction and group functioning. It can facilitate the transmission of messages, enhance group coordination, expand societal discourse, raise awareness, and mobilize communities to address issues (Nirmala 2018). A study by Ariyo et al. (2013) found that radio was a more accessible and primary conduit for disseminating livestock technologies to farmers.

Television

Television is an electronic medium that broadcasts audio and video to a global audience, effectively communicating with a large and geographically dispersed population. Television is a prominent channel of choice among farmers due to its visual and auditory components, making it a valuable tool for extension work

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and training purposes. It also generates awareness and disseminates knowledge about the latest technologies among farmers. In a study by Nazari and Hassan (2011), farmers' awareness levels increased from 3.73 to 6.26, highlighting the effectiveness of television in enhancing farmers' knowledge and its utility in disseminating agricultural and animal husbandry knowledge to target audience.

Touch Screen Information Kiosk

The touchscreen monitor features educational modules on livestock farming, including textual content, visual images, graphical representations, and audio files. It provides up-to-date information on livestock production and management, with a multimedia interface and voice interface for those who cannot read. Studies show that touch screen information kiosks can improve disease prevention, animal health, and save time, labor, and financial resources for marginalized populations (Sharma, 2014; Rathode and Dixit,2020).

Multimedia Modules (Cd/Dvd)

Effective communication strategies are essential for addressing challenges like illiteracy and traditional practices among livestock farmers. CD-ROMs, a storage medium, provide expedited access to data, including text, sound, computer graphics, animation, slides, and motion video. They offer benefits such as storage capacity, robustness, data security, portability, user-friendliness, and affordability. Multisensory CD-ROMs facilitate enhanced learning experiences and can be efficiently replicated and disseminated for educational purposes. Studies have shown that CD-ROMs can significantly improve knowledge scores, with a significant increase in knowledge scores after exposure. Overall, effective communication strategies are essential for livestock farmers to adopt innovative approaches and improve their knowledge (Vidya and Manivannan 2010; Nirmala et al. 2016; Madhu and Verma 2020).

Interactive Expert Systems

Numerous institutions worldwide are exploring the use of information technology, particularly expert systems, in disseminating knowledge related to livestock management. The Interactive Expert module helps to acquire domain-specific expertise, which is then analyzed and processed to derive optimal conclusions for the problem. This knowledge is then transferred to experts in information systems for validation and transformation into an expert system program. Expert systems are computer programs designed to tackle problems or offer guidance in specialized domains. In animal husbandry, a computer program stores specialized knowledge in disease diagnosis, allowing users to input symptoms in textual or digital images. These systems can be used in both online and offline modalities, with some institutions like ICAR developing specialized systems for specific animal species to support field personnel. Examples include the "Animal Health Information System in English" for Para Veterinarians, the Expert System for Dairy Cattle Management developed by KVK, ICAR-CTRI, the Poultry Expert System from the College of Veterinary Science, and the Information System on Organic Livestock Farming (ISOLF) (Meena and Singh 2013; George 2014).

Video Conferencing

Video conferencing (VC) allows remote meetings between individuals in different locations, enabling simultaneous two-way communication. The Village Resource Centre, a satellite communication application enabling farmers to receive information and actively communicate. Interactive video conferencing enhances farmers' understanding of diverse animal husbandry practices. Virtual Research Centres (VRCs) provide

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reliable information directly from experts, reducing travel time and expenses. This facilitates the rapid dissemination of location-specific technologies to rural farmers (Shamna et al. 2017).

Web Portals

Web portals, also known as online portals, are a gateway to information and services, revolutionizing communication and providing access to animal husbandry information. The World Wide Web (WWW) is a collection of data and resources accessible through web servers. Scientists, students, extension functionaries, traders, and farmers can easily access necessary information through the internet. ICAR institutes and State Veterinary Universities host information on veterinary science and management practices, while relevant state or central government departments host information on government programs, projects, and schemes.

Web Portal For Market Information

e-Choupal

In the Indian context, e-Choupal serves as a trading platform that effectively minimises transaction costs by establishing a connection between buyers and farmers through the utilisation of Internet kiosks. Furthermore, e-Choupal extends its services to farmers by providing valuable resources, including disseminating best practices to enhance productivity and the facilitation of price benchmarking to augment sales prices.

Agrisnet

The AGRISNET project, supported by the Department of Agriculture and Cooperation, aims to establish an Agricultural Resources Information System and Networking in India. State governments have developed agricultural portals, such as Sikkim AGRISNET, Andhra Pradesh agri-portal, KISSAN in Kerala and Uttar Pradesh Agrisnet Knowledge Portal. To address challenges faced by agriculture and allied sectors, the Department of Agriculture and Cooperation (DoA&C) has included Agriculture as a Mission Mode Project (MMP) in the National eGovernance Plan (NeGP). The MMP provides farmers with information on seeds, fertilizers, government initiatives, management practices, weather conditions, and marketing of produce. The DoA&C has implemented a dual approach to lead the Mission Mode Project (MMP) implementation in the agricultural sector, using AGRISNET and two portals, AGMARKNET and DACNET.

Kisan Call Centres

The Kisan Call Centres (KCC) were established in India in 2004 to provide farmers with online agricultural advice and information. These call centres are accessible through a toll-free number, specifically 1551, and employ experts in the native language. The goal is to address concerns raised by farmers in their native language promptly. The Farmer Call Centre combines ICT and the expertise of Scientists and Extension Officers to enhance accessibility of information and services to the farming community.

Mobile Telephony

Mobile telephony has experienced significant growth in rural areas, bridging the digital divide and providing economic benefits and social mobilization through improved communication. Mobile phones can catalyze revitalising extension services in India, allowing farmers to bridge the information gap and alleviate its effects. This has led to increased farm output in areas with unfavorable biotic and abiotic conditions.

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Mobile phones can serve as a central role in disseminating livestock-related information among livestock owners, enhancing safety, yield time, and cost savings while mitigating the perishability of farm goods. They also offer significant economic benefits, such as optimizing transportation expenses, minimizing time constraints, and mitigating spoilage of farm produce. Mobile phones have significantly enhanced farmers' ability to access, exchange information, transforming their interactions with markets and providing up-to-date and relevant information crucial for decision-making. They are widely acknowledged as the current and future technological platforms for development, offering advantages such as mobility, security, and flexibility.

m-KISAN :

The m-KISAN platform is a mobile-based agricultural information system that aims to provide farmers access to relevant and timely information. The KVK Kisan Mobile Advisory Services (KMAS) initiative involves using a text message platform to disseminate information to a large number of registered farmers in a district. This platform is utilised during essential livestock production periods to provide specific operational guidance and weather alert messages.

Mobile Applications

Mobile applications have become increasingly popular in the digital environment, with various organizations developing apps tailored to the farming community in India. Some of the most popular mobile applications include the eNAM app, IVRI Vaccination Guide App, KVK Mobile App, INAPH (Information Network for Animal Productivity and Health), e-Gopala, Bhuvan app and Kisan Sarathi app. The KVK Mobile App aims to optimize communication between Krishi Vigyan Kendras (KVKs) and farmers. It offers functionalities such as providing information on KVK facilities, upcoming events, guidance on management practices, agro-meteorological advisory services, and market prices for agricultural commodities. INAPH is an IT application that captures real-time data on nutrition, breeding, and health services for farmers. The INAPH system can transmit communications to farmers, delivering relevant guidance on livestock, and improving the health and productivity of animals. The e-Gopala application assists farmers in developing a well-balanced ration, optimizing feed costs, and obtaining information on ayurvedic veterinary practices, frozen semen, IVF embryos, sexed sorted semen, and buying and selling bovines.

Social Media

Social media platforms enable the sharing and exchange of information among individuals, including user-generated content. These platforms provide opportunities for cultivating interpersonal connections, disseminating information, and engaging with a diverse demographic. WhatsApp, for example, provides numerous benefits in animal husbandry, facilitating one-to-many and many-to-many forms of communication. Veterinary doctors and scientists provide up-to-date information and schemes, assisting farmers in emergency health concerns. WhatsApp is a low-cost and convenient tool for farmers, even those with limited literacy skills. It was found that using ICT tools helps farmers acquire information about farm operations, address livestock diseases, and access market-related information. A significant proportion of livestock farmers rely on WhatsApp as a primary source for obtaining livestock-related information, participating in groups dedicated to livestock farming, and conversing with fellow farmers. The study also found that 61.05% of participants expressed a positive inclination towards using WhatsApp to access livestock advisory services. India has a higher annual growth rate of social media users, with farmers using platforms like Facebook, Twitter, and

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WhatsApp to acquire and distribute information. Farmers use these platforms to share visual representations of their farms, facilitate product sales, and establish connections with industry experts (Dishant et al. 2020 ; Shobha et al. 2023).

Conclusion

The utilisation of Information and Communication Technologies (ICTs) holds significant promise in effectively distributing substantial quantities of valuable information to various communities. The information provided covers various subjects, such as markets, technologies, pricing, successful case studies, credit options, governmental services and regulations, climatic conditions, animal husbandry practices, and conservation of natural resources. Knowledge acquisition and information plays a significant role in livestock production and interventions that aim to improve food security and increase livestock productivity. Several media types, such as the internet, web-based platforms, mobile telephony, and computer-mediated networks, are utilised in various initiatives across India. The primary objective of these initiatives is to provide development solutions and improve livestock productivity. To cultivate a positive attitude among farmers towards the integration and utilisation of information and communication technology (ICT) tools, it is crucial to improve their user-friendliness. The successful implementation of policy initiatives and the provision of initial support plays a vital role in facilitating the extensive adoption of information and communication technology (ICT) tools within the livestock farming community.

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Black Soldier Fly (Bsf); Life Cycle And Rearing Conditions

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Introduction:

Black soldier fly [*Hermetia illucens* (L.)] belongs to the family Stratiomyidae in the order Diptera of class, Insecta. It is a harmless insect which is widespread known for its ecological and economic importance, especially in waste management and sustainable protein production and its byproducts. The fly originated in North America, but climate change and human activities, animals, goods, foods, and fruit transportation worldwide facilitated its spread to other continents such as Europe, Asia, and Australia.

They are generally considered a beneficial insect and non pests. The adult fly does not have mouthparts and doesn't even feed during its short lifespan. They do not bite or sting, feed only as larvae, and are not associated with disease transmission. Black solider flies make breeding areas of houseflies less desirable. The fly is often associated with the outdoors and livestock, usually being found around decaying organic matter such as animal waste or plant material. Black soldier flies (BSF) have the capability to thrive even under hostile conditions and has a typical life cycle of 1- 2 months. The larval stage is the only feeding stage wherein they feed voraciously on organically rich waste. The adult flies have single mating in their entire life span.

Life Cycle of Black Soldier Fly:

The five stages of life cycle are egg, larvae, pre-pupae, pupae and adult. Black soldier fly takes 40–44 days to complete the whole life cycle. The fertilized eggs hatch at a temperature of 24°C in 102–105 hours. Larvae that have just hatched are opaque-white in colour and eagerly move toward the substrate to feed on whatever food is accessible at that stage of their lives. The larvae achieve maturity in about two weeks.

Egg: Eggs are usually creamy yellow in colour and take 4 days to incubate and hatch under optimum conditions of around 20°C to 30°C.

Larva: Due to, photophobic nature the larvae have a dull, yellowish hue just after hatching and attempt to hide from light. It consumes food scraps and manure wastes, quickly converting them into calcium, protein, and fat. The ideal temperature range for larvae to effectively use feed is between 27 and 33˚C. Lower temperatures are probably feasible since the metabolism of larvae and feeding activity will provide some heat, enabling their growth in colder regions. Larvae attain full size (20 to 25 mm) in about 4 weeks at ideal conditions; but, if temperature and sufficient nourishment are not available, it may take up to 2-4 months. The optimum moisture of ideal feed requires from 60% to 90% for the growth of larva.

Pre-pupa: larvae (12.5 mm-long maggots) reach their maximum size, the larvae cease eating, turn black, and harden their skin; at this stage, known as the pre-pupa stage. Migratory larvae secrete chemicals that other maggots can follow which form a migration pattern that depends on humidity and temperature also.

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Pupa: In addition to becoming drier, the pupation location needs ambient humidity around 60% in order to emergence of adults. Pupation may take 7-10 days, depending on the surrounding humidity and temperature.

Adult: Adults emerge from their pupae cases after 10–14 days at 27–36 ˚C. The adults rely on the lipids accumulated from the larval stage for their activities and do not eat; instead, they consume water or other liquids when available. Two days after emerging from the pupal stage, adults mate and after copulation, females deposit their eggs in dry cracks and crevices close to their larval home The fly is similar in size to a honeybee, measuring between 13 and 20 mm, and it only lives for 6 to 10 days in adulthood. As they are photophilic, adult flies need temperatures between 5˚C and 35 ˚C as well as bright sunshine spectrums in order to facilitate mating.

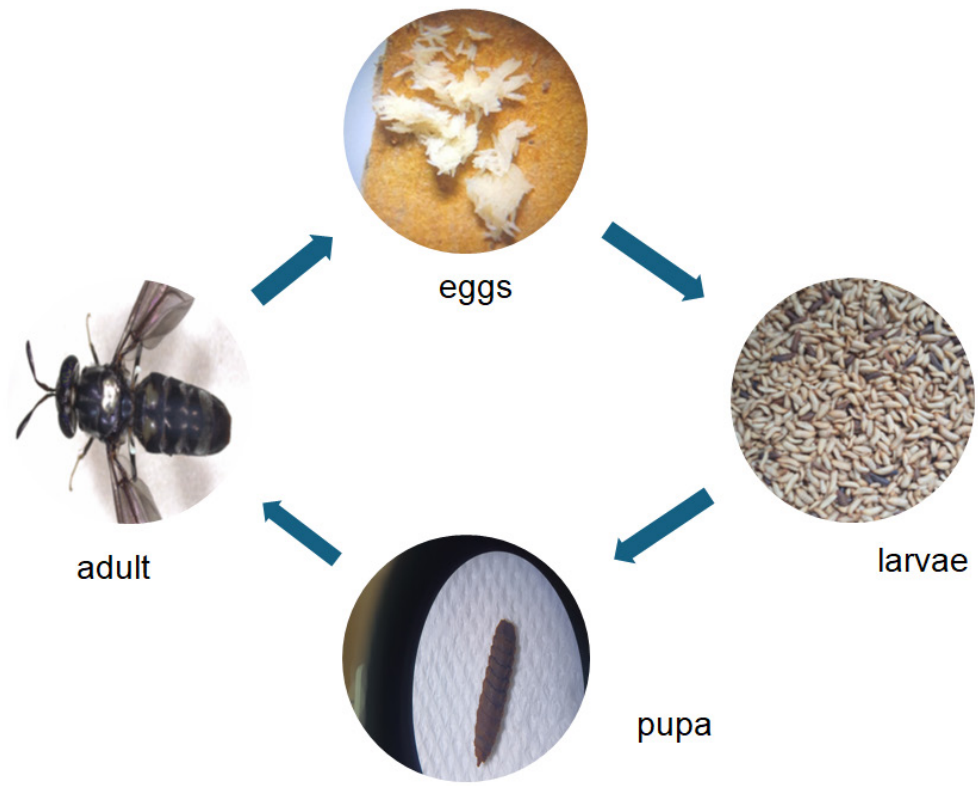

Figure: 01; Different stages of life cycle of black soldier fly (BSF)

Rearing and environmental conditions for black soldier fly:

Temperature and relative humidity (RH): The temperatures below 15°C and above 40°C was found to negatively impact on survival of the fly at all stages resulting in extremely high mortality rates. Highest mating and oviposition occur in the temperature range of 27.5 to 37.5°C combined with 70-90% relative humidity. 50-90% relative humidity is ideal for rearing of BSF in temperate regions. Below 25% humidity level results in higher desiccation and mortality rates of egg whereas at 70% and above, adults live longer.

Substrate type and moisture level: The optimal moisture content for BSF development is 80%, while the ideal moisture levels for healthy larval growth and development are 52–70%. High-fat diet is preferred by larvae. The BSF prefers a moist food, in contrast to other insects like mealworms. The enhanced larval development was similarly observed in neonates nourished with a plant-based substrate compared to those on an animal-based diet, as they host microorganisms that produce plant-degrading enzymes.

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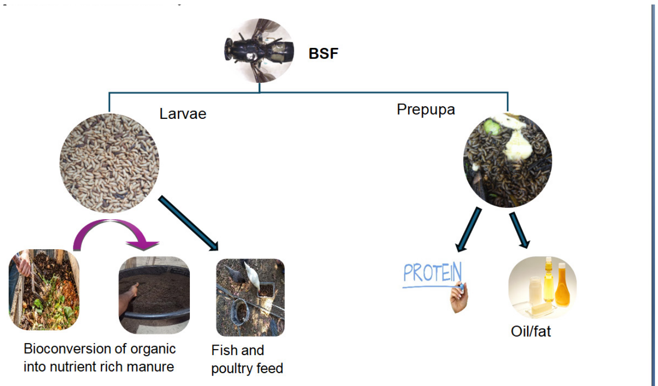
pH: The substrates contain pH values between 6.0 and 10.0 can be favourably regulate the higher larval growth and larger pupal mass; however, development is significantly inhibited at pH values below 2.0.

Light exposure and intensities: The ommatidia of BSF contains photoreceptors cells sensitive to blue (440 nm), green and UV (367 nm) light having trichromatic visibility; therefore, the LEDs (14-24 Wm^2) based illumination significantly increased the egg clutch yields resulting in higher larval production and higher number of fertile eggs produced comparative to fluorescent tubes. Researchers also stated that a 500-watt quartz iodide lamp with an intensity as high as 135 $\mu mol\ m^2 s^{-1}$ was able to promote the mating and oviposition at rates similar to those observed in the presence of natural sunlight.

Importance of black soldier fly:

Figure: 02; Valuation of different life cycle stages of black soldier fly



- Larvae as fish feed
- Larvae as poultry feed
- Prepupae as a source of protein and oil/fat
- Recycle food waste
- Organic fertilizer from black soldier fly larvae
- Municipal waste management problems
- Solving antibiotics problem by use of larvae as feed of poultry instead of harmful tannery waste which is harmful to human health and pesticides problem due to use of chemical fertilizers, the application of larvae into bioconversion of organic waste to nutrient rich manure.

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Role of Vegetable Crops In Human Health In The Post-covid Era

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Abstract

The COVID-19 pandemic highlighted the critical link between nutrition, immunity, and human health. Vegetables, as rich sources of vitamins, minerals, dietary fiber, antioxidants, and bioactive compounds, gained renewed importance during and after the pandemic. Scientific evidence indicates that regular consumption of diverse vegetable crops enhances immune competence, reduces inflammation, and lowers the risk of comorbidities such as diabetes, obesity, and cardiovascular diseases that aggravated COVID-19 severity. This popular article discusses the role of vegetable crops in human health in the post-COVID era, emphasizing policy initiatives, dietary shifts, and the contribution of both major and minor vegetables in strengthening resilience against infectious diseases.

Keywords: COVID-19, Vegetable crops, Immunity, Human health, Nutrition, Post-pandemic.

Introduction

Coronavirus disease 2019 (COVID-19) emerged in December 2019 in Wuhan, China, caused by the novel severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2). Within a short span, it spread rapidly across continents through human-to-human transmission, prompting the World Health Organization (WHO) to declare it a global pandemic in March 2020. The disease primarily affected the respiratory system but also caused systemic complications involving cardiovascular, renal and neurological organs. By 2023, more than 770 million confirmed cases and over 7 million deaths were reported globally, with the Americas and Europe being the most affected regions in terms of mortality. Beyond its direct health impact, COVID-19 exposed the vulnerability of populations suffering from malnutrition, micronutrient deficiencies and lifestyle-related disorders. Countries and regions with a high prevalence of obesity, diabetes, and cardiovascular diseases experienced disproportionately severe outcomes. Conversely, certain populations showed relatively better tolerance, partly attributed to dietary habits rich in plant-based foods. Traditional food patterns emphasizing vegetables, fruits, and minimally processed diets appeared to provide protective benefits. For instance, populations in parts of North-Eastern India, which are geographically isolated and traditionally consume diverse leafy vegetables, fermented foods and indigenous crops, demonstrated better nutritional status and immune resilience. Similar observations were noted in Mediterranean and East Asian dietary patterns, where vegetable-based diets dominate. During the pandemic, the Indian Council of Medical Research (ICMR) issued advisories promoting balanced diets with adequate intake of vegetables, fruits, pulses, and micronutrient-rich foods to support immunity. At the global level, the Food and Agriculture Organization (FAO) and WHO jointly recommended healthy diets rich in vegetables to combat the nutritional and health challenges posed

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by COVID-19. Several scientific reports further highlighted the role of exotic and minor vegetable crops in enhancing immune response and reducing disease severity. WHO also recognized specific vegetables as functional foods capable of supporting immune health. Overall, the pandemic reaffirmed that vegetables are not merely food commodities but essential components of preventive healthcare.

Impact of COVID-19 on Human Health and Nutrition

COVID-19 severity was strongly linked with underlying health conditions such as obesity, type-2 diabetes, hypertension, and compromised immunity. Lockdowns, stress, and disrupted food supply chains further aggravated poor dietary habits, leading to reduced consumption of fresh vegetables and increased reliance on processed foods in many regions. Nutritional deficiencies, particularly of vitamins A, C, D, E, iron, zinc, and selenium, were frequently associated with poor immune response and higher mortality rates. Vegetables provide a natural and affordable source of these micronutrients, emphasizing their importance in public health nutrition during pandemics.

Vegetables are an indispensable component of the human diet, providing essential phytochemicals that support growth, immune function, and disease prevention. Based on the edible part, vegetables are grouped into leafy, stalk, flower, root, bulb, fruit and tuber type each vegetable group providing a distinct nutritive profile. Green leafy vegetables (spinach, lettuce, curly lettuce, chard, chicory) are rich sources of iron, calcium, vitamin A, C and riboflavin. Stalk vegetables, such as celery and asparagus, are rich sources of minerals, vitamins and folic acid. Flower and inflorescence vegetables broccoli, cauliflower, and artichoke are good sources of iron, phosphorus, vitamin A, and C, with artichoke providing minerals, especially potassium, calcium, and high dietary fibre. Bulb vegetables (garlic, onion, leek, chive, Welsh onion) are abundant in thiosulfides, flavonoids such as quercetin and kaempferol which have been linked to reducing various chronic diseases. Fruit vegetable (tomato, brinjal, okra, chilli) are important sources of antioxidants. Tuber crop (potato) major source of carbohydrates, dietary fibre, and potassium.

This nutritional diversity is particularly relevant in the post-COVID era, where individuals face elevated risks of cardiometabolic, cardiovascular disorders, and persistent inflammation. Cardiovascular disease accounts for about 29.6 % of global mortality, largely driven by unhealthy lifestyles and eating habits. Vegetables have been shown to reduce cardiovascular disease due to their low content of saturated fat, trans fat, cholesterol, high bioactive compounds such as flavonoids, phytoestrogen, organosulfur compounds, soluble dietary fibers, isothiocyanates, monoterpenes and sterol (Asaduzzaman and Asao 2018). Beyond this, vegetables also provide fermentable substrates that strengthen gut barrier function, regulate infection and long-term cardiometabolic health

Role of Vegetable Crops in Enhancing Immunity

Vegetables contribute to immune health through multiple mechanisms, including antioxidant activity, regulation of gut microbiota and modulation of inflammatory responses. Table 1 summarizes key nutrients from major vegetable groups and their health benefits.

Table 1: Vegetable-derived nutrients and their health-promoting role in disease prevention

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Vegetable	Key nutrient/ Source	Health Promoting Activities	Reference
Tomato	Vitamin A, Ascorbic acid, Lycopene	Antioxidant, anti-inflammatory effect; reduces oxidative stress, anti-atherogenesis, cardiovascular, and prostate cancer risk	Shah et al. (2021)
Spinach, Kale, Amaranthus	Vitamin A, C, K, folates	Strengthen the immune system, reduce DNA damage, prevent infections, such as coronavirus, pneumonia, common cold and flu, asthma, and bronchitis.	Khalid et al. (2022)
Broccoli, Cabbage, Cauliflower	Glucosinolates, sulforaphane	Prevent cardiometabolic disorders such as dyslipidemia, insulin resistance, impaired glucose tolerance, hypertension, and central adiposity, musculoskeletal, neurological, psychiatric disorders, and cancer	Connolly et al. (2021)
Pea and Soyabean	Protein	Improve gastrointestinal and glycaemic activity, reduce insulin resistance, blood pressure, inflammation, and have anti-cancer, DNA repair properties	Kumari and Deka (2021)
Carrot	β-carotene	Anti-inflammatory, antioxidant, reduces ROS, and enhances innate immunity	Anjani et al. (2022)
Pumpkin	β-carotene	Antioxidant, anti-inflammatory, anti-microbial, anti -ulcerative properties support wound healing, reproductive health, and prostate function	Batool et al. (2025)
Garlic, onion, leek	organosulfur compounds	Antimicrobial, enhances immunity, reduce tumour, stomach, ovary, breast and colon cancer	Nicastro et al. (2016)
Potato	Carbohydrates	Improve satiety, gut health, antidiabetic, anti-inflammatory, anticancer, anti-obesity, and anti-hyperlipidemic	Raigond et al. (2023)

Contribution of Minor and Exotic Vegetable Crops

Minor and underutilized vegetables gained attention during the pandemic due to their high nutraceutical value. Crops such as moringa, drumstick leaves, bitter gourd, ivy gourd, ridge gourd, and leafy brassicas are rich in antioxidants and bioactive compounds. Exotic vegetables like broccoli, kale, zucchini, and lettuce were reported to enhance immune defence due to high vitamin C, flavonoids, and polyphenols. Scientific studies reported that moringa leaves possess antiviral, anti-inflammatory, and immunomodulatory properties, while bitter gourd showed potential in regulating blood glucose levels an important factor in reducing COVID-19 severity among diabetic patients.

Policy Initiatives by ICMR, FAO, and WHO

During the COVID-19 pandemic, ICMR released dietary guidelines emphasizing the consumption of seasonal vegetables, green leafy vegetables, and traditional foods to boost immunity. Advisories highlighted the importance of vitamin-rich vegetables and recommended kitchen gardens to ensure household-level nutritional security. FAO and WHO jointly promoted the concept of “healthy diets” during COVID-19,

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advocating increased intake of vegetables, fruits, whole grains, and legumes while limiting sugar, salt, and ultra-processed foods. These organizations recognized vegetables as critical for maintaining immune resilience and preventing non-communicable diseases that exacerbate infectious disease outcomes. Changing food patterns in the Post-COVID era post-pandemic, there has been a noticeable shift toward plant-based diets, home gardening, and consumption of locally available vegetables. Urban consumers increasingly prefer organic and nutrient-dense vegetables, while governments promote vegetable-based nutrition programs to strengthen public health systems.

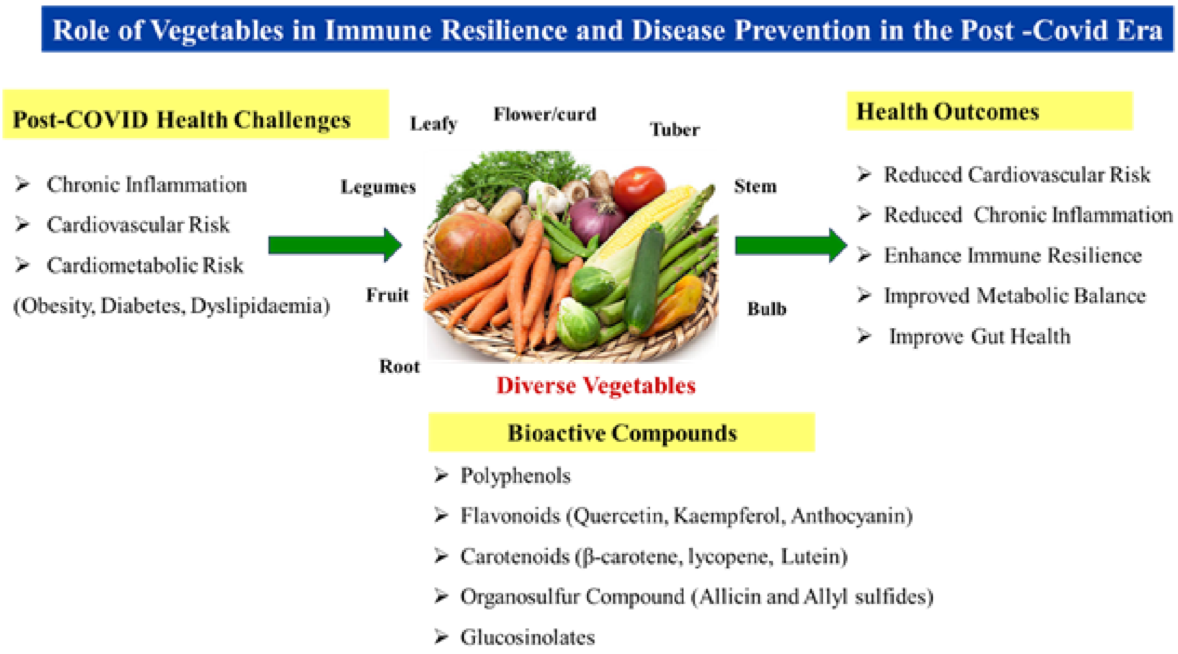

Fig.1. Role of Vegetables in Immune resilience and disease prevention in the post -Covid-19 era.

Conclusion

In the post-COVID era, vegetable crops have emerged as a strategic, agriculture-driven public health intervention rather than merely a dietary component. While vegetables do not directly prevent viral infection, overwhelming scientific evidence indicates that vegetable-rich diets strengthen immune resilience, stabilize metabolic health, improve gut microbiota, and reduce cardiometabolic risks, all of which are key determinants of COVID-19 severity and recovery outcomes. The pandemic clearly demonstrated that dietary quality is as critical as healthcare preparedness, with populations consuming diverse vegetables showing better tolerance to infection and faster recovery compared to those dependent on ultra-processed foods.

Future research predicts that nutrition-sensitive food systems, emphasizing micronutrient-dense, functional, and biofortified vegetables, can significantly enhance population-level resistance to emerging infectious diseases, including COVID-19–like pandemics. Integrating vegetables into preventive nutrition strategies, supported by clinical nutrition research, metabolomics, and gut–immune interaction studies, is expected to reduce disease burden and healthcare costs. Strengthening policy alignment between agriculture, nutrition, and public health, promoting vegetable accessibility, and expanding dietary education will be critical to translating scientific knowledge into impact. If these strategies are embedded within post-COVID food and health frameworks, vegetable-based diets represent one of the most scalable, equitable, and sustainable solutions for preventing future pandemics and building resilient societies in the decades ahead.

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Clean Label Meat Products: Redefining Preservation through Natural Bio-Interventions for Sustainable Food Safety

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Abstract:

Rising consumer demand for safe, natural, and minimally processed foods has driven the development of clean label meat products, which replace synthetic additives with natural alternatives while aiming to maintain quality and safety. However, removing conventional preservatives such as nitrites and phosphates creates challenges in ensuring microbial stability, sensory quality, and shelf life. Natural bio-interventions like plant extracts, organic acids, bacteriocins, and starch-based coatings show promise but may lead to limitations such as reduced shelf life and off-flavors. Overall, optimized formulations and clear regulations are essential to support the growth of clean label meat products.

Key words: Clean label foods, Bio-Interventions, Meat products

Introduction:

The global food industry is increasingly driven by consumer demand for natural, minimally processed, and additive-free foods, leading to the emergence of clean label meat products. These products emphasize simple, recognizable ingredients and transparent labelling to enhance consumer trust. In contrast, conventional processed red meat products contain additives such as nitrites, phosphates, and sodium, which are used to improve shelf life, safety, and sensory quality. However, excessive intake of processed meats and certain additives has been associated with an increased risk of cardiovascular diseases and certain cancers (Wolk, 2017).

Replacing synthetic additives with natural alternatives offers both opportunities and challenges. Plant extracts, organic acids, and bacteriocins can enhance microbial safety and maintain quality, but their effectiveness may be limited and may affect sensory properties and shelf life. Moreover, conventional additives serve multiple essential functions, including color stability, antimicrobial protection, and pathogen control, making complete replacement difficult.

Although clean label meat products are gaining popularity, the concept remains inconsistently defined due to differences in consumer perception and regulatory interpretation. Therefore, optimized natural preservation strategies and clear regulatory frameworks are needed to ensure product safety, quality, and consumer acceptance.

What are clean label meat products?

Clean label meat products are those formulated using simple, familiar, and naturally derived ingredients, with an emphasis on transparency and minimal processing. Unlike conventional processed meat products, these formulations exclude the use of synthetic preservatives, artificial additives, and chemically synthesized ingredients.

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Natural alternatives such as celery powder (as a curing agent) and plant extracts like rosemary are often used in place of synthetic compounds to enhance preservation and antioxidant properties.

Although widely used, the concept of "clean label" remains ambiguous and varies among consumers. Generally, it refers to products formulated using recognizable ingredients, subjected to minimal processing, and free from artificial additives, and produced through traditional processing methods (Edward, 2013). The growing demand for such products reflects consumer preference for safer, more transparent foods, highlighting the need for clear definitions and regulatory standards (Yong et al., 2020).

Key Characteristics of Clean Label Meat Products

- **Consumer-Oriented Development:** Driven by increasing demand for healthier and minimally processed foods.
- **Recognizable Ingredients:** Use of familiar, easily identifiable ingredients such as salt, spices, and celery powder
- **Natural Preservation Methods:** Use of natural antimicrobials and antioxidants like vinegar, celery powder, and plant extracts
- **Absence of Synthetic Additives:** Free from artificial preservatives, MSG, nitrites/nitrates, and phosphates
- **"Free-From" Labelling:** Often labelled as gluten-free, non-GMO, allergen-free, or organic

Challenges in Conventional Meat Preservation

Conventional meat preservation faces challenges in balancing safety, quality, and consumer demand, especially with the push to reduce additives like MSG and nitrites.

- **Microbial Safety:** High susceptibility to pathogens like *Listeria* and *Salmonella*.
- **Quality Loss:** Changes in texture, color, flavor, and drip loss during processing.
- **Synthetic Additive Concerns:** Health risks linked to nitrites/nitrates.
- **Cold Chain Issues:** Difficulty in maintaining consistent refrigeration.
- **Clean Label Conflict:** Need for preservatives vs demand for natural ingredients.
- **Natural Alternatives Limitations:** May affect taste and aroma.
- **Oxidation:** Leads to rancidity and reduced shelf life.

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Natural bio-interventions used in clean label meat products

Meat Product	Natural Ingredients	Impact on Product
Chicken products	Wheat sprout	Reduces fat content
	Plum powder/fibre	Replaces phosphates
	Beetroot, paprika, tomato	Reduces/replaces nitrites (color development)
	Vinegar, lemon, cherry powder	Inhibits L. monocytogenes
Red meat products	Clove & cinnamon oils	Antimicrobial effect
	Rosemary extract, olive leaf	Antioxidant activity
	Celery juice/powder, carrot, beet	Natural nitrite source
Fish & Marine products	Nisin, pediocin	Controls spoilage/pathogens
	Bacteriophages	Target specific bacteria
	Tapioca/corn/rice starch	Reduces drip loss (coating)
	Organic acids (acetic, lactic, citric)	Antimicrobial activity
Pork products	Eggshell/oyster calcium	Phosphate replacement
	Cellulose, chitosan	Improves water-holding capacity
	Inulin, pectin	Fat replacers
	Paprika powder	Reduces lipid oxidation

(Source: Inguglia et al., 2023; Ozaki et al., 2021; Chumsri et al., 2022; Chattopadhyay et al., 2024)

Impact on Shelf Life

Clean label meat products generally have a shorter shelf life compared to conventionally preserved products due to the absence of synthetic additives. Natural alternatives such as spice powders (bioactive components), essential oils, oleoresins and plant extracts can extend shelf life (Singh, 2022), but their effectiveness is often limited. Additionally, the use of plant-based compounds at higher concentrations may lead to off-flavors and sensory changes, requiring careful optimization.

Implications for Food Safety

Natural bioactive compounds (including plant extracts, essential oils, and oleoresins) exhibit strong antimicrobial activity against spoilage and pathogenic microorganisms. These ingredients help improve the microbial safety and freshness of meat products. However, achieving effective microbial control while maintaining sensory quality remains a key challenge in clean label formulations.

Challenges in Clean Label Meat Products

- **Difficulty in Removing Additives:** Eliminating artificial or chemical-sounding ingredients is not as simple as expected.

- **Role of Nitrites/Nitrates:** These compounds are essential for curing, color development, and controlling microbial growth.

- **Food Safety Risks:** Removal of synthetic preservatives may increase the risk of pathogenic contamination.

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- **Control of *Listeria monocytogenes*:** A major concern in ready-to-eat (RTE) and processed meat products, leading to foodborne illnesses and recalls.

- **Regulatory : Constraints:**
Strict regulations, such as the zero-tolerance policy for *L. monocytogenes* by USDA-FSIS, must be met.

- **High cost and formulation complexity** of natural ingredients can limit large-scale adoption of clean-label products

Consumer Acceptance and Market Trends

Consumers are increasingly concerned about their health and well-being, which has significantly influenced their food purchasing behaviour. Many are now willing to pay a premium price for products that offer perceived health benefits and greater transparency. Additionally, consumers are more likely to shift from their usual brands to those that provide clear and informative labelling. This shift reflects a broader global trend in which individuals actively examine ingredient lists and product labels before making purchasing decisions. As a result, there is a growing demand for food products, including meat, that align with consumer expectations for natural ingredients, transparency, and improved quality, thereby driving the expansion of the clean label market.

Future prospects

- Advanced natural preservation methods to enhance shelf life and safety.
- Rising demand for transparency and traceable, clean ingredients.
- Growth of sustainable practices and eco-friendly packaging.
- Stronger regulations to standardize and ensure clean label integrity.

Conclusion:

The clean label movement is transforming the meat industry by encouraging the use of natural, minimally processed, and transparent ingredients instead of synthetic additives. Although natural bio-preservatives show potential in improving food safety and quality, their use may be constrained by shorter shelf life and possible sensory changes. Achieving a balance between safety, quality, and consumer acceptance remains a key challenge. Therefore, continued research, innovation, and clear regulatory standards are essential to advance clean-label meat products and address evolving consumer expectations.

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Carbon Farming and Green Agriculture: A Sustainable Pathway for Future Farming

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Introduction

The present situation in agriculture finds itself at a crucial crossroads. Though it has been the cornerstone of human existence, agriculture has also become a significant source of greenhouse gas emissions. Rising temperatures, unpredictable precipitation cycles, and poor soil fertility have compelled agriculturalists and researchers to consider new farming techniques. Against this backdrop, carbon farming and green agriculture have proven to be viable ways of solving the problem.

Carbon farming is a form of agriculture where carbon dioxide from the atmosphere is captured and stored in the soil and plant matter. Green agriculture emphasizes the use of sustainable methods in farming without harming the environment.

Understanding Carbon Farming

The concept behind carbon farming revolves around one main idea. Namely, an increase in the level of carbon that gets into the soil. Plants breathe in carbon dioxide as part of their photosynthesis process and release it back into the soil where it can stay for a significant period if specific agricultural practices are employed.

Among them are:

- Cover cropping, which implies planting certain plants such as legumes or grasses during idle seasons
- Reduced tillage or no tillage at all, thus avoiding destruction of the topsoil layer
- Agroforestry, where planting trees alongside regular crops or cattle is used
- Various organic additives such as compost and manure

Notably, apart from helping the environment by decreasing carbon dioxide levels in the atmosphere, these practices lead to improved soil quality and increased fertility.

Green Agriculture: Concept and Importance

Green agriculture emphasizes sustainability, environmental protection, and efficient use of natural resources. It promotes practices that reduce chemical inputs, conserve water, and maintain ecological balance.

Key components of green agriculture include:

- Organic farming
- Integrated pest management (IPM)

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- Efficient irrigation methods like drip and sprinkler systems
- Use of renewable energy in farming operations

Green agriculture ensures long-term productivity without degrading natural resources. It also aligns with global sustainable development goals, particularly those related to climate action and responsible consumption.

Carbon Sequestration in Soil: The Science Behind It

Soil acts as a major carbon sink. It contains more carbon than the atmosphere and vegetation combined. When organic matter such as crop residues and manure decomposes, it contributes to soil organic carbon (SOC).

The process involves:

1. Photosynthesis: Plants absorb CO_2 from the atmosphere
2. Carbon transfer: Carbon moves into roots and soil microorganisms
3. Stabilization: Carbon becomes part of soil organic matter

Healthy soils with high organic carbon content are more fertile, retain more water, and support better crop growth. This makes carbon farming both an environmental and agricultural strategy.

Economic Opportunities: Carbon Credits for Farmers

Carbon credits are another thrilling element of carbon farming. Farmers can accumulate carbon credits by using techniques that facilitate carbon sequestration. These credits can then be traded on carbon markets for companies seeking carbon offsets.

Such possibilities would provide additional sources of income:

- Extra source of income for farmers
- Motivation to engage in sustainable practices
- Encouragement of environmental farming

Yet, carbon markets are still in their nascent stages in countries such as India, and many farmers are unaware of them. Under the right conditions, they could be economically significant.

Benefits of Carbon Farming and Green Agriculture

1. Environmental Benefits

- Reduction in greenhouse gas emissions
- Improved biodiversity
- Better soil and water conservation

2. Agricultural Benefits

- Increased soil fertility
- Higher crop yields in the long term
- Improved resilience to drought and climate stress

3. Economic Benefits

- Reduced input costs (fertilizers, pesticides)

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- Potential earnings through carbon credits
- Long-term sustainability of farming system

Challenges and Limitations

Despite its benefits, carbon farming and green agriculture face several challenges:

- Lack of awareness among farmers
- Initial transition costs
- Limited access to carbon markets
- Policy and institutional gaps

In addition, measuring and verifying carbon sequestration is complex and requires scientific tools and monitoring systems. Small and marginal farmers may find it difficult to adopt these practices without external support.

Scope in India : Carbon farming has great possibilities in India owing to its vast agricultural land and varying agro-climatic zones. Various practices such as agroforestry, organic farming, and conservation agriculture have already been encouraged by several governmental schemes.

Some of the schemes are:

- National Mission for Sustainable Agriculture (NMSA)
- Paramparagat Krishi Vikas Yojana (PKVY)
- Soil Health Card Scheme

Given that climate change is becoming an issue of great importance, carbon farming may prove helpful in making the Indian agricultural sector sustainable and resilient to the changes.

Future Prospects : The future of agriculture lies in balancing productivity with sustainability. Carbon farming and green agriculture are not just trends but necessities in the face of climate change.

Technological advancements such as remote sensing, AI-based soil analysis, and digital carbon tracking systems will further enhance the effectiveness of these practices. Moreover, global demand for sustainably produced food is increasing, which can benefit farmers adopting green practices.

Conclusion

The concept of carbon farming and green agriculture marks a new approach to agriculture. Rather than seeing farming as an activity that contributes to global warming, it sees farming as an answer. Through its efforts at improving the soil condition, fostering biodiversity, and cutting greenhouse gas emission, carbon farming ensures that the farmer reaps profits while protecting the environment. However, awareness, policies, and incentives would have to be put in place for its widespread adoption.

India, being one of the most populous nations, would benefit immensely from the practice of carbon farming as a path to more sustainable agriculture. Though there would be some hard work, it would surely prove rewarding.

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Quality Seed Production

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Abstract

Quality seed production forms the back bone of modern agriculture by ensuring the availability of high-quality, genetically pure, and viable seeds to farmers. As agriculture shifts from subsistence to market-oriented farming, the demand for reliable seeds with superior yield potential, disease resistance, and adaptability has increased significantly. This article explores the concept of quality seed production, its importance, major steps involved, quality control measures and challenges faced by the seed industry. Emphasizes placed on how scientific management, regulatory frameworks, and skilled human intervention work together to deliver seeds that ultimately determine cropper furnace and food security.

Introduction:

Seeds are more than just planting material, they are the starting poin to flife in agriculture. Every successful harvest begins with a good seed, making seed quality one of the most critical factors influencing crop productivity. In traditional farming systems, farmers of ten saved seeds from their own fields. While this practice worked for generations, it could not meet the demands of modern agriculture, which requires uniformity, higher yields, resistance to pests and diseases and adaptability to changing climates.

Quality seed production emerged to address these needs. It is a specialized and carefully regulated process aimed at producing seeds of known genetic identity and high physiological quality on a large scale. Unlike grain production, seed production focuses not only on yield but also on maintaining genetic purity, germination capacity, and physical health of the seed. This makes it a knowledge-intensive and management-driven agricultural enterprise.

Concept and Scope of Quality Seed Production:

Quality seed production refers to the organized multiplication of genetically pure seeds of improved varieties under controlled conditions, followed by processing, testing, certification and marketing.

The scope of quality seed production includes:

- Production of breeder, foundation, certified, and hybrid seeds
- Maintenance of genetic purity and varietal identity
- Seed processing, storage, and packaging
- Quality assurance through testing and certification

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Enhanced Crop Productivity:

High-quality seeds ensure better germination, uniform cropstand, and vigorous plant growth, leading to higher yields.

Genetic Purity and Uniformity

Quality seed production maintains the genetic identity of varieties, which is especially crucial for hybrids and improved cultivars.

Adoption of Improved Technologies

New varieties developed through plant breeding reach farmers only through efficient seed production and distribution systems.

Economic Benefits

Seed enterprises generate employment and income for seed growers, processors, and marketers, contributing to rural development.

Risk Reduction for Farmers

The Certified seeds reduce uncertainty in crop performance, giving farmers greater confidence at the time of sowing.

Steps Involved in Quality Seed Production

1. Selection of Variety and Seed Source

The process begins with selecting a suitable variety and obtaining seeds from anauthentic source. Breeder or foundation seeds are used to ensure genetic purity.

2.Selection of Suitable Area and Field

Seed crops require specific Agro-climatic conditions. Fields should have fertile soil, good drainage, and a history free from volunteer plants or related crops that may cause contamination.

3.Isolation

Isolation is critical to prevent unwanted dcross- pollination. Depending on the crop, isolation can be maintained by distance, time (staggeredsowing) or physical barriers. Isolation distance of rice varietal seed production is 3m for certified seed production.

4. Land Preparation and Sowing

Proper land preparation ensures good seed bed conditions. Sowing is done at their commended time, spacing,

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and seed rate to promote healthy crop growth.

5. CropManagement

This includes irrigation, nutrient management, weed control, and plant protection measures. Special attention is given to maintaining plant health and uniformity. This includes irrigation, nutrient management, weed control and plant protection measures.

6. Rouging:

Rouginginvolvestheremovalofoff-type,diseased,or undesirableplantsatdifferentgrowthstages.Itisa criticaloperatio ntomaintaingeneticpurity.

7.HarvestingandPost-HarvestHandling

Seedcropsareharvestedatphysiologicalmaturity. Care is taken to avoid mechanical damage, moisture absorption or mixing with other seeds.

8.SeedProcessingandStorage

Seeds are cleaned, graded, treated and dried to safe moisture levels.Proper storage conditions are essential to maintain viability and vigor.

Quality Control and Certification:

Quality assurance is a defining feature of quality seed production.Seeds undergo laboratory testing for germination percentage, physical purity, moisture content and seed health. Certification agencies monitor field operations and processing units to ensure compliance with established standards. Certified seeds are labeled and sealed, providing assurance to farmers regarding quality and authenticity.

Challenges in Quality Seed Production:

Despite its importance, seed production faces several challenges:

* Climatic uncertainties affecting seed yield and quality
* High costs of production and certification
* Risk of genetic contamination
* Storage and transportation losses
* Limited awareness among farmers in some regions

Addressing these challenges requires continuous research, training, policy support and adoption of modern technologies.

Conclusion:

Quality production is a corner stone of modern, sustainable agriculture. It transforms scientific innovations in plant breeding into practical solutions that reach farmers' fields in the form of high-quality seeds. By focusing on genetic purity, physiological quality and rigorous management practices, quality seed production ensures reliable cropper furnace and contributes directly to food security and economic growth. As agriculture faces challenges such as climate change, population growth and shrinking natural resources, the role of quality seed production becomes even more significant. Strengthening seed systems through innovation, skilled human involvement

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and supportive policies will not only benefit farmers but also safe guard the future of global agriculture. In essence, investing inequality seeds is an investment in the foundation of life and lively hoods.

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Pre-harvest Fruit Bagging: A Simple and Effective Technique to Improve Mango Fruit Quality

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Mango (*Mangifera indica L.*) is one of the most important fruit crops of India, often referred to as the "king of fruits" due to its wide adaptability, rich nutritional value, and high consumer preference. India is the leading producer of mango in the world, contributing a major share to global production. Despite its importance, mango cultivation is constrained by several factors, particularly during fruit development and maturation stages, which affect both yield and quality. Among the major biotic stresses, fruit fly (*Bactrocera spp*.) is serious pests that cause significant quantitative and qualitative losses. Fruit fly infestation leads to internal damage, premature fruit drop, and rotting, making fruits unfit for consumption and marketing. In addition, fungal pathogens cause fruit spots, blemishes, and surface defects, reducing the aesthetic and export quality of fruits.

These problems not only reduce yield but also severely affect market acceptability, consumer preference, and export potential. Farmers often rely on repeated pesticide sprays to manage these issues. However, indiscriminate use of pesticides results in residue accumulation on fruits, environmental pollution, development of pest resistance, and health hazards to consumers and farm workers. Moreover, pesticide application becomes difficult and less effective at advanced fruit stages.

In this context, pre-harvest fruit bagging has emerged as a simple, cost-effective, and eco-friendly technique. Fruit bagging involves covering developing fruits with suitable materials such as paper bags to create a physical barrier against insect pests, diseases, and external injuries. It also helps in improving microclimatic conditions around the fruit, resulting in better colour development, reduced blemishes, and enhanced fruit quality. The technique is widely adopted in several fruit crops like apple, guava, and pomegranate, but its potential in mango under local conditions needs further evaluation. In view of these, fruit bagging can be used as an effective field-level practice to protect fruits, improve quality, and reduce dependence on pesticides in mango cultivation.

Fruit Bagging Technique

During January to April season, fruit bagging was practiced in mango variety Khadar under normal orchard conditions. Well-maintained and healthy trees were selected, and routine crop management practices were followed.Fruit bagging was done at the marble stage (about 50 days after fruit set), which is the most suitable stage to protect fruits from pest and disease damage. Before covering the fruits, a preventive insecticide spray was given to control early infestation of pests. This step is important because once fruits are covered, pest control becomes difficult.

After spraying, selected fruits on the tree were covered using double-layered brown paper bags. The bags were carefully placed over individual fruits and tied properly to the stalk to ensure protection, while allowing sufficient aeration. Care was taken to avoid water entry and damage to the fruits.

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In the field, two types of practices were followed to clearly understand the benefit of fruit bagging under normal farmer conditions. In some trees, fruits were allowed to grow naturally without any covering, as generally practiced by farmers. In the other set, individual fruits were covered using double-layered brown paper bags at the marble stage. Care was taken to properly tie the bags to the fruit stalk so that they remain intact even during wind and light rains. This covering helped in protecting the fruits from direct exposure to insect pests, diseases, and sun damage. By comparing these two practices under the same orchard conditions, it was possible to observe how fruit bagging improves fruit quality, reduces pest incidence, and enhances shelf life over the usual method followed by farmers.Regular observations were made on fruit growth, pest and disease incidence, and quality parameters till harvest.

Benefits of Fruit Bagging in Mango

- **Improvement in Fruit Quality**

  Fruits covered with brown paper bags showed clear improvement in size, weight, and overall quality compared to normal (uncovered) fruits. The average fruit weight (250.10 g) and pulp weight (211.60 g) were higher in bagged fruits. In addition, the fruits developed uniform colour, smooth surface, and better external appearance, making them more attractive in the market. Such fruits fetch better price due to their premium quality.

- **Better Taste and Consumer Preference**

  Bagged fruits were found to be superior in taste, aroma, and texture. They were more appealing to consumers compared to fruits grown without covering. The improved sensory qualities make them suitable for both local markets and high-value sales.

- **Higher Fruit Retention and Shelf Life**

  Fruit drop was reduced in bagged fruits, resulting in higher fruit retention (80.90%). Farmers can get more marketable fruits per tree. Also, bagged fruits remained fresh for 10–12 days after harvest, maintaining good firmness and quality. This helps farmers in better storage, transport, and marketing, especially for distant markets.

Protection from Pests and Diseases : Fruit bagging works as a physical protective cover around the developing fruits and prevents direct contact of pests, diseases, and harsh environmental conditions. Once the fruits are covered properly, fruit flies are unable to lay eggs on the fruit surface, thereby preventing internal damage and rotting. This is especially important during the maturity stage when fruit fly attack is severe. Similarly, mealy bugs are restricted from reaching the fruits, reducing sap sucking damage and preventing formation of sticky honeydew, which otherwise leads to sooty mould development.

The paper cover also acts as a barrier against fungal infection, as it reduces direct exposure of fruits to spores, dust, and splashing rainwater. As a result, the occurrence of fruit spots, blemishes, and surface defects is minimized. In addition, bagging protects fruits from latex burn and sun scorch, which commonly occur due to high temperature and direct sunlight. By creating a mild microclimate around the fruit, it helps in maintaining better skin quality.

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Another important advantage observed was the reduction in spongy tissue disorder, which is a major problem in mango affecting internal fruit quality. Bagging helps in regulating temperature and moisture conditions around the fruit, thereby reducing this disorder. Overall, fruits remain clean, blemish-free, and healthy, which increases their market demand and price. Farmers can also reduce the number of pesticide sprays, making this practice both economical and eco-friendly.

Advantage During Rainy Period

During the month of April, with the onset of summer showers and increased humidity, the field conditions become highly favourable for the multiplication of fruit flies. At this stage, mango fruits are nearing maturity and become very attractive for egg laying by adult flies. The female fruit fly punctures the fruit skin and lays eggs inside, which later hatch into maggots and feed on the pulp. This results in internal rotting, premature fruit drop, and complete loss of market value.

Under normal farmer practice (without bagging), severe infestation is commonly observed during this period, especially after intermittent rains. Even repeated pesticide sprays may not provide effective control, as the larvae develop inside the fruit where sprays cannot reach.

In contrast, fruits covered with paper bags remain physically protected, as the adult fruit flies are unable to reach the fruit surface for egg laying. The bags also reduce direct exposure to rainwater and humidity, which further helps in minimizing pest build-up and disease incidence. As a result, bagged fruits show very low damage, better external appearance, and higher marketable yield, even during peak pest incidence period. This clearly shows that fruit bagging is a highly effective and reliable practice during critical stages, particularly in seasons with unexpected rains.

Hence, adopting fruit bagging before the onset of April showers can help farmers avoid heavy losses and secure better returns.

Overall Benefit to Farmers

By adopting fruit bagging in mango cultivation, farmers can achieve multiple benefits under field conditions. Firstly, it helps in reducing the number of pesticide sprays, as the fruits are physically protected from major pests like fruit fly and mealy bugs. This not only lowers the cost of plant protection but also reduces pesticide residues on fruits, making them safer for consumption. Fruit bagging also results in better quality produce, with improved size, colour, and clean surface free from spots and blemishes. Such fruits have higher consumer preference and are more suitable for premium markets.

Due to improved appearance and quality, farmers can fetch higher prices in the market, thereby increasing their overall income. In addition, the reduction in pest and disease damage leads to higher marketable yield, as fewer fruits are lost due to infestation or spoilage. Another important advantage is the extension of shelf life, which allows farmers to store and transport fruits without immediate spoilage. This gives flexibility in marketing and reduces distress selling.

Overall, fruit bagging is a simple, cost-effective, and eco-friendly practice that helps farmers minimize losses, improve fruit quality, and increase profitability in mango cultivation.

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Conclusion

Pre-harvest fruit bagging using double-layered brown paper bags has proved to be a simple, practical, and effective technique for improving the quality and marketability of mango fruits, especially in variety Khadar. By covering the fruits at the right stage, farmers can protect them from major pests like fruit fly and mealy bugs, as well as from fungal spots, sun damage, and physiological disorders such as spongy tissue. This practice not only helps in reducing the need for repeated pesticide sprays, thereby lowering production costs and avoiding residue problems, but also results in clean, uniform, and attractive fruits with better size, colour, and taste. The improvement in shelf life further supports better storage and transportation, reducing post-harvest losses. Importantly, fruit bagging becomes highly beneficial during critical periods such as April, when fruit fly incidence is high due to increased humidity and intermittent rains. Farmers adopting this method can safeguard their crop during such vulnerable stages and ensure higher marketable yield.

Overall, fruit bagging is an eco-friendly, cost-effective, and farmer-friendly practice that enhances fruit quality, reduces losses, and increases income. Hence, it can be confidently recommended to farmers as a sustainable production practice in mango cultivation for achieving better returns and improved consumer acceptance.

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Microplastics in Agriculture: An Emerging Challenge for Soil and Crop Health

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Abstract

Microplastics, defined as plastic particles smaller than 5 mm, have emerged as a pervasive environmental pollutant with far-reaching consequences. While their presence in oceans and aquatic systems has been widely studied, recent research indicates that agricultural soils are also becoming major sinks for microplastic accumulation. Sources such as plastic mulching, irrigation systems, sewage sludge application, and degradation of larger plastic debris contribute significantly to their presence in farmlands. These particles can alter soil properties, disrupt microbial communities, and potentially affect plant growth and crop productivity. Moreover, the possibility of microplastics entering the food chain raises serious concerns about food safety and human health. This article explores the sources, impacts, and implications of microplastics in agriculture, highlighting the urgent need for sustainable management practices.

Keywords: Microplastics, soil pollution, sustainable agriculture, soil health, crop productivity, environmental contamination

Introduction

In recent decades, plastic has become an indispensable part of modern life due to its versatility, durability, and low cost. However, the widespread use and improper disposal of plastic materials have led to severe environmental pollution. One of the most concerning forms of this pollution is the accumulation of microplastics—tiny plastic particles that are often invisible to the naked eye.

While early studies focused primarily on marine environments, it is now evident that terrestrial ecosystems, particularly agricultural soils, are equally vulnerable. Agriculture is both a contributor to and a victim of microplastic pollution. In fact, soils may act as major sinks for microplastics, accumulating them over time through various agricultural activities (Tian *et al*., 2022). The extensive use of plastic materials such as mulch films, greenhouse coverings, and irrigation pipes has increased the risk of plastic residues entering the soil.

Soil, being the foundation of crop production, plays a crucial role in maintaining agricultural productivity and ecosystem stability. The presence of microplastics in soil systems raises important questions about their long-term effects on soil health, crop growth, and food safety. Understanding this emerging issue is essential for developing sustainable agricultural practices.

Sources of Microplastics in Agricultural Soils : Microplastics enter agricultural soils through multiple

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pathways, many of which are directly linked to modern farming practices. One of the primary sources is the use of plastic mulch films, which are widely adopted to conserve soil moisture, regulate temperature, and suppress weeds. Over time, these films degrade into smaller fragments that remain in the soil (Bello *et al*., 2025).

Irrigation systems, particularly drip irrigation pipes made of plastic, also contribute to microplastic contamination through wear and tear (Garfansa *et al*., 2025). Additionally, the application of sewage sludge and compost derived from urban waste introduces microplastics into agricultural fields, as these materials often contain plastic residues (Mahon *et al*., 2017).

Atmospheric deposition is another significant but often overlooked source. Microplastics present in the air can settle onto soil surfaces, adding to the overall contamination. Furthermore, improper disposal and burning of plastic waste near agricultural lands can lead to fragmentation and incorporation into the soil.

Impact on Soil Physical Properties

Microplastics can significantly alter the physical characteristics of soil. Their presence affects soil structure, aggregation, and porosity, which are critical for water movement and root penetration. Depending on their size and shape, microplastics can either increase or decrease soil bulk density.

They may also influence soil water dynamics by altering water retention capacity and infiltration rates (Chakraborty *et al*., 2025). In some cases, microplastics create channels that facilitate rapid water movement, leading to reduced water availability for plants. In other cases, they may hinder water flow, causing waterlogging.

Such changes in soil physical properties can ultimately impact crop growth and productivity, especially in regions already facing water stress.

Effects on Soil Chemical and Biological Properties

Microplastics interact with soil chemistry in complex ways. They can adsorb and transport harmful substances such as heavy metals, pesticides, and organic pollutants. This can increase the persistence and bioavailability of these contaminants in the soil environment (Yang *et al*., 2025).

The presence of microplastics also affects soil microbial communities, which play a vital role in nutrient cycling and organic matter decomposition. Changes in microbial diversity and activity can disrupt essential soil processes, leading to reduced soil fertility.

Moreover, microplastics may influence soil pH and nutrient availability, further complicating nutrient management in agricultural systems.

Impact on Crop Growth and Productivity

Emerging research suggests that microplastics can have both direct and indirect effects on plant growth. They may interfere with seed germination and root development by creating physical barriers or altering soil conditions.

In some cases, microplastics have been found to affect nutrient uptake by plants, potentially leading to

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deficiencies or imbalances. There is also growing concern that very small plastic particles, known as nano plastics, may be absorbed by plant roots and transported to other plant parts (Sutanto *et al*., 2024).

Although research in this area is still developing, the potential impact of microplastics on crop yield and quality cannot be ignored.

Microplastics and Food Safety Concerns

One of the most alarming aspects of microplastic pollution in agriculture is its potential entry into the food chain. If microplastics are taken up by crops or adhere to their surfaces, they may ultimately be consumed by humans and animals (Lehel and Murphy, 2021).

This raises serious concerns about food safety and long-term health effects. Microplastics can carry toxic chemicals and pathogens, which may pose additional risks when ingested. While the full extent of these risks is still under investigation, the issue highlights the need for precautionary measures.

Implications for Sustainable Agriculture

The presence of microplastics in agricultural soils poses a challenge to the principles of sustainable agriculture. Healthy soil is the cornerstone of sustainable farming, and any factor that degrades soil quality can undermine long-term productivity (Chen *et al*., 2025).

Microplastic pollution threatens soil health, reduces efficiency of resource use, and may increase dependence on external inputs. Addressing this issue is essential for maintaining ecological balance and ensuring food security.

Sustainable practices such as reducing plastic use, promoting biodegradable alternatives, and improving waste management can help mitigate the problem.

Management Strategies and Way Forward

To tackle microplastic pollution in agriculture, a multi-faceted approach is required. Farmers should be encouraged to adopt eco-friendly alternatives such as biodegradable mulch films and organic amendments free from plastic contamination.

Improving waste management systems and recycling infrastructure is critical to reducing plastic leakage into the environment. Policies and regulations should be strengthened to control the use and disposal of agricultural plastics.

Research and innovation are also essential for developing new technologies to detect, monitor, and remove microplastics from soil systems. Awareness programs can play a key role in educating farmers and the public about the impacts of microplastics and the importance of sustainable practices.

Conclusion

Microplastics represent a hidden but growing threat to agricultural sustainability. Their accumulation in soils has the potential to disrupt soil health, affect crop productivity, and compromise food safety. As

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agriculture continues to intensify and rely on plastic-based technologies, the risk of microplastic contamination is likely to increase. Addressing this issue requires collective efforts from farmers, researchers, policymakers, and consumers. By adopting sustainable practices and reducing plastic dependence, it is possible to minimize the impact of microplastics and protect the integrity of agricultural systems. Ensuring healthy soils today is essential for securing food and environmental sustainability for future generations.

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Smart Seeds

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ABSTRACT

Smart seeds represent a transformative advancement in modern agriculture, integrating biotechnology, data science, and environmental adaptability to improve crop productivity and resilience. These seeds are engineered or enhanced to respond to environmental conditions such as soil moisture, temperature, and pest presence, enabling farmers to optimize yields while minimizing resource use. This article explores the concept of smart seeds, their technological foundations, benefits, challenges, and future potential. As global food demand rises alongside climate uncertainty, smart seeds offer a promising pathway toward sustainable and efficient agricultural systems.

INTRODUCTION

What makes a Seed "Smart"?

Imagine planting a seed that "knows" when it needs more water or can protect itself from pests. That's the basic idea behind smart seeds.

Today, farmers face many problems—unpredictable weather, less water, poor soil, and increasing demand for food. Traditional seeds often struggle in these conditions. Smart seeds are designed to handle these challenges better.

https://agtech.folio3.com/blogs/modern-seed-farming/

There are two main types of smart seeds:

- **Improved (Genetically Modified) Seeds:** These seeds are developed in labs to survive drought, resist pests, or grow faster.
- **Technology-Coated Seeds:** Some seeds are covered with special coatings that help them sense soil conditions or absorb nutrients more efficiently.

Think of smart seeds as "upgraded" versions of normal seeds. They are created to give farmers better results

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with less effort and fewer resources.

These seeds are also part of a bigger concept called **smart farming**, where technology helps farmers make better decisions. Instead of guessing when to water crops or apply fertilizers, farmers can rely on data and smarter inputs like these seeds.

How Smart Seeds Help Farmers : Smart seeds are not just about fancy technology—they actually make a big difference in real farming.

How Do They Work?

Some smart seeds are designed at the genetic level. This means scientists carefully adjust their characteristics so they can survive in tough environments. Others are coated with tiny materials that help them grow better or protect them from diseases.

In more advanced cases, these seeds can be connected to modern tools like sensors, mobile apps, or farm machines that track crop health.

Benefits of Smart Seeds

- **Better Crop Yields:** Farmers can grow more crops even in difficult conditions.
- **Less Water Needed:** Some seeds can survive with less water, which is very important in dry regions.
- **Reduced Use of Chemicals:** Smart seeds can resist pests naturally, so farmers don't need as many pesticides.
- **Stronger Crops:** Plants become more resistant to diseases and weather changes.
- **Higher Income for Farmers:** More yield often means better earnings.

Where Are They Used?

Smart seeds are already being used in crops like rice, wheat, and maize. They are also helpful in growing fruits and vegetables that last longer after harvest.

Even modern farming methods like greenhouse farming and vertical farming benefit from smart seeds because they allow better control over plant growth.

Overall, smart seeds make farming more efficient and less stressful.

Challenges and the Road Ahead : While smart seeds sound amazing, they are not perfect. There are still some concerns and challenges that need attention.

Challenges

- **Cost:** Smart seeds can be expensive, especially for small farmers.
- **Dependence on Companies:** Many smart seeds are produced by big companies, which means farmers

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may need to buy new seeds every season.

- **Limited Awareness:** Not all farmers know how to use these seeds effectively.
- **Regulations:** Some countries have strict rules about genetically modified seeds.

Ethical Concerns

There are also questions about fairness and sustainability:

- Should companies control seed production?
- Will traditional seed varieties disappear?
- Are these seeds safe in the long run?

These are important discussions happening around the world.

Future of Smart Seeds

The future looks promising. Scientists are working on seeds that can:

- Adjust automatically to weather changes
- Grow in very poor soil conditions
- Provide even higher nutritional value

There is also a strong push to make smart seeds more affordable so that small farmers can benefit too.

Conclusion

Smart seeds are changing the way we think about farming. They bring together science and nature to solve real-world problems like food shortages and climate change. While there are challenges to overcome, their benefits are too significant to ignore.

In a world where feeding everyone is becoming more difficult, smart seeds might just be one of the smartest solutions we have.

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Harvesting Health and Wealth: The Success Story of Farmer B. Raja Reddy with ABV-04 Bio-fortified Bajra

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Millets are ancient small-seeded cereal crops valued for their high nutritional content and their ability to grow in dry and challenging environmental conditions. They are increasingly seen as a sustainable substitute for rice and wheat because they are rich in dietary fiber, protein, and essential minerals. Among them, pearl millet (*Pennisetum glaucum*), belonging to the Poaceae family, is the fourth most important staple crop in India. It is a highly cross-pollinated species, exhibiting protogynous flowering and relying primarily on wind for pollination. Pearl millet is particularly appreciated for its health benefits, including aiding digestion and helping in the regulation of blood sugar levels. However, its productivity continues to be limited by the widespread use of traditional cultivars that have relatively low yield potential and limited resistance to pests and diseases.

In Andhra Pradesh, pearl millet is cultivated across an area of about 30,000 hectares, underscoring its significance as a resilient crop in semi-arid regions. Within the state, SPSR Nellore accounts for approximately 1,177 hectares under kharif cultivation. Despite the crop's adaptability, both the state and the district continue to face productivity constraints due to dependence on conventional varieties, which limits overall yield as well as resistance to pests and diseases. To address these challenges and enhance nutritional security, the Krishi Vigyan Kendra (KVK), Nellore, introduced the biofortified pearl millet variety ABV-04 through a Front Line Demonstration conducted in the field of farmer B. Raja Reddy in Kampasamudram village of Marripadu mandal. The ABV-04 variety is medium-duration (85-90 days), tall, and erect, and it produces thick, compact panicles with bold, grey, obovate grains. It also demonstrates resistance to downy mildew, smut, and blast diseases, along with good tolerance to drought conditions. In terms of nutritional value, ABV-04 offers clear advantages over commonly cultivated varieties. Conventional pearl millet types typically contain about 45.0-50.0 ppm iron and 30.0-35.0 ppm zinc, whereas ABV-04 is enriched with approximately 70.0 ppm iron and 63.0 ppm zinc, making it a more effective option for mitigating micronutrient deficiencies

The demonstration was conducted on sandy clay loam soil, with sowing carried out during the first fortnight of June at a seed rate of 7.5 kg ha^{-1}. The crop was managed with a recommended fertilizer application of 80:40:30 kg NPK ha^{-1}, supplemented by six irrigations and plant protection measures involving chlorantraniliprole for the management of stem borer. The results indicated that ABV-04 significantly outperformed the local variety across all evaluated growth and yield parameters. ABV-04 recorded a maximum plant height of 216.7 cm, a higher number of productive tillers (3.2), longer panicles (35.3 cm), and a superior test weight of 14.27 g. In terms of productivity, ABV-04 achieved a grain yield of 3,738 kg ha^{-1}, representing an 11.93% increase over the local hybrid yield of 3,214 kg ha^{-1}. Economically, although the cost of cultivation remained comparable between treatments, ABV-04 resulted in higher gross returns (Rs. 93,450 ha^{-1}) and net returns (Rs. 43,238 ha^{-1}). Consequently, it recorded a benefit-cost ratio (BCR) of 1.86, as against 1.58 in the local variety.

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Encouraged by the positive results, farmer B. Raja Reddy expressed satisfaction with the performance of ABV-04 and showed interest in continuing its cultivation in subsequent seasons. His experience also created awareness among neighboring farmers, motivating them to adopt improved pearl millet varieties for better productivity and income. This success story highlights the role of frontline demonstrations conducted by KVKs in bridging the gap between research and farmer's fields. The adoption of ABV-04 has demonstrated that improved varieties, when combined with proper management practices, can significantly enhance yield, profitability, and nutritional security.

The following comparison highlights the significant physiological and economic advantages of adopting the biofortified bajra variety ABV-04 over local varieties.

S.No.	Parameters	T_1: ABV-04	T_2: Local Variety
1.	Plant population/m^2	28.00	28.00
2.	Plant height (cm)	216.7	205.1
3.	No. of producitve tillers/plant	3.2	2.8
4.	Panicle length (cm)	35.3	30.4
5.	Test weight (g)	14.27	11.09
6.	Grain yield (kg/ha)	3,738	3,214
7.	Increase in yield (%)	11.93	-
8.	Cost of cultivation (Rs./ha)	50,213	50,820
09.	Gross returns (Rs./ha)	93,450	80,350
10.	Net returns (Rs./ha)	43,238	29,530
11	BCR	1.86	1.58

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Field Visit to Biofortified Bajra Variety ABV-04 at Kampasamudram Village, Marripadu Mandal

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Optimizing Rice for Climate Change: Advancing Hybrid Breeding for Greenhouse Gas Control

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Abstract

Hybrid rice plays a vital role in global food security but is also associated with significant greenhouse gas (GHG) emissions, particularly methane (CH_4) and nitrous oxide (N_2O). This study highlights the potential of integrating hybrid rice systems with climate-smart agricultural practices to mitigate emissions while sustaining productivity. Improved water management strategies such as alternate wetting and drying (AWD), along with optimized nitrogen fertilization, significantly reduce CH_4 and N_2O emissions. Hybrid rice varieties exhibit lower emission intensity due to higher yield, shorter growth duration, and enhanced resource-use efficiency. Plant traits such as root architecture, aerenchyma formation, and rhizodeposition strongly influence methane dynamics in rice fields. Emerging technologies, including genomic selection, genome editing, and rhizosphere engineering, provide new opportunities to develop low-emission, climate-resilient rice cultivars. Additionally, machine learning tools enable accurate prediction and optimization of GHG emissions across diverse environments.

Key words: Rice, Climate Change, Hybrid Rice, Greenhouse Gas

Introduction:

Rice is a staple food for nearly half of the world's population, making its production crucial for global food security. However, rice cultivation is also one of the major contributors to agricultural greenhouse gas (GHG) emissions, particularly methane (CH_4), due to the anaerobic (oxygen-deficient) conditions created in flooded paddy fields. Under these waterlogged environments, microbial decomposition of organic matter promotes methanogenesis, leading to substantial CH_4 release into the atmosphere. In addition, excessive nitrogen fertilization can enhance nitrous oxide (N_2O) emissions, further increasing the climate footprint of rice farming. In 2025, India emerged as the world's largest rice producer, recording 150.18 million tonnes, overtaking China (145.28 million tonnes). India now contributes nearly 28% of global rice output. However, China remains the biggest consumer (190.94 million tonnes), while India's consumption is lower (140.28 million tonnes).

With global temperature rise and changing rainfall patterns, rice ecosystems are becoming more vulnerable, as warmer conditions can accelerate microbial activity and intensify methane production. Climate change is therefore not only affected by rice cultivation but also threatens rice productivity through heat stress, water scarcity, and unpredictable weather extremes. In this scenario**,** hybrid rice has emerged as a promising strategy due to its higher yield potential and better resource-use efficiency, offering opportunities to produce more grain per unit area and potentially reduce emissions intensity. Therefore, integrating hybrid rice cultivation with climate-smart management practices is crucial for sustaining rice production while mitigating its contribution to global warming..

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GHG emission from rice field : CH_4 and N_2O

Methane (CH_4) is a key greenhouse gas released from rice fields. It is generated in flooded soils through methanogenesis, a microbial process that occurs under oxygen-poor, low redox conditions. This process is driven by methanogenic Archaea, which utilize substrates like acetate, CO_2, H_2, and alcohols derived from decomposing organic matter and root exudates.

Methane is produced through three main biochemical pathways:-

Hydrogenotrophic pathway – CO_2 is reduced with hydrogen to produce CH_4.

Acetoclastic pathway – acetate is split into CO_2 and CH_4 (the major pathway in rice soils).

Methylotrophic pathway – methane is formed from methyl compounds like methanol and methylamines (Conrad, 2007; Conrad *et al*., 2007).

Around 90–95% of methane emissions occur through rice plants, while 5–10% are released through gas bubbles (ebullition) (Aulakh *et al*.,2000; Adviento-Borbe *et al.,* 2015; Komiya *et al*.,2015)..Methane emissions are partially reduced by methanotrophic bacteria, which oxidize CH_4 to CO_2 in oxygen-rich zones near the soil surface and rhizosphere. Methane from rice fields reaches the atmosphere through three main pathways: plant transport into the roots by diffusion of CH4 gas in the aerenchyma and cortex and simultaneous release into the atmosphere via stomata (Davamani *et al.,* 2020), ebullition loss by release of gas bubbles, and transport through rice plants.

N_2O is produced mainly by microbial transformation of nitrogen in soil through the process of nitrification and denitrification.

Nitrification involves two main steps: oxidation of NH_3 to NO_2^- by ammonia-oxidizing bacteria (e.g., Nitrosomonas), followed by oxidation of NO_2^- to NO_3^- by nitrite-oxidizing bacteria (e.g., Nitrobacter) (Norton, 2015).

Denitrification requires three key conditions: low oxygen, availability of organic carbon, and sufficient NO_3^-. It is more active in surface soils due to higher organic matter. A wide range of bacteria, including Azospirillum, Bacillus, Paracoccus, and Rhodopseudomonas, are involved in this process (McLain and Martens, 2006).

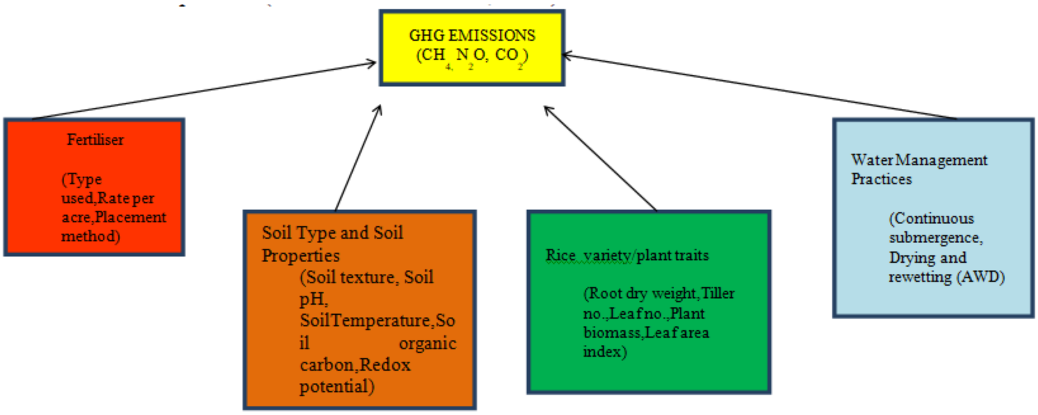

Fig. Factors affecting GHG emissions

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Breeding Strategies for Low-Carbon Hybrid Rice Systems:

- Breeding Focus should be to develop hybrids with: Efficient water & N use, low CH_4 emission traits, ability to perform under stress condition.Efforts to identify genes associated with low CH_4 emissions should focus on traits that enable higher grain production under low soil nitrogen conditions. This includes genes involved in high-affinity nitrogen uptake systems, such as NRT2 (Nitrate Transporter 2) and AMT1 (Ammonium Transporter 1), which facilitate the absorption of nitrate (NO_3^-) and ammonium (NH_4^+), respectively, at low nitrogen levels (<250 mM) (Li and Zhang, 2009; Dechorgnat *et al*., 2019).

- A strategy depends on identifying suitable genotypes that naturally exhibit low methane emission due to reduced root exudation and improved carbon partitioning. In a study, the low-methane genotype Heijing 5 was used as a donor parent because it released less glucose into the rhizosphere. It was crossed with high-yielding genotypes such as Xiushui, Huayu, and Jiahua to combine low methane emission with high yield potential.At the gene level, breeding can target sugar transporter genes such as SUT-C and SWEET, which regulate the movement of carbohydrates from leaves to stems and grains. Higher expression of these genes promotes carbon allocation to grain rather than roots, reducing glucose exudation into flooded soils. As a result, methanogenic microbes receive less substrate for methane production.(Hu *et al*., 2024).

- A promising breeding strategy for climate-resilient rice is the selection of genotypes with high radial oxygen loss (ROL), as this trait suppresses methanogen activity and reduces methane formation under high nitrogen fertilizer conditions. The Candidate genes within qtl qROL-2-1, including OsTCP7, OsMYB21, OsARF8, OsTRX, OsWBC8, and OsLRR2 are proposed to positively regulate root oxygen release, while genes such as OsDEF7, OsEXPA, OsNIP2, Oscb5, and OsPLIM2a may regulate oxygen flux in roots. Therefore, pyramiding favorable alleles for these QTLs and genes could help develop rice hybrids with stronger root aeration, improved stress tolerance, and lower methane emissions.(Duyen *et al*..2022)

- Recent studies suggest that rice can maintain high grain yields under water stress if key biochemical traits are sustained, such as increased carbohydrate accumulation in leaves, stable stomatal conductance and photosynthesis, and effective canopy temperature regulation (Fukuda *et al*., 2018; Barnaby *et al*., 2019; McClung *et al.,* 2019).

Mitigating strategies for low emission of GHG_s :

1. **Wide-scale adoption of improved low-ghg-emitting rice hybrids:** According to the IRRI's hybrid rice program, the estimated area under hybrid rice cultivation by 2030 will be approximately 23.63 m/ha.Hybrid rice varieties are more productive per unit time than inbred types, require shorter field duration, and use less irrigation, making them more efficient in reducing greenhouse gas emissions from rice fields. It is important to recognize that some hybrid rice varieties emit less CH_4, and identifying these is crucial. (Smartt *et al*. 2018) showed that hybrids such as CLXL729, XL753, and CLXL745 produced significantly lower CH_4 emissions compared to the inbred variety RoyJoy. Hybrid varieties have greater root porosity than inbred cultivars and can therefore transport more O2 into the soil for methanotrophs, promoting greater CH4 oxidation.

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2. **Carbon sequestration capacity of hybrid rice:** Hybrid rice, due to its superior yield, enhances CO_2 fixation by increasing photosynthesis and biomass production, thereby improving carbon sequestration in rice paddies.

3. **Applying machine learning to design low-carbon hybrid rice practices**.: Machine learning (ML) and deep learning (DL) can model complex relationships between variables, offering fast computation and high predictive accuracy (Kamir *et al*., 2020; Khatibi and Ali, 2024). ML has already been applied to estimate soil GHG emissions, such as identifying moisture and soil N as key drivers of N_2O emissions and improving predictions of CO_2, N_2O, and CH_4 fluxes. However, major opportunities remain for applying ML/DL to rice paddies, where AI can integrate multi-source datasets across large spatial and temporal scales. These tools can support prediction of best management practices, improve decision-making, and decode rice microbiome–GHG interactions using high-throughput sequencing data, ultimately aiding optimization of management systems and genomic selection for reducing CH_4 and N_2O emissions.

4. **Hybrid Rice Productivity Enhancement under Variable Nitrogen Regimes Using APSIM model:** The APSIM model supports precision nitrogen management by simulating crop growth under varying nitrogen levels to determine the optimal fertilizer dose for maximum yield, especially in hybrid rice. It helps in deciding the correct timing of nitrogen application by aligning nutrient supply with critical growth stages, while also integrating soil, weather, and crop parameters to provide location-specific recommendations. The model predicts grain yield and biomass response to different nitrogen regimes, thereby improving nitrogen use efficiency and reducing losses such as leaching and volatilization. Additionally, APSIM enables scenario analysis under changing climatic conditions like elevated CO_2, helping to estimate future nitrogen requirements.

5. **Genome editing approaches to modify genes regulating reduced GHG emissions:** Large-scale phenotyping, QTL mapping, and association mapping can help identify genomic regions and allelic variation linked to low CH_4 emissions in rice. Genome editing, particularly CRISPR-Cas9, offers a rapid and precise approach to modify key genes influencing GHG emissions in rice and its microbiome. Key targets include enhancing photosynthesis for higher CO_2 uptake, developing deeper root systems for long-term carbon storage, and improving soil microbial processes to increase carbon retention and reduce CH_4 and N_2O emissions.

6. **Rhizosphere engineering approaches to minimize GHG emissions from rice paddies**: It involves manipulating plant–microbe interactions in the root zone (Khatibi *et al.,* 2024), key strategies include improving carbon allocation toward grains, modifying root exudate composition to limit methanogen activity, increasing methanotroph populations, and altering root architecture to enhance oxygen transport. Evidence shows that redirecting photosynthates toward seeds and reducing glucose in root exudates can significantly lower CH_4 emissions while improving yield. Breeding hybrid rice with optimized carbon partitioning, controlled exudates, reduced aerenchyma formation, and enhanced methanotroph stimulation could collectively mitigate CH_4 release. However, outcomes are influenced by complex plant–microbe interactions and environmental factors such as soil, water management, and climate.

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Conclusion

Rice-based agroecosystems represent a major anthropogenic source of CH_4 and N_2O due to the dominance of anaerobic decomposition under flooded conditions and nitrogen transformations during intermittent aerobic phases. With projected climate warming, these biogeochemical processes are expected to intensify, leading to increased GHG fluxes and potential yield penalties. The magnitude of emissions is governed by complex interactions among soil redox dynamics, carbon availability, nitrogen cycling, microbial community structure, and genotype-specific plant traits such as rhizodeposition, aerenchyma development, and root-mediated oxygen transport.

Mitigation of rice-field emissions therefore requires a systems-level strategy integrating genotype improvement with precision agronomic interventions. Hybrid rice provides a strong mitigation platform due to its high biomass productivity, shorter crop duration, improved water-use efficiency, and enhanced capacity for carbon sequestration. Breeding programs should prioritize the development of short-duration, high-yielding hybrids with reduced carbon exudation, improved methane oxidation potential, enhanced nitrogen-use efficiency, and tolerance to abiotic stresses such as heat and drought. Advanced molecular breeding approaches, including genomic selection, GWAS-assisted gene discovery, and high-throughput phenotyping, will accelerate the identification and deployment of low-emission traits.

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Pests and Diseases of Silkworm: A Hidden Challenge in Sericulture

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Silkworms: Guardians of Silk and Their Hidden Battles

Silkworms (*Bombyx mori*), the humble architects of shimmering silk threads, have been nurtured by humans for over 5,000 years. Sericulture the art and science of rearing silkworms has shaped cultures, economies and traditions across Asia and beyond. From the legendary Silk Road to modern textile industries, silk has symbolized elegance, prosperity and innovation. Yet, behind this beauty lies a fragile biological system constantly threatened by diseases and pests. For farmers, these challenges are not just scientific hurdles but economic risks that can devastate livelihoods. Understanding the pathogens and predators of silkworms is therefore essential to sustaining sericulture as both a cultural heritage and a modern industry.

Major Diseases of Silkworms

Silkworms are vulnerable to multiple pathogens are protozoa, viruses, bacteria and fungi. The four most notorious diseases are:

Pebrine (Protozoan Disease)

Causative organism: *Nosema bombycis* (a microsporidian protozoan).

- **Symptoms:** Black spots on the body, sluggish growth, poor appetite, irregular molting and weak cocoon formation. Infected eggs transmit the disease to the next generation, making it highly destructive.
- **Impact:** Known as the "scourge of sericulture," Pebrine can wipe out entire crops if not detected early through microscopic egg examination.

Grasserie (Viral Disease)

- **Causative organism:** *Nuclear Polyhedrosis Virus*
- (NPV).
- **Symptoms:** Worms appear swollen, shiny and fragile,

as if filled with liquid. Their skin becomes transparent and they burst easily when handled.

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- **Impact:** Leads to heavy crop losses, especially in warm and humid conditions that favor viral multiplication.

Flacherie (Bacterial Disease)

- **Causative organisms:** Multiple bacteria including *Streptococcus*, *Staphylococcus* and *Bacillus* species.
- **Symptoms:** Worms become soft, emit a foul odor, lose appetite and die prematurely. Often triggered by poor hygiene, contaminated mulberry leaves or stressful rearing conditions.
- **Impact:** Causes sudden mortality in large numbers, particularly during late instar stages.

Muscardine (Fungal Disease)

- **Causative organism:** *Beauveria bassiana* (white muscardine), though other fungi like *Isaria fumosorosea* can also cause similar infections.
- **Symptoms:** Infected worms turn stiff and chalky-white, resembling mummified bodies. The fungal spores spread rapidly in humid environments.
- **Impact:** Outbreaks are common during rainy seasons, making environmental control critical.

Common Pests of Silkworms

Beyond diseases, silkworms face attacks from external pests:

- *Uzi Fly (Exorista bombycis*)
  - A parasitic fly that lays eggs on silkworms.
  - Larvae penetrate the worm's body, feeding internally until the host dies.
  - One of the most serious pests in sericulture.

- **Ants and Wasps**
  - Opportunistic predators that invade rearing houses, feeding on worms and cocoons.
  - Their presence indicates poor biosecurity.

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- **Rodents**
  - Damage cocoons and feed on silkworms.
  - Cause significant economic losses if rearing houses are not rodent-proof.

Impact on Sericulture

- Diseases and pests together can cause 15–45% crop losses, depending on season, hygiene, and breed.
- **Bivoltine breeds** (producing silk twice a year) are more vulnerable compared to **multivoltine breeds** (producing silk multiple times annually).

Management and Prevention

- **Hygiene:** Regular disinfection of rearing houses, trays, and equipment.
- **Resistant Breeds:** Adoption of silkworm varieties with genetic resistance to Pebrine and other diseases.
- **Monitoring:** Early detection through microscopic egg examination and removal of infected worms.
- **Biological Control:** Use of parasitoids like *Nesolynx thymus* to manage Uzi fly populations.
- **Environmental Control:** Maintaining optimal temperature (24–28°C) and humidity (70–80%) to reduce fungal outbreaks.
- **Integrated Pest Management (IPM):** Combining cultural, biological and chemical methods for sustainable control.

Conclusion

Silkworms may be delicate creatures but they are the backbone of the silk industry a sector that sustains millions of rural families and preserves centuries-old traditions. Protecting them from pathogens and pests is not merely a technical challenge; it is a cultural and economic necessity. By combining scientific innovation, farmer awareness and sustainable practices, sericulture can overcome these biological threats. In doing so, it will continue to weave threads of tradition, resilience and prosperity ensuring that silk remains not just a fabric of luxury, but a symbol of human ingenuity and rural empowerment for generations to come.

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Sustainable Agriculture Practices For A Greener Tomorrow

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Abstract:

Sustainable agriculture is an environmentally sound and economically viable approach to farming that aims to meet the growing food demands of the present generation without compromising the needs of future generations. It emphasizes the efficient use of natural resources, conservation of soil and water, protection of biodiversity and reduction of chemical inputs. Sustainable agriculture also supports farmer livelihoods, improves food security and contributes to climate change mitigation. By promoting eco-friendly technologies and responsible farming methods, sustainable agriculture paves the way for a greener, healthier, and more resilient agricultural system.

Introduction:

Modern intensive farming practices have led to serious environmental problems such as soil degradation, water scarcity, loss of biodiversity and climate change. Sustainable agriculture practices have emerged as an essential approach to ensure long-term agricultural productivity while protecting natural resources. It mainly focuses on environmentally friendly farming methods that conserve soil and water, reduce dependence on chemical inputs and promote ecological balance. By integrating traditional knowledge with modern scientific techniques, sustainable agriculture practices aim to achieve food security, economic stability for farmers, and a greener, healthier future for coming generations.

Organic Farming:

- Uses natural fertilizers like compost and green manure
- Avoids synthetic pesticides and chemical fertilizers
- Improves soil fertility and protects biodiversity Crop Rotation and

Diversification:

- Growing different crops in sequence
- Prevents soil nutrient depletion
- Reduces pest and disease outbreaks Soil Conservation

Techniques:

- Practices like mulching, contour farming, and cover cropping
- Prevent soil erosion and improve soil structure
- Maintain long-term soil health

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Efficient Water Management:

- Drip irrigation and rainwater harvesting
- Reduces water wastage
- Ensures sustainable use of water resources Integrated pest

Management:

- Combines biological, cultural, and mechanical pest control methods
- Minimizes chemical pesticide use
- Protects beneficial insects and ecosystems Agroforestry:
- Integration of trees with crops and livestock
- Enhances biodiversity
- Improves carbon sequestration and soil quality Use of Renewable Energy:
- Solar pumps, biogas, and wind energy on farms
- Reduces dependence on fossil fuels
- Lowers greenhouse gas emissions Benefits of

Sustainable Agriculture:

- Conserves natural resources
- Protects the environment and biodiversity
- Improves farmer income and food security
- Reduces climate change impacts
- Ensures healthy and nutritious food

Key Outcomes of Sustainable Agriculture for Tomorrow Healthy Soil for the Future Sustainable practices like crop rotation, organic manure and mulching improve soil fertility and prevent soil erosion, ensuring long-term productivity.

Conservation of Water Resources

Efficient irrigation methods such as drip irrigation and rainwater harvesting reduce water wastage and help preserve water for future use.

Environmental Protection

Reduced use of chemical fertilizers and pesticides lowers pollution and protects biodiversity, leading to a cleaner and safer environment.

Climate Change Mitigation

Practices like agroforestry and organic farming reduce greenhouse gas emissions and increase carbon sequestration.

Food Security and Nutrition

Sustainable farming ensures continuous food production and provides healthier, nutritious food for future generations.

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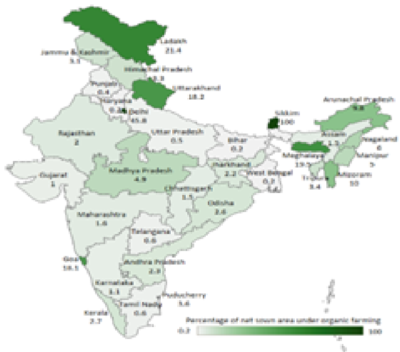
Economic Stability for Farmers

Lower input costs and better yields improve farmers' income and ensure sustainable livelihoods. Enabavi Village — Organic Farming Leader, Enabavi, a village in Hanamkonda district, It became Telangana's first chemical free village first chemical free village. Farmers stopped chemical inputs and shifted to regenerative, organic agriculture using compost, natural pest control, and water harvesting. The entire village now grows crops like paddy and vegetables without chemical fertilisers or pesticides, improving soil health and yield.



- Biochar adoption areas (e.g., Kothapally)
- Organic farming clusters in various districts
- Agroforestry around Hyderabad and nearby regions
- Natural and eco-friendly farms like in Antharam

Sustainable agriculture is partially practiced Adoption is slow but steadily increasing. It uses advanced technologies such as GPS, sensors, drones, and data analytics to manage crops and soil more accurately. It helps farmers apply water, fertilizers, and pesticides only where and when they are needed.

Role of Precision Agriculture in Sustainable Farming

- **Efficient Use of Resources** : Precision agriculture helps farmers use water, fertilizers, and pesticides only where they are needed. This reduces resource wastage and lowers production costs.
- **Improved Crop Productivity :** By monitoring soil fertility and crop health, farmers can take timely actions that improve crop growth and yield.
- **Environmental Protection :** Reduced use of chemicals prevents soil degradation and water pollution, helping to maintain ecological balance.
- **Soil Health Management :** Precision farming helps identify nutrient deficiencies and soil conditions, allowing farmers to maintain soil fertility over the long term.

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- **Climate Change Adaptation :** Precision technologies help farmers adjust irrigation, planting, and harvesting times according to weather conditions, reducing risks from climate change.

Conclusion:

Sustainable agriculture is essential for a greener tomorrow. By adopting eco-friendly farming practices, we can protect the environment, support farmers, and ensure long-term food security for future generations.

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