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A Resonance in Agriculture

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AGRIVOLTAIC FARMING

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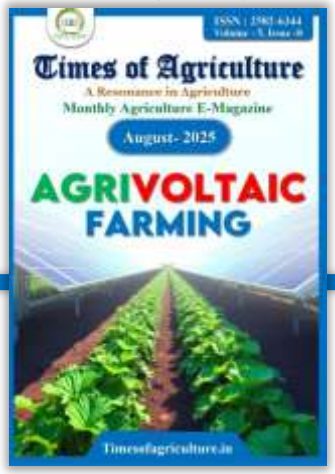

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From the Editor's Desk

Dear Readers of Times of Agriculture Magazine,

Necessity is the mother of invention. Indeed, the highly advanced system of farming known as Agri-Voltaics is the central theme of this issue of the **Times of Agriculture Magazine**, which is filled with valuable information for all of you.

As we all know, India has now become the most populous country in the world. At the same time, agricultural land is steadily shrinking, and natural resources are not being utilized efficiently. In such a situation, Agri-Voltaic technology can prove to be a boon for both farming and farmers. Through this technology, farmers can install solar panels in their fields to generate electricity while simultaneously cultivating crops beneath them—reaping double benefits. This method not only protects crops from excessive heat but also reduces the need for irrigation.

Crops such as leafy vegetables, turmeric, ginger, chilies, eggplant, and tomatoes can be successfully grown using this system. In this way, rural areas can increase their earnings by producing electricity along with agricultural produce. In fact, this technology has the potential to shape the future of farming.

Therefore, let us read this issue of the Times of Agriculture Magazine carefully, understand this new agricultural technology, and share the knowledge with our farmers.

Thank you, Enjoy Reading....

Editor-In-Chief

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CONTENT

Times of Agriculture
A Resonance in Agriculture

AGRICULTURE UPDATES

Cabinet Approves ₹6,520 Crore Outlay to Boost PMKSY, Food Irradiation Units and Testing Labs

The Union Cabinet chaired by Prime Minister Shri Narendra Modi has approved a total outlay of Rs. 6,520 crore, including an additional Rs. 1,920 crore, for the Central Sector Scheme **"Pradhan Mantri Kisan Sampada Yojana" (PMKSY)** during the 15th Finance Commission Cycle (2021-22 to 2025-26). The approval includes Rs. 1,000 crore for the establishment of 50 multi-product food **irradiation units** under the Integrated Cold Chain and Value Addition Infrastructure (ICCVAI) and 100 NABL-accredited **food testing laboratories** under the Food Safety and Quality Assurance Infrastructure (FSQAI). Additionally, Rs. 920 crore has been allocated for sanctioning projects under various PMKSY components.

Both ICCVAI and FSQAI are demand-driven schemes, and Expressions of Interest will be floated to invite proposals from eligible entities across the country. The 50 proposed irradiation units are expected to create preservation capacity of 20 to 30 lakh metric tonnes annually, depending on the food products being irradiated. The planned 100 food testing labs will enhance India's food safety ecosystem, improve **export quality** certification, and reassure consumers about the availability of safe, hygienic, and high-quality food products. By creating modernized infrastructure, the scheme is also expected to generate direct and indirect **employment** opportunities, particularly in rural and semi-urban areas.

The government's decision is aimed at boosting India's agri-food value chain by expanding processing infrastructure, reducing post-harvest losses, and securing better returns for farmers. The expansion of PMKSY will further strengthen farmer-producer organizations and agri-entrepreneurs, enabling them to add value to raw produce. With the twin push on processing and cooperative empowerment, the enhanced allocation is expected to enhance efficiency, increase farmers' incomes, and improve the global competitiveness of India's agricultural sector, aligning with the vision of doubling farmers' income and promoting sustainable agriculture.

ICRISAT and ICAR Discover Resistance Gene to Protect Pigeonpea from Sterility Mosaic Disease

In a scientific breakthrough that could transform **pulse production** in South Asia, researchers at the **International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)** and the **Indian Council of Agricultural Research (ICAR)** have identified a resistance gene that can shield pigeonpea farmers from devastating yield losses caused by **Sterility Mosaic Disease (SMD)**. The gene, named **Ccsmd04**, is linked to high-level resistance and offers a lifeline for one of India's most economically and nutritionally important crops. SMD, spread by microscopic mites, can wipe out up to 90% of pigeonpea harvests, endangering farmer livelihoods and food security.

The research team, led by **Dr Manish K. Pandey** at ICRISAT in collaboration with the Indian Institute of Pulses Research (IIPR), Rajendra Prasad Central Agricultural University (RPCAU), and the Indian Agricultural Research Institute (IARI), combined advanced **genomics, phenomics, and bioinformatics** to pinpoint the resistance gene. By analyzing contrasting pigeonpea varieties—'Asha' (SMD-resistant) and 'Maruti' (susceptible)—they discovered that in susceptible plants, four frameshift mutations disrupt the dormancy/auxin-associated protein encoded by Ccsmd04. The study also validated four **InDel markers** that enable breeders to conduct early-generation selection, making it possible to develop resistant varieties much faster than before.

Experts say the discovery provides breeders with a **high-confidence genetic target** for breeding, gene editing, and even integrating resistance from wild relatives. With India aiming for self-sufficiency in pulses, this breakthrough could reduce pesticide use, stabilize farmer incomes, and safeguard protein security. "Disease resistance isn't just a plant trait—it's a safeguard for livelihoods and the environment," said **Dr Stanford Blade**, Deputy Director General – Research & Innovation, ICRISAT.

CM Naidu Launches Annadata Sukhibhava-PM Kisan Scheme, ₹3,175 Crore Disbursed to Farmers

Andhra Pradesh Chief Minister **Nara Chandrababu Naidu** launched the **Annadata Sukhibhava-PM Kisan scheme** at East Veerayapalem in Prakasam district, marking a historic step to empower farmers. A total of ₹3,175 crore has been disbursed to 46.85 lakh farmers, with each farmer receiving ₹7,000 in the first phase. Of this, ₹5,000 was contributed by the State government (₹2,343 crore) and ₹2,000 by the Centre (₹832 crore), as part of an annual support package of ₹20,000 per farmer. The scheme aims to address immediate financial needs in the agricultural sector while strengthening rural livelihoods.

Officials highlighted that **SMS alerts** will be sent to beneficiaries one day before fund transfers to ensure transparency and prevent lapses. The launch is being celebrated across every **village secretariat, gram panchayat, and mandal headquarters**, with the Chief Minister declaring that the initiative should be observed "like a festival" across Andhra Pradesh. Naidu emphasized that no eligible farmer should be left behind due to paperwork delays or technical hurdles. The grant combines both the State's contribution and the Centre's **PM-Kisan** support, ensuring seamless delivery of aid to cultivators. Strict eligibility norms, such as mandatory eKYC and **bank-Aadhaar linkage**, have been implemented to guarantee fair inclusion.

To further strengthen delivery, a toll-free **helpline (155251)** and updated digital platforms, including WhatsApp and the Manamitra app, have been activated for farmer queries and grievance redressal. **Rythu Seva Kendras** are assisting farmers with eKYC completion and Aadhaar-bank linking to avoid disruptions in benefit transfers. The scheme is expected to significantly ease farmers' financial burdens, improve rural purchasing power, and set the foundation for sustainable agricultural growth in Andhra Pradesh.

Blueprint of Agricultural Revolution 4.0

The Government of India has adopted **Artificial Intelligence (AI)** and **IoT-enabled systems** to enhance crop productivity, improve sustainability, and strengthen farmer livelihoods by addressing long-standing challenges in the agriculture sector. Several initiatives are being implemented under the **Digital Agriculture Mission** and related schemes to provide technology-driven solutions to farmers. A notable example is **'Kisan e-Mitra'**, a voice-based AI chatbot that assists farmers with their queries related to the PM-Kisan Samman Nidhi scheme. Supporting 11 regional languages, the chatbot currently handles more than 20,000 farmer queries daily and has already resolved over 95 lakh queries.

To tackle the growing threat of climate change-induced crop losses, the **National Pest Surveillance System** uses AI and Machine Learning to detect pest infestations and enable timely interventions. Over 10,000 extension workers are using the tool, which allows farmers to capture pest images for identification and mitigation. The system currently supports 61 crops and over 400 pest combinations. In addition, AI/ML-based analytics are being deployed for **crop health assessment** and pest identification through field photographs, while advanced tools monitor rice and wheat crops using **satellite imagery**, soil moisture data, and weather patterns. These innovations are enabling more precise and proactive farm management.

Under the **National e-Governance Plan in Agriculture (NeGPA)**, states and Union Territories are being funded to adopt digital agriculture projects that leverage AI, ML, and IoT. By integrating these emerging technologies, the government aims to provide actionable insights, reduce crop losses, and improve farmer resilience. Such technology-driven interventions are expected to transform Indian agriculture into a more **climate-resilient, data-driven, and sustainable sector**, empowering farmers with real-time advisories and access to critical information for decision-making.

Union Agriculture Minister to Distribute ₹3,200 Crore Crop Insurance Claims to 30 Lakh Farmers

Union Agriculture Minister **Shivraj Singh Chouhan** will distribute crop insurance claims worth over ₹3,200 crore to more than 30 lakh farmers during a mega event in **Jhunjhunu, Rajasthan**. According to the Ministry of Agriculture and Farmers' Welfare, the payments will be directly transferred to the bank accounts of beneficiaries through **Direct Benefit Transfer (DBT)**. Of the total settlement, ₹1,156 crore will go to farmers in **Madhya Pradesh**, ₹1,121 crore to 7 lakh farmers in Rajasthan, ₹150 crore to cultivators in Chhattisgarh, and ₹773 crore to farmers in other states, reflecting the government's commitment to providing timely financial relief.

The Union Minister emphasized that the Centre has introduced a **simplified claim settlement system** under which farmers will receive proportional payouts based solely on the central subsidy share, without waiting for state premium contributions. This innovation is designed to accelerate the release of insurance benefits and reduce delays in fund transfers. The programme in Jhunjhunu is expected to witness large farmer participation from Sikar, Jaipur, Kotputli-Behror, and surrounding districts, while lakhs of cultivators across the country will connect virtually to witness the disbursal process.

Since its launch in 2016, the **Pradhan Mantri Fasal Bima Yojana (PMFBY)** has covered more than 78 crore farmer applications and disbursed claims worth ₹1.83 lakh crore against a total farmer-paid premium of ₹35,864 crore. Officials noted that the scheme has not only safeguarded farmers against climate risks and crop losses but also ensured stability in rural incomes. By combining technology-enabled claim settlement with transparent DBT transfers, the government aims to strengthen trust in the crop insurance system and provide a robust safety net for the nation's farming community.

IRRI releases four rice varieties in the Democratic Republic of Congo

The **International Rice Research Institute (IRRI)** has released four new rice varieties in the **Democratic Republic of Congo (DRC)** under the **Great Lakes Accelerated Innovation Delivery Initiative Rapid Delivery Hub (AID-I GLR)**, also known as the **Kugwiza Project**. Developed in partnership with the **International Institute for Tropical Agriculture (IITA)**, CGIAR Centers, and local stakeholders, these varieties are tailored to the ecologies of DRC, Burundi, and Rwanda. The initiative aims to benefit 1.2 million households by promoting adoption of high-yielding, climate-resilient rice varieties that can strengthen food and nutrition security across the Great Lakes region.

The newly launched rice varieties include **Tengetenge (IR 143725-52 RGA)**, **Kirera Bana (IR 16M1142)**, **Mubusi (IR 19A1137)**, and **Rutete (IR 107015-18-3-1-B)**. These were developed at IRRI's Headquarters in the Philippines and the Regional Crop Improvement Hub at the University of Burundi. Adding to 56 improved rice varieties already released in sub-Saharan Africa since 2011, these new varieties are designed to deliver higher yields, greater **disease resistance**, and improved milling recovery. They are also well-suited to irrigated lowland ecologies, where traditional rice varieties often fail to meet production and market demands.

Experts emphasized that the lack of improved varieties has been a major constraint in DRC's rice sector. Farmers typically rely on traditional varieties with low yield and poor quality. The new IRRI releases not only promise better productivity but also meet **consumer preferences** for non-sticky texture, good cooking quality, and appealing grain color. With higher market value and profitability, these varieties are expected to raise farmer incomes while contributing significantly to the country's food security and resilience. By integrating local needs with scientific innovation, IRRI and its partners aim to accelerate the transformation of the rice value chain in Central Africa.

Rajasthan Conducts India's First Drone-Based Artificial Rain Trial at Ramgarh Dam

In a landmark experiment, **Rajasthan** has initiated India's first **drone-based artificial rain trial** at **Ramgarh Dam**, shifting from traditional aeroplane-assisted cloud seeding to the use of unmanned aerial vehicles. Around 60 drones are being deployed in the project, which is a joint effort by the **state agriculture department** and **GenX AI**, a technology firm based in the US and Bengaluru. The initiative, inaugurated by Agriculture Minister **Kirodi Lal Meena**, aims to enhance rainfall through advanced cloud seeding methods and has secured approvals from the **DGCA**, the India Meteorological Department, district authorities, and the state agriculture department.

Originally scheduled for July 31, the trial was postponed due to heavy rain aler ts. Since then, multiple drone readiness tests have been carried out in **Jaipur** to ensure operational safety and efficiency. The launch event at Ramgarh Dam has been opened for public viewing, marking a significant step in blending technology with agriculture and water management. Unlike conventional aircraft, **drones** can fly at higher altitudes with greater flexibility and precision, allowing for targeted cloud seeding operations. The deployment of 60 drones is expected to make the process more cost-effective while increasing coverage and efficiency in rain enhancement efforts.

According to studies, **cloud seeding** has the potential to increase precipitation by 5 to 20 percent under favourable conditions. However, experts note that its success relies heavily on the presence of suitable clouds and weather patterns. International examples, such as a project in **Idaho, USA**, have shown that silver iodide can boost snowfall from super-cooled clouds. While the results are promising, scientists caution that cloud seeding is not a guaranteed solution for drought or water scarcity. Rajasthan's drone-based trial, however, represents a bold technological advancement and could pave the way for future large-scale rainmaking projects in India.

ICRISAT Launches AI-Powered Initiative for Climate-Resilient Agriculture

The International Crops Research Institute for the Semi-Arid Tropics (**ICRISAT**) has joined forces with leading national and international institutions to launch a pioneering initiative that leverages **artificial intelligence (AI)** and **machine learning (ML)** for climate-resilient farming. The initiative, titled *'AI-powered Context-Specific Agromet Advisory Services for Climate-Resilient Agriculture at Scale'*, is supported under the Government of India's **Monsoon Mission III**. It aims to deliver hyper-local, real-time climate advisory services, enabling smallholder farmers to make informed decisions and adapt effectively to increasing climate variability.

Launched during an inception workshop held on 29–30 July 2025 at Hyderabad, the project brings together a strong consortium of partners. These include ICRISAT, the Indian Council of Agricultural Research (ICAR) – Central Research Institute for Dryland Agriculture (CRIDA), and the International Livestock Research Institute (ILRI). Key technical support is being provided by the Indian Institute of Tropical Meteorology (IITM), India Meteorological Department (IMD), the Center of Excellence in AI for Agriculture (IIT Ropar), CSIR–Central Scientific Instruments Organisation (CSIO), and the Indian Institute of Science (IISc). By combining expertise in climate science, AI technology, and agricultural systems, the initiative will ensure context-specific, actionable advisories reach farmers at scale.

The project is expected to **revolutionize agri-advisory services** by providing personalized recommendations on crop planning, sowing windows, irrigation scheduling, and risk management. By integrating advanced climate models with AI-powered analytics, farmers will gain access to hyper-local forecasts tailored to their fields, helping reduce crop losses, optimize resource use, and enhance resilience. The long-term vision is to empower millions of smallholder farmers, ensuring sustainable agricultural productivity while safeguarding livelihoods against the mounting challenges of climate change.

COVER STORY

AGRIVOLTAIC FARMING

Innovating Land for Inclusive Growth

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Agrivoltaic systems (AV) are those systems that are able to facilitate both farming and renewable energy by establishing photovoltaic panels on the crop land, or involve the installation of solar panels (2-3 meters) above regions that are used for crop cultivation. For growing crops under the solar panels, it is important to adjust the panel spacing and placement angles. Concerning agriculture, the cultivation of crops with the simultaneous use of solar energy helps to generate extra revenue that again contributes to the stability of farming households. In today's world, a rising global population of 8 billion causes immense pressure on the energy, water, and food supply systems, which currently rely only on the burning of fossil fuels, as a result produces extreme levels of greenhouse gases. The deliberate release of these GHGs deteriorates human health and adds to severe climate change (ultimately reducing crop production). To cope with this, agrivoltaics is a successful strategy that prevents the current environmental problem of enhanced carbon emissions from electricity generation. APV aims for an eco-friendly energy production, to make a sustainable and environmentally conscious agricultural system.

Global scenario

The increase in resource intake has accelerated due to the increased global population, necessitating the need to develop a new kind of agricultural system. On a wider scale, many countries like France, the USA, Japan, China, Germany, and South Korea are expanding the scale of AV systems because these systems can produce food and energy more efficiently, in contrast to the open system of crop cultivation. According to a study conducted on Broccoli in South Korea (as shown by the above image), the crop grown under the solar panels was similar in taste and of good quality, with a deeper green shade as compared to an open field-grown crop. A similar project in Kenya showcases the fixing of solar panels some meters above the ground with gaps between them. These panels provide shade to the vegetables underneath, thereby protecting them from the heat stress and water loss. France, too, on the other side, established more than 5000 solar panels over a farm in the Amance town that is capable of producing 2.5 megawatts of power. Despite this much evidence, the adoption rate of this technology is currently limited due to its high initial investment. Nevertheless, with government intervention and financial support, Avs can be greatly accepted worldwide.

India's Potential in Photovoltaics

An agroforestry system (the early version of agri-voltaics) consisted of intercropping between crops and trees. The urge for more food and energy production has already divided the land and has been used as a solution to the problem of competition for land resources. Now, following the idea of this agroforestry, *a new concept of agrivoltaics/agroPV / agro photovoltaics/solar sharing/ PV agriculture* has been invented in the 1980s to overcome the issues of increased competition between food and energy production.

India has approximately 83.4% and 81.33% of the total landmass, which is suitable for generating solar and wind-based energy, respectively. Amongst these, harnessing wind power is a difficult task due to issues like the requirement of open and large space, the nature of the topography, and annual wind intensity. On the other hand, solar panels are ideal for power generation from rooftops, farmlands, and even from roadsides and other places. With 300 days of clear solar energy potential in India, the calculated solar energy incidence on the land area is five quadrillion kilowatt-hours per hour. India has already developed 2,200 AV systems with a generation capacity of 2.8 GW in the year 2020. The solar energy sector is an important contributor to the grid-connected power generation that has benefited many Indian villages over the years. As per the National Institute of Solar Energy (NISE) data, India has a solar potential of about 748 GW, which holds a vital position in the National Action Plan on Climate Change, along with the National Solar Mission (NSM) as one of the key objectives. Moreover, the promotion of solar power in the country has also been done by the various government schemes like the solar park scheme, the Defence scheme, Grid Grid-connected solar rooftop scheme, the Viability gap funding, and CPSU.

Agrivoltaic: Concept and Working

Agrivoltaics, or agro-photovoltaics, makes use of the concept of cultivating crops beneath the photovoltaic panels (PV) that are mounted several meters above the ground (in the air). This system is more resilient to climate change as the installed PV panels protect the crops from scorching heat and also regulates the temperature of the soil. The application of solar technology with agriculture started in 1975 with the introduction of the first photovoltaic water pumps. Agro PV systems, though, devised in the 1980s, have now evolved into three general types. The first type makes use of the space between the crop rows to set up the solar panel *(Interspersed PV arrays*), while in the remaining two, the PV modules are installed at some height above the crops either by removing a small part of the greenhouse cover with panels. These panels can further be classified as static panels (set up in a fixed way) or dynamic panels (set up in a dynamic way), depending on their way of installation and inclination for managing the crops.

These solar panels help in the generation of electricity by harnessing sunlight, and the space below is utilized for cultivating crops and raising livestock at the same time. They also allow the sunlight and rain to reach the crops raised beneath, and also make it easy for the farmers to use their implements for intercultural operations

Potential of Agrivoltaics

Increased land productivity

Protected from Extreme weather

Energy can used to run pumps

Farms are pollinator-friendly

300 clear sunny days

2,200 Agrivoltaic Systems installed

748 GW solar potential

Open Field

Food Only

Agrivoltaics

Food + Energy

Potential Benefits of Agrivoltaics

1. Increased land productivity (land use efficiency gets enhanced by the combination of both agriculture and solar energy production.
2. The land maintenance cost will be low due to these agricultural activities beneath the panels.
3. The crop is protected from weather hazards like hailstorms, dust erosion, and deposits on the panels.
4. Harnessing solar power along with crop production.
5. In rural areas, agrivoltaics are used to run pumps to extract water from the tubewells. The obtained water supports the crop growth even in dry regions by enabling a more efficient irrigation system.
6. Agrivoltaics farms are also considered pollinator-friendly, as the region beneath the solar panels region, promotes biodiversity and more sustainable ecosystem for the cross-pollinated crops.

Opportunities of Agrivoltaics in India

To fulfill several objectives, like employment and food security, there is a crucial need to develop creative strategies and to adhere to the rules of the Paris Agreement at the same time. Hence, PV systems are a potential addition to India's energy portfolio and play a vital role in energy transformation. As a consequence, the Agri-voltaic sector possesses considerable capabilities and a vast scope, particularly in light of the need for energy transition and socioeconomic transformation. As of right now, India has 22 operational and 3 upcoming projects underway in various states. Below are some of the solar-powered agriculture-related active projects of India.

Major Agrivoltaic Projects in India

Project Name	Energy Capacity
CAZRI plants in Jodhpur, Rajasthan	105 kW
Junagadh Agriculture University Plant, Gujarat	7.2 kW
NISE Plant near Gurgaon, Haryana	100 kW
GIPCL Plant Vastan, Gujarat	1MW
Dayalbagh project Agra, Uttar Pradesh	200 kW
Solar-Agri electric model Ahmedabad, Gujarat	3000 kW

Government Initiatives for Agrivoltaics

There is a need to install solar systems all around the nation to boost the amount of electricity produced via solar energy and to achieve sufficient food security. For the Global Hunger Index (GHI), India comes under the category of "serious level of hunger" with a composite rank of 105 out of 127 nations. This necessitates the nation to utilize its great potential in agro-voltaic systems. The Indian government has already executed several interventions like **Jawaharlal Nehru National Solar Mission (JNNSM)** in 2010, the **PM KUSUM (Pradhan Mantri Kisan Urja Suraksha Evam Uthaan Mahabhiyaan**) in 2019, the **Solar Park Scheme**, **Grid-Linked Solar Rooftop Scheme**, and the **Viability Gap Financing Scheme**, to achieve significant improvement in the food and energy sectors.

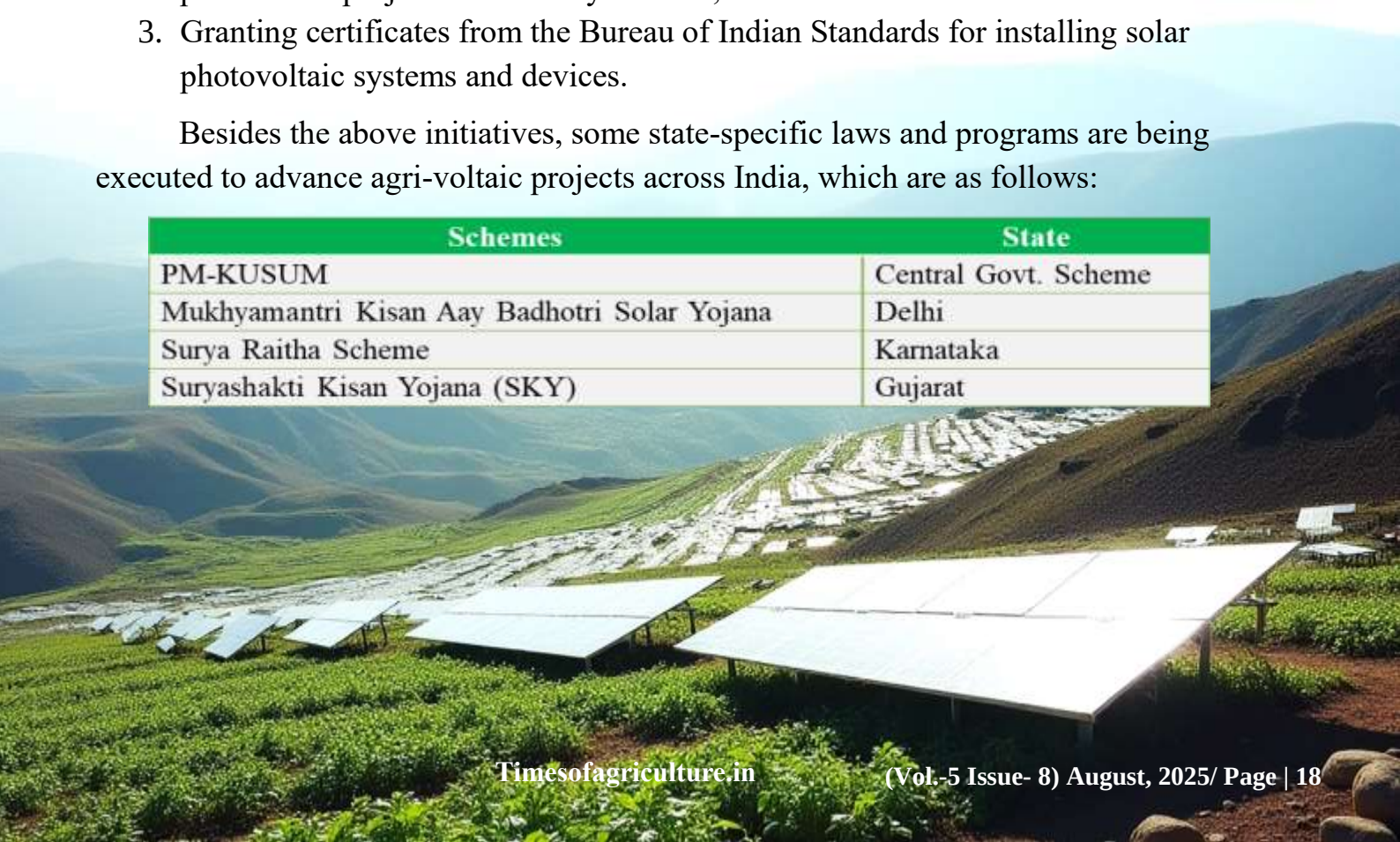
Moreover, the **National Solar Federation of India (NSFI)** has also launched an initiative called the ***India Agrivoltaics Alliance*** **(IAA)** with the main focus on integrating the solar energy infrastructure with all the agricultural regions of the nation. It is dedicated to promote, support, and standardize agrivoltaics practices by coordinating with all stakeholders, *viz.,* government bodies, farmers, solar panel developers, and financial institutions. With this initiative, NSFI strives to boost the adoption of agrivoltaics, thereby ensuring sustainable energy generation and conserving agricultural productivity simultaneously.

Along with this, the Government of India has also made various efforts to increase the use of solar energy, which include:

1. Allowing a maximum of **100% automatic FDI** in the renewable energy sector.
2. Interstate transmission system fees will be waived for the interstate sales of solar power from projects finished by June 30, 2025.
3. Granting certificates from the Bureau of Indian Standards for installing solar photovoltaic systems and devices.

Besides the above initiatives, some state-specific laws and programs are being executed to advance agri-voltaic projects across India, which are as follows:

Schemes	State
PM-KUSUM	Central Govt. Scheme
Mukhyamantri Kisan Aay Badhotri Solar Yojana	Delhi
Surya Raitha Scheme	Karnataka
Suryashakti Kisan Yojana (SKY)	Gujarat



Suitable Crops for Agrivoltaics Systems

A variety of shade-tolerant crops like leafy greens (lettuce, spinach, and kale), root vegetables that include potatoes, carrots, and beets, and berries, among others, are well-known examples that can be cultivated alongside solar development. These crops are hardy, which means they are more tolerant of drought and heat. Also these plants exhibit a high evapotranspiration rate, which helps in cooling the solar panel, hence enhancing the efficiency and longevity of the panels.

Major Challenges

Although there are several benefits of agrivoltaics, like imparting a favorable microclimate for crops, there are still many downsides of establishing agrivoltaic systems in India:

- High upfront cost required in the installation of panels because dual-use solar systems require larger, more intricate mounting systems.
- It is not possible to cultivate all the crops with shade, like wheat, which requires high levels of sunlight.
- Loss of fertile cropland for the reason that solar photovoltaic generation requiring a lot of land.
- Shortage of information about agrivoltaics in the Indian farming community.
- E-waste generated by solar panels adds more to the unsuitability of these systems in rural areas.

Throughout the world, Agrivoltaics is expanding quickly as a potential alternative to the competition for land between food and energy. Several pilot projects associated with agrivoltaics in India showed promising results with crops like lettuce, spinach, kale, potatoes, carrots, beets, and berries, resolving the primary concern of reduced yield due to shading. Along with this, some well-designed Agro PVs prove that crop yields can be increased up to 30% in arid and semi-arid conditions. Therefore, the need for further investment and research in agrivoltaics has become more to be done for some other vegetables, like chard, parsley, broccoli, cassava, yams, and sorrel, to address India's energy and food security concerns. Agrivoltaics could become a vital resource for India to fight against high food demand and climate change, and the right policies and collaborations (that include marginal farmers, FPOs, and even other nations) help to make it achievable.

■■■

DAIRY

BHARAT'S DAIRY FARMERS' DILEMMA

A CASE OF BEING IN A PRODUCTIVITY TRAP, FOREVER

About Author

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Dairy is both an economic engine and the rural household safety net for India: as the country's single largest agricultural commodity, milk contributes about 5% to national GDP and engages over 8 crore farmers - livelihoods driven majorly by women- while India now produces roughly a quarter of the world's milk (230.6 MMT in 2022–23).

For small farmers, it is the most reliable year-round cash flow: milk contributes close to one-third of rural household gross income, helping smooth seasonal shocks and convert crop by-products into value. Its centrality to everyday nutrition is clear too, wherein per-capita availability reached ~459 g/day in 2022– 23, while local jobs across input, collection, chilling, and logistics chains multiply the impact on village economies and recycle nutrients back to fields, anchoring rural incomes, food security, and inclusive growth.

It's no surprise India has held firm in the ongoing tariff and market-access talks with the Trump administration: those red lines are real and exist to safeguard millions of small dairy households whose daily cash flow and resilience depend on milk. If that feels abstract, take a short trip to any of the over 6lac+ villages across the country - the weave of rural life and dairying is unmistakable - making prudent protection essential while the sector should continue to modernise and grow.

India's dairying is smallholder-led, not the western model of large herds on vast grasslands. A typical household works a couple of acres of land and keeps just a few milch animals, so western playbooks just don't copy-paste in Bharat.

And yet India's dairy ecosystem delivers BIG: the democratized livestock holdings are backed by time tested and excellent milk collection cooperatives like Amul & the other state cooperatives that run dense, near farm collection networks, transparently & scientifically test milk for quality and quantity, and then make fully digital, on-time payments straight to

the farmers bank accounts and they take pride in keeping prices fair and cash flowing for small producers.

The co-operatives across the country act as village shock absorbers, turning a perishable litre into a dependable daily wage. They ensure a year-round demand and smoothen price swings, which would otherwise would whipsaw household cash flow. Also in the business milk intermediation stays lean and reducing: and in case of Amul a fair 80%+ of the final sale value flows back to farmers. The result is price stability, quality-linked incentives, and a fair marketplace where small herds can compete on merit rather than muscle. Compare that to studies of fruits and vegetables that show farmgate realisations for the farmers typically in the range ~25–45% depending on crop, season, and supply chain length.

Yet beneath the surface, a deeper risk is building - unrelated to geopolitics or Trumponics and yet far more consequential. India's dairy system is edging toward a productivity trap: farmers add feed, labour, and capital but don't see proportional gains in yield or quality, so costs rise while margins thin. If unchecked, this slow squeeze will erode the very foundations that have sustained smallholder dairying for generations.

The Productivity Trap is a well-documented economic phenomenon that occurs when individuals or enterprises are unable to increase their output or income despite working harder or even investing more. It is often seen in sectors where marginal gains are limited, capital is scarce, and where systems lack efficiency or scalability. This trap creates a vicious cycle where increased effort or investment does not lead to proportionate improvement in outcomes-eventually discouraging innovation and business growth.

In India's rural economy, few examples illustrate the Productivity Trap as starkly as the dairy farmer's dilemma.

Understanding the productivity trap in dairying

At its core, the productivity trap is a slow, step-down spiral. It starts with low output per unit of input: animals are often fed imbalanced & yet expensive rations, genetics are uneven, heat stress and subclinical disease persist, and green fodder is scarce - so each litre of milk costs too much effort.

Thin margins then restrict capital for upgrades: better heifers, balanced rations, mineral mixes, cooling, AI services, cow comfort, and preventive health. To hold the line, households stretch what they have - more family labour, cheaper concentrates, small high-cost loans - while costs creep up anyway: feed prices, vet visits, transport, electricity, and the hidden cost of time.

The extra push delivers less and less: adding concentrate without quality green fodder depresses fat/SNF; pushing late-lactation cows raises feed cost per litre; longer calving intervals and mastitis penalties erase volume gains. Eventually net income plateaus or slips-the daily milk incomesstruggles to cover feed, credit repayments, and household needs - triggering distress choices like cutting feed or selling a productive animal, which deepens the decline.

The stress is showing. The livestock in India is 50% as productive as its global peers at 4 lts of milk a day *vs* the global average of 8 lts.

Farmers caught in this trap experience a ceiling on what they can produce without significant investment, but they lack the financial or institutional capacity to make that leap. They are locked into low-yield, high effort systems where each additional unit of input-whether livestock feed, labor, vet expenses or animals - brings less and less marginal return.

And the dairy farmers' are starting to question the economics. In a shaded courtyard in Uttar Pradesh, 55- year-old Lallan Yadav runs a proud hand along the glossy flank of his three Murrah buffaloes and the cow tethered beside his home. Pride isn't his problem - green fodder is. Green fodder is the key component in milk production. The grazing fields are long gone; now on his tiny plot he squeezes in a season of berseem, knowing every square metre he gives to fodder takes away from cash crops. By summer even the berseem is finished and the ration tilts to expensive concentrates along with bhusa (straw) - enough to keep the milk flowing, but not enough to lift it. The daily milk incomes has stopped growing even as costs creep up, and Lallan has made his peace with not adding animals: why take on more debt for the same hard return? Sonu, his son, watches him putting in the effort thru' the day, and asks if it's worth it. Lallan doesn't answer. He just pats a buffalo's neck and tightens the rope, as if holding together a way of life that is slipping, not for lack of work but for want of natural green fodder.

Lallan's story has remarkable similarities around the country. The 40% national deficit of

green fodder is starting to take a ton. But Lallan and others like him drag it on- as milk still ensures regular cashflow unlike crop based incomes which are more milestone based and are also open to vagaries of price fluctuations and extreme climate events.

Lallan's dilemma as a case study of the productivity trap

Lallan like his breadthen across the country - the Indian small dairy farmers - typically own just about 2 – 4 cattle, the numbers are a slightly higher in case of ruminants. For such livestock farmers ever increasing green fodder shortage, means that the farmer has to turn to an increased dose of commercial supplements/ concentrates in the animals diet. The high costs of commercial supplements sharply increase the overall input costs for the farmers.

In case the farmers withdraw the commercial concentrate dose of a few kilos per day, the subsequent dry fodder based diet is devoid of anymeaningful nutrition – it is all fibre and very little crude protein and required minerals and vitamins. The unavailability of quality green fodder year round just means an increase in input costs and no real increase in outputs. Inadequate nutrition also leads to extended calving intervals and that remains a major constraint on maximizing calf production and the overall profitability of the Indian dairy sector.

Veterinary services have vastly improved over the years, but still a long way to go to make a omnipresent & economical. The genetic potential of some of the livestock is low or poorly utilized (of course not in case of Lallu). There is a lot of work that's on in this area, but it will take generations of livestock to fix it.

Climate stress is further limiting productivity. Summer heat tends to stress out the livestock and leads to lower yields.

So despite their best efforts, these farmers produce only 3–6 liters of milk per animal per day - barely enough to generate profit after accounting for input costs (feed supplements, fodder, water, medicine, transport, etc.). You would notice I have not included "cost of labour" as it is the farmer's family that comes together, especially the women folk, and put in the much needed effort and *they don't put a cost to their effort or time* – although they should. Things change for the worse if external labour costs have to be incurred.

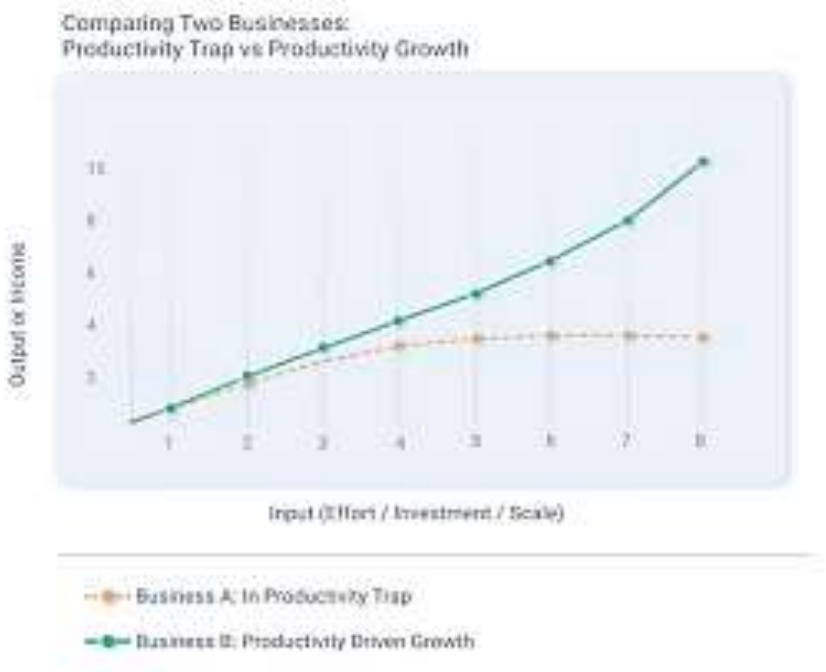
When these farmers try to scale their operations - something that most of them want to do - by acquiring more animals, they face more costs on account of labour / effort / hours, increased feed costs (which scale linearly or worse), higher risks of disease and no improvement in per-animal productivity.

Thus, they remain in the trap: expending more but not earning more. Over time, many dairy farmers report shrinking margins or even losses, forcing them to cut corners on nutrition or veterinary care - further reducing output.

Translating the productivity trap into plain numbers is easy. Using a few simple terms - milk price, litres per animal, and the real cost of feed, labour, and care - we can see that, past a point, each extra rupee of input delivers less milk than it costs, flattening profits. The formulas also make clear how raising underlying productivity- reliable green fodder, better genetics, and preventive health - shifts the whole system back into a higher-return zone.

We can represent the productivity trap in dairy as:

Income = (Milk per Animal × Number of Animals × Price) - (Cost / inputs per Animal × Number of Animals)



Without improving milk per animal, adding more animals just multiplies both income and cost—often unevenly, due to diminishing marginal returns.

In short:

- Low productivity × high input cost = trap
- More effort = more cost, but not more profit

This diagram illustrates two contrasting business trajectories:

Business A (Productivity Trap):

Input increases, but output plateaus, leading to stagnation or decline—typical of small dairy farmers without access to better inputs or system.

Business B (Productivity Enabled):

As inputs rise, output scales efficiently—reflecting businesses that leverage innovation, technology, and optimized practices.

It visually emphasizes how escaping the productivity trap unlocks sustainable growth. The Productivity trap grips millions of rural workers, especially small dairy farmers, in a cycle of effort without requisite reward. Breaking it requires external intervention like better inputs, tools, market access & linkages rather than internal escalation (more animals, hours, or effort).

Breaking the trap

Escaping the cycle means lifting productivity per animal - not simply adding animals. That starts with dependable, balanced nutrition: year-round access to high-quality green feed, steady dry-matter, and minerals so the rumen runs like a metronome. Fresh hydroponic sprouted feed - like Shunya's Nutri Ankurit Feed, raises digestibility, reduces mycotoxin risk, stabilizes cost, and supports higher peak yield and longer lactations. The hydroponic feed is a powerful combo of grains and greens that packs a nutrition-dense punch and helps reduce the dependence on commercial feeds.

Pair that with preventive care and early diagnostics: routine vaccination and deworming, mastitis screening, heat-stress management, mineral profiling, and simple record-keeping that flags issues before they become income-sapping crises. Then lock in genetic and reproductive gains: structured AI with proven sires, heat detection and timely breeding, shorter calving intervals, targeted replacement heifers so each cow produces more litres and better fat/SNF over her lifetime.

Shunya Agritech's "fodder-as-a-service" plugs directly into this upgrade path. Reliable, nutrient-rich sprouted feed delivered to the farmers doorstep, daily and fresh, lifts litres per animal without piling on labour or capital, improves Fat and SNF percentages (read as bonus earnings), and reduces volatility from land, water, and fodder scarcity. In other words, it breaks the linear "more input = just a bit more output" pattern and moves households to a higher-efficiency system.

Wonder why hardworking dairy families stay poor despite long days? The constraint is structural, not behavioural. The way out is structural too - better inputs, timely diagnostics, genetics, and market incentives that reward quality. When each litre costs less to produce and earns more at collection, the trap opens and smallholder dairying becomes both productive and sustainable.■

SMART FARMING

ON LEVERAGING TECHNOLOGY TO EMPOWER INDIAN FARMERS

About Author

Amit Gupta
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Indian agriculture is undergoing a seismic shift in 2025, driven by innovative technologies that make farms smarter, more productive and resilient to the stresses of population growth and climate change. As the world's second-largest producer of food, empowering India's over 150 million farmers has vast implications not just for the domestic economy, but for global food security. Smart farming, a blend of precision agriculture, artificial intelligence, digital platforms and sustainable practices is at the heart of this change.

Precision agriculture goes mainstream

The year 2025 signifies a critical milestone in Indian agriculture as precision farming moves from experimental stages into mainstream adoption. Precision agriculture tailors farm inputs such as irrigation, fertilizers and pesticides that are at a micro-plot level, ensuring resources are optimally utilized, reducing waste and significantly improving crop yields. This advancement enables farmers to maximize production efficiency while maintaining ecological balance.

Modern technologies play a pivotal role in this transformation. GPS-enabled tractors and sophisticated robotic farm machinery are replacing manual labour, vastly increasing operational efficiency and allowing farmers to manage larger areas with ease. The extensive use of drones has revolutionized pesticide application, crop health monitoring and early disease detection. These drones, equipped with advanced multispectral imaging technology, enable real-time identification of stressed or diseased plants long before visible symptoms spread, thus mitigating crop loss.

urther complementing these innovations are IoT-enabled soil and environmental sensors that provide continuous data on soil moisture levels, pH balance and essential nutrients. This invaluable information guides farmers in making precise decisions on when and how much fertilizer or water to apply, promoting sustainable farming practices.

Industry projections indicate that by 2025, over 30% of Indian farms will adopt high-precision agriculture technologies. This widespread adoption promises to reshape agricultural productivity, enhance yield accuracy, improve sustainability and support the nation's food security objectives.

Artificial Intelligence and Machine Learning on the Farm

The integration of AI and machine learning is perhaps the most significant force reshaping Indian agriculture. AI-powered advisory platforms analyse massive datasets (weather, soil, crop health) and send personalized recommendations on what to plant, when to irrigate, what disease to watch out for directly to farmers' smartphones. Predictive modelling enables timely pest and

disease forecasting, helping avoid substantial crop loss. AI platforms can detect the earliest signs of stress and recommend actionable interventions, boosting resilience. AI-led transformation is evidenced by optimized input use, improved financial health and a noticeable reduction in farmer debt.

Drones, Satellite Imagery and Remote Sensing

High-resolution satellite imagery enables real-time farm monitoring, assisting in accurate yield estimation and environmental impact analysis. Several companies provide these advanced services through user-friendly mobile apps, making precision agriculture accessible to farmers. Additionally, drones equipped with multispectral cameras offer targeted pest control, variable rate fertilization and scalable field surveillance. These technologies empower smallholder farmers to enhance productivity and efficiency, allowing them to compete effectively with larger corporate farms. By leveraging satellite and drone technologies, agriculture is becoming more data-driven and sustainable, supporting better decision-making and resource management across diverse farming operations

Mobile Apps, E-Marketplaces and Digital Platforms

Digital platforms, mobile apps and e-marketplaces are revolutionizing Indian agriculture by bridging crucial gaps in credit, advisory services and market linkages. Mobile-based advisory services, such as Kisan Suvidha, deliver localized information, including weather updates, pest alerts and price forecasts in multiple regional languages, enabling farmers to make timely and informed decisions. E-marketplaces are empowering farmers by connecting them directly with buyers, significantly reducing their dependence on intermediaries and ensuring they receive fairer prices for their produce. Additionally, digital credit and insurance platforms are transforming financial access for farmers by accelerating loan approvals and facilitating quicker insurance claims. These platforms often incorporate blockchain technology to provide transparent and tamper-proof transaction records, which further increases trust and efficiency in the supply chain.

This digital empowerment is becoming widespread, with over 60% of Indian farmers using mobile apps by 2025 to access information and market opportunities. As these technological advancements continue to scale, they play a vital role in improving farmers' livelihoods, enhancing agricultural productivity and encouraging inclusive growth within the rural economy. The integration of digital tools marks a significant step forward in India's journey toward a modern, technology-driven agricultural landscape.

Sustainable and Climate-Resilient Practices

Gene-edited, climate-resilient crops developed through CRISPR-Cas technology are bypassing traditional regulatory hurdles and rapidly reaching Indian farms, enhancing pest and drought tolerance. In addition, solar-powered cold storage units are now operational in Punjab, Maharashtra and Andhra Pradesh, significantly reducing post-harvest losses. Furthermore, automated irrigation controllers connected to IoT sensors are improving water-use efficiency, a critical advancement to address India's increasing water stress. These sustainable and climate-resilient practices are transforming agriculture in the country.

Blockchain, Geospatial and Digital Twin Technologies

Blockchain technology is revolutionizing agricultural supply chains by enhancing transparency and traceability, which helps open new export markets and builds greater consumer trust. This technology ensures that each step of the supply chain is recorded securely, reducing fraud and improving accountability. Alongside blockchain, Geographic Information Systems (GIS) and remote sensing technologies play a crucial role in precision land mapping, accurate disaster prediction and more effective disaster response, thereby safeguarding crops and livelihoods. Additionally, Digital Twin simulations empower farmers by allowing them to virtually test different farming strategies before implementation. This reduces risks and optimizes agricultural outcomes by providing insights into potential results without real-world trial and error. Together, these advanced digital tools are transforming Indian agriculture into a more transparent, precise and resilient sector, driving sustainable growth and innovation

How Technology is Changing Farmers' Lives?

Smart farming is transforming Indian agriculture by boosting productivity and profitability for both smallholders and large agribusinesses. Precision input techniques help increase crop yields by up to 30% while reducing input costs, as fertilizers, water and pesticides are applied only where needed. Farmers benefit from improved product quality, real-time market access and enhanced traceability, enabling better pricing. Enhanced resilience to climate extremes is achieved through predictive analytics that help farmers plan for erratic monsoons, droughts, pest outbreaks and extreme weather. Real-time weather and soil data empower proactive measures to protect harvests. Smart farming also improves credit, insurance and supply chains such as digital loan approvals to facilitate timely investments, while drone data and satellite imagery enable swift insurance claim settlements. Blockchain technology ensures transparent supply chains, providing farmers access to advanced markets. Together, these advancements are making Indian agriculture more efficient, resilient and profitable.

Government and Policy Support

Much of this technology, once limited to large farms, is reaching

smallholders through low-cost devices, local-language apps and collaborative government initiatives such as the Digital Agriculture Mission launched in 2024.

Launched in September 2024 with an outlay of Rs. 2,817 crore, India's Digital Agriculture Mission aims to integrate advanced technologies such as AI, IoT, blockchain and geospatial data at scale. A key initiative under this mission is the development of 'Agristack,' a comprehensive digital repository containing farmer profiles, land records and crop advisories. The mission also seeks to foster public-private partnerships and support the growth of agritech startups. Through an aggressive push for digitization, direct benefit transfers to farmers and focused research and development on climate-smart crop varieties, the government is setting the foundation for scalable, data-driven farming that promotes sustainability and resilience in Indian agriculture.

Challenges and the Road Ahead

Despite rapid advancements in agricultural technology, India continues to face significant challenges in fully realizing the potential of precision and smart farming. One of the primary hurdles is the upfront cost of technology. Affordable and user-friendly tools are essential for widespread adoption among farmers, especially smallholders who often operate under tight financial constraints. Targeted subsidies and financial support can play a critical role in overcoming this barrier. Additionally, digital literacy remains a key concern as many farmers require training and ongoing support to bridge the knowledge gap and effectively use new technologies. Efforts are underway to address this through extension services and educational programs. Connectivity is another major issue, as rural broadband expansion is still in progress and has not reached all farming regions, limiting access to real-time data and digital platforms. Furthermore, data integration poses a challenge: agricultural data often exists in silos, making it difficult to derive actionable insights for farm management. Several are emerging as leaders in unifying this data to enable better decision-making on farms.

Despite these challenges, there is optimism that continued reductions in technology costs, strong government support and a vibrant agritech startup ecosystem will help India overcome these obstacles in the near future. There are already inspiring success stories demonstrating the impact of modern technology on Indian agriculture. For example, in Andhra Pradesh, cooperative societies utilizing drone surveillance for winter paddy reported a 22% reduction in pest-related crop losses. In rural Maharashtra, solar-powered cold storage units have cut post-harvest spoilage by 40% for grape and mango growers, improving income stability and reducing waste. In Punjab, AI-powered mobile applications delivered 20,000 localized pest alerts during the 2025 wheat season, enabling farmers to undertake targeted interventions that minimized crop damage. These examples highlight the transformative potential of precision farming technologies in enhancing productivity, sustainability and resilience across India's diverse agricultural landscape.

A Tech-Driven Green Revolution

Smart farming in India is not a distant dream rather it is a reality in motion, led by the synergy of AI, IoT, remote monitoring, digital access and climate-smart biotech. With over a quarter of all farms leveraging advanced technology by 2025, India is on its way to a more resilient, sustainable and prosperous agricultural future.

Smart farming is rapidly reshaping the landscape of Indian agriculture, ushering in a new era of data-driven, sustainable and resilient food production. By harnessing technologies such as artificial intelligence, IoT sensors, drones and digital platforms, Indian farmers, whether smallholders or large-scale producers they are able to make informed decisions, optimize their inputs and boost yields while safeguarding natural resources. These advancements not only improve profitability and reduce production risks but also democratize access to vital information and market opportunities. Supported by government initiatives and a vibrant agritech ecosystem, the adoption of smart farming is steadily overcoming challenges related to cost, connectivity and digital literacy.

The transformation is visible in farmers' increased incomes, reduced wastage and a heightened ability to withstand climate uncertainties. As adoption accelerates in the coming years, smart farming holds the promise of empowering millions of Indian farmers, making India's food system more secure and sustainable for future generations. The collaboration between technology providers, policymakers and the farming community will be pivotal in realizing the full potential of this agricultural revolution.

■■■

TINY IN SIZE WITH MIGHTY IMPACT

MICROGREENS- A SUSTAINABLE TRACK TO NUTRITION

About Author

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Microgreens are tiny, young plants harvested soon after their first true leaves grow. They come from the seeds of vegetables and herbs, and are known for their bright colors, strong taste, and rich nutrients. Lately, microgreens have become very popular, especially in cities where people care more about eating healthy. Since they are simple to grow and good for health, they are now often seen in urban homes, high-end restaurants, and health-focused stores. This article talks about why microgreens are becoming more important by covering three main points—nutrition, sustainability, and urban gardening. It explains how these small plants can help people stay healthy and support better food choices.

Introduction

Mini greens with many benefits, microgreens are becoming more popular with health-focused people living in cities. These soft, young plants are picked just a few days after they start growing and are full of flavor and nutrients. They're not just a food trend—they're a smart and eco-friendly way to get good nutrition, especially in today's busy world where space is limited.

What are microgreens?

Microgreens are the tender, early stage of vegetables and herbs, usually picked about one to two weeks after sprouting, once their first true leaves appear. Sprouts are ready in just 2 to 5 days, while microgreens need around 7 to 21 days to grow, depending on the type of plant. They are different from baby greens, which are grown for a longer time. What makes microgreens special is their strong flavor, bright color, and rich nutrients. Even though they're small, they often have more vitamins A, C, E, and K, along with antioxidants and plant nutrients, making them a great choice for better health.

How to grow microgreens indoors

Growing microgreens indoors is a simple, accessible gardening activity that requires minimal space and equipment.

Follow these steps to grow your microgreens successfully:

1. Prepare the Tray: Fill your tray with 1 to 2 inches of soil or another growing material. Smooth out the top gently without pressing too hard, so the roots have room to grow.

2. Sow the Seeds: Sprinkle the seeds evenly across the soil. Since microgreens don't need much space, you can plant them close together. Gently press the seeds into the soil so they touch it, but don't cover them.

3. Moisten and Cover: Gently spray the surface with water using a spray bottle. Then, cover the tray with a lid

or another tray to keep it dark and moist for the first couple of days.

4. Germination Period: Keep the tray covered for 1 to 2 days while the seeds germinate. Maintain moisture during this time by misting once or twice daily.

5. Provide Light and Care: Once the seedlings begin to sprout and push against the cover, remove it and expose the tray to light. Place the tray near a bright window or under a grow light for 12–16 hours daily. Continue watering regularly to keep the soil evenly moist.

6. Harvest: Within 7 to 15 days, when the microgreens are 1–3 inches tall and have developed their first true leaves, they are ready to harvest. Use clean scissors to cut them just above the soil line. After washing its ready to eat immediately, or store in a sealed container in the fridge for a few days.

Research shows they can contain up to 40 times more nutrients than their mature counterparts.

Suitable plants for microgreens

Here are some of the most popular types of microgreens around the world, known for their health benefits and how they can make meals better **(Table:1).**

Nutrition and health benefits

Microgreens might be small, but they pack a big nutritional punch. Studies have found that these young greens often have much higher levels of important vitamins, minerals, and antioxidants than fully grown vegetables. For instance, research by Xiao et al. (2012) showed that microgreens can have 5 to 40 times more nutrients like vitamin C, vitamin E, and beta-carotene per gram compared to mature plants.

Eating vegetables is known to lower the risk of several health problems because they are rich in vitamins, minerals, and helpful plant compounds. Microgreens, in particular, may help reduce the risk of the following:

- ✓ **Heart disease**: Microgreens are full of polyphenols, a type of antioxidant linked to a lower risk of heart disease. Some studies show they can help lower triglycerides and bad LDL cholesterol.
- ✓ **Alzheimer's disease**: Foods high in antioxidants, especially those rich in polyphenols, may be connected to a reduced risk of Alzheimer's.
- ✓ **Diabetes**: Antioxidants can lower the type of stress that stops sugar from entering cells properly. In lab tests, fenugreek microgreens helped boost sugar absorption in cells by 25–44%.

A 100g of serving of sunflower and basil microgreen mix

- ✓ 15.9mg of iron
- ✓ 66mg of magnesium
- ✓ 66mg of phosphorus
- ✓ 298mg of potassium

will provide:

- ✓ 28 calories
- ✓ 2.2g of protein
- ✓ 4.4g of carbohydrate
- ✓ 2.2g of fiber
- ✓ 11mg of sodium

Due to their versatility, microgreens can easily be added to a variety of dishes, providing both a nutritional boost and a burst of fresh flavor. Incorporating them into the

Table:1

Common name	Family	Scientific name	Plant color
Arugula	Brassicaceae	*Eruca sativa*	Tangy green
Broccoli	Brassicaceae	*Brassica oleracea* var. *italica*	Green
Celery	Apiaceae	*Apium graveolens* L.	Green
Coriander	Apiaceae	*Coriandrum sativum* L.	Green
Sunflower	Asteraceae	*Helianthus annuus* L.	Yellowish-Green
Amaranthus	Amaranthaceae	*Amaranthus hypochondriacus* L.	Red
Opal Radish	Brassicaceae	*Raphanus sativus* L.	Greenish-Purple
Popcorn Shoots	Poaceae	*Zea mays* L.	Yellow
Red Beet	Chenopodiaceae	*Beta vulgaris* L.	Reddish-Green
Red Cabbage	Brassicaceae	*Brassica oleracea* L. var. *capitata*	Purplish-Green

Xiao et al. (2012)

daily diet is an easy and effective way to improve overall health and well-being, especially for individuals in urban areas were access to fresh, high-quality produce may be limited.

Incorporating microgreens into your diet

Microgreens are a flexible ingredient that can be added to many different meals to boost both flavor and nutrition. Their soft texture and strong taste make them a great addition to everyday food. You can use microgreens as toppings for soups, omelets, grain bowls, or even pizza. They add a splash of color and a fresh, slightly spicy or herbal flavor, depending on the type.

Rainbow of Microgreens:

Fruits and vegetables are available in different colors. Microgreens of different colors represent different healthy compounds called phytochemicals, as well as other micronutrients.

- **Red vegetables** contain lycopene, which is a powerful antioxidant.
- **Orange and yellow** vegetables contain carotenoids like beta carotene and lutein, which the body converts into vitamin A.
- **Blue and purple** vegetables contain anthocyanin which can help protect cells from damage.
- **Green vegetables** contain a wide range of different Phyto chemicals including saponins, indoles, and carotenoids.
- **Brown and white** vegetables like garlic contain allicin which has antibacterial properties.

Microgreens should ideally be eaten within 3 to 5 days after harvesting, as they are delicate and spoil easily. Washing them gently before using helps keep their texture and reduces the chance of spoilage. Whether added as a garnish or used as a main ingredient, including microgreens in your daily meals is an easy and healthy way to support your overall well-being and add variety to your diet.

The urban gardening solution

Microgreens are perfect for city gardening because they don't need much space and grow fast. According to Choe et al. (2020), they're easy to grow indoors and full of nutrients, which makes them a great option for people living in cities. With just a few simple tools and little work, microgreens can be grown on small spots like windowsills or shelves, making it easy to have fresh food even in small homes.

Conclusion

Adding microgreens to your daily routine is an easy and rewarding way to live a healthier and more eco-friendly lifestyle. Growing them at home is simple, low-cost, and highly beneficial. With just a small tray, some seeds, and regular care, you can grow a steady supply of fresh, nutritious greens. Microgreens are rich in helpful compounds that support good health. Plus, because they grow quickly and don't need much space, they're ideal for people who are short on time or don't have room for a full garden. Growing microgreens not only improves your diet but also promotes sustainability and more control over your own food.

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FROM 4G TO 5G

ESCALATING ELECTROMAGNETIC THREATS TO HONEY BEE NAVIGATION AND SURVIVAL

About Author

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Pollinators are indispensable to agriculture and biodiversity. Among them, honey bees are responsible for pollinating over 70% of the major crops consumed by humans, including fruits, vegetables, nuts and oilseeds. Their economic value is estimated in the billions of dollars annually. However, bee populations across continents are declining at alarming rates due to various anthropogenic pressures. The most widely discussed causes of this decline include pesticide exposure (particularly neonicotinoids), monoculture farming, climate change, habitat fragmentation and emerging pathogens such as *Nosema ceranae* and *Varroa destructor*. Yet, in recent years, researchers have begun to explore a new and potentially pervasive threat: electromagnetic radiation emitted from communication technologies such as mobile phones, Wi-Fi and cell towers. Electromagnetic fields (EMFs) can affect biological systems in subtle but critical ways. Honey bees rely heavily on their ability to detect magnetic fields for orientation and navigation. With the advent of 4G technology and now the global rollout of 5G networks, EMF exposure is increasing in both frequency and density. This raises concerns about how such radiation may be affecting pollinators.

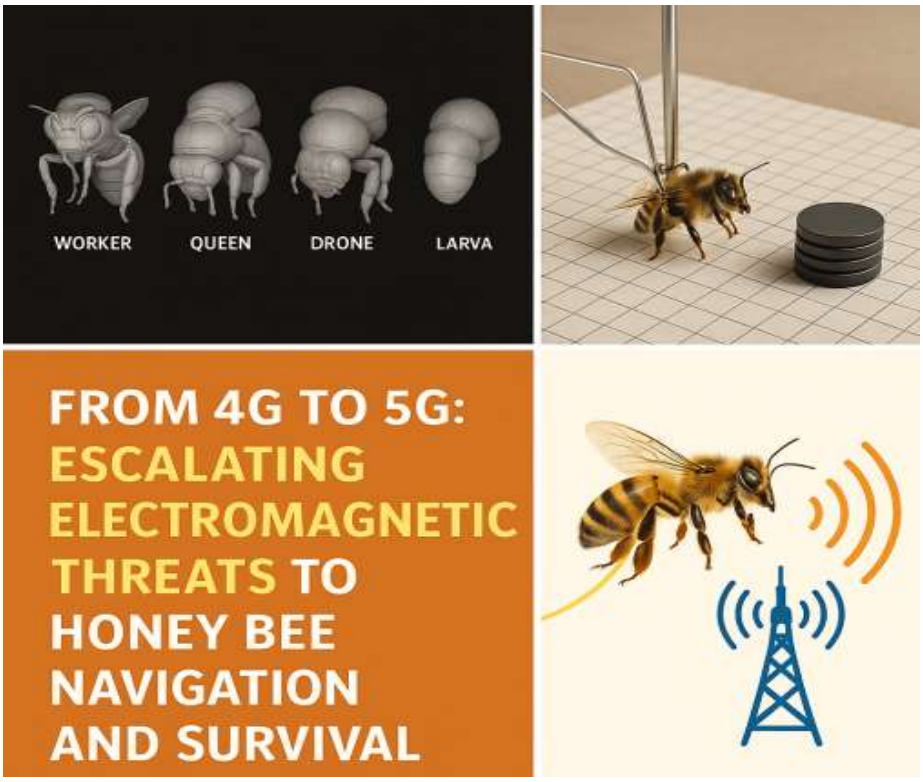
Honey bees use a complex set of tools to navigate, including the sun's position, polarized light, visual landmarks and, crucially, the Earth's geomagnetic field. They possess magnetoreceptors iron-containing structures in their abdomen that allow them to detect magnetic fields and use them as a compass. This ability is vital when bees forage for food, as it helps them return to their hive from distances of several kilometers. Any disruption to their magnetic sensitivity could impair their navigation, causing bees to become disoriented and fail to return to the hive. This is a key feature of Colony Collapse Disorder (CCD), where adult worker bees disappear, leaving behind the queen, brood and food stores. While no single cause of CCD has been identified, EMR is now being studied as a possible contributing factor.

Understanding 4G and 5G Networks

4G (Fourth Generation) cellular networks operate primarily in the 700 MHz to 2.6 GHz frequency range. These frequencies are considered “low to mid-band” and have broad coverage with fewer towers.

5G (Fifth Generation) networks introduce “millimeter waves” (mmWave), operating in frequencies ranging from 24 GHz up to 100 GHz. These higher frequencies require dense infrastructure, including small cells mounted on buildings, poles and even trees at intervals as short as 100 meters.

While 5G offers high-speed internet and low latency, the



biological impact of millimeter-wave radiation is not fully understood. The denser placement of towers and the increased cumulative exposure of living organisms raise concerns about chronic low-level exposure, especially for insects. A study published showed that insects absorb significantly more radiation at higher frequencies. Due to their small body size and the resonance effect, the exposure level in insects is higher than in mammals. This suggests that 5G could disproportionately impact insects like honey bees.

Multiple experiments have demonstrated that electromagnetic radiation (EMR) can disrupt various aspects of honey bee behavior and biology. In controlled conditions where beehives were intermittently exposed to mobile phone radiation for short durations each day, researchers observed a noticeable reduction in egg-laying by queen bees. Additionally, the number of worker bees returning to the hive after foraging declined significantly within a period of just ten days, indicating potential disorientation or navigational failure. Other studies have found that bees subjected to EMR show stress-related behaviours, such as the emission of "worker piping" sounds. These signals typically occur under stressful hive conditions, such as before swarming or during emergency events, suggesting that electromagnetic exposure may induce a state of alarm in the colony. Further observations revealed a pattern of increased mortality among worker bees, along with slowed brood development and interruptions in feeding behaviour. These findings imply that even low-intensity but repeated exposure to electromagnetic fields may have cumulative biological effects, potentially weakening overall colony health and functioning.

However, anecdotal reports and localized surveys have indicated declining forager returns and disrupted hive activity in areas near 4G/5G towers. Despite this, there is minimal formal research on EMR impacts specific to Indian bee strains or agro-ecological conditions. India's telecom policy currently does not require environmental impact assessments before tower installation. With 5G rollout expected to accelerate by 2026, India must prioritize pollinator safety in its development agenda.

Most existing EMR safety standards (such as those by ICNIRP and FCC) focus on human exposure and are based on thermal (heating) effects. However, non-thermal biological effects such as behavioural changes and reproductive disruption are well-documented in invertebrates. There are no international guidelines for maximum safe exposure levels of EMR for insects. As a result, pollinators like honey bees remain unprotected in regulatory frameworks, even as EMR sources become more pervasive.

To address the emerging threat of EMR from 4G and 5G networks on honey bees, the following steps are recommended:

Expand research: Fund long-term, field-based studies that evaluate chronic EMR exposure in different ecological settings.

Monitor hive health: Encourage beekeepers to track behavioural changes and correlate them with tower proximity.

Policy reform: Incorporate bee health indicators into Environmental Impact Assessments for telecom projects.

Regulate tower placement: Limit tower installations near apiaries, natural reserves and flowering crops.

Promote EMR-Free zones: Designate safe foraging zones free from high-intensity EMR to protect pollinators during peak activity.

International collaboration: Coordinate research across countries to establish global standards for EMR exposure in insects.

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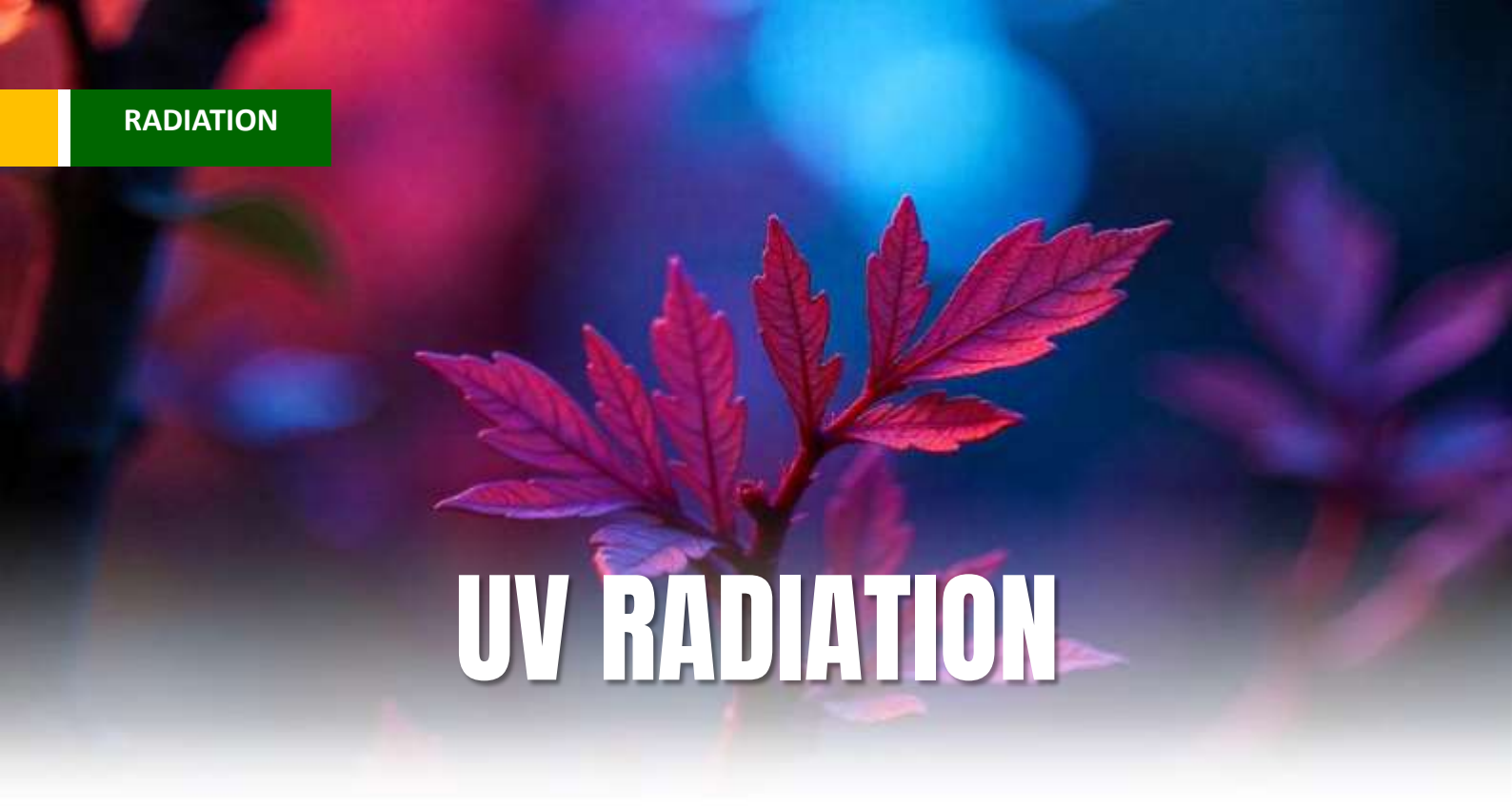
Previous Issues

Website Statistics (July 2025)

152K	56K	3.5M
Monthly Pageview	Monthly Visitor	Monthly Impression

Social Stats

6.5K	5.8K	9.5K	1.7K	2.1K



UV RADIATION

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Ultraviolet radiation, most commonly known as the UV Radiation is a form of the electromagnetic radiation. With a wavelength of 100 nm to 400nm, a wavelength shorter than that of visible light 400 to 700 nm and longer than that of X – rays. It's a natural part of sunlight but invisible to human eye. UV radiation is one that is both essential and detrimental to plants. Analyzing the essential side, it forms the core of photomorphogenesis, and run through on its detrimental side exposes the DNA damage. Oxidative stress, disruption in cellular processes, an effect of it. The categorization of UV radiation on their basis of the wavelength further explains its role in the earth's surface. It is followed by the UV-B radiation falling under 280 nm and 320 nm, being the one that is less abundant but more biologically abundant and most hazardous to plants causing severe and detrimental effects. The final one is the UV – C radiation, the falls, under 200 nm and 280 nm and said to be the most harmful of all. Absorbed by the ozone layer, UV – C radiation doesn't have any sort of incidence on the earth's surface. We are exposed to a wide range of light spectrum and though UV radiation is a minor part of it, we fall prey to the effects of UV radiation. Thus, its necessary we learn about the ultraviolet radiation, its increasing intensity, impacts and consequences, photoprotective mechanisms and responses.

Photo protective mechanisms in plants

Photoprotective mechanisms are simply strategies or methodologies that are explored in areas of heavy/high intensity of light in order to protect the plants from any kind of damage. They help in the prevention of photo-oxidative damage which paves way to reduction in photosynthetic efficiency, growth, productivity, cellular damage, high risk of diseases and pest if left untreated. Hence these mechanisms help in enhancing the yield of crops, tolerance to high light intensities etc.

1. Accumulation of UV absorbing compound

The UV– absorbing compounds play a vital role in the plant defense mechanism against the harmful UV radiation. The most common UV absorbing compounds include the secondary metabolites like flavonoids, carotenoids, phenolics and hydroxycinnamic acids.

Flavonoids: Flavoids, a secondary metabolic belonging to a class of plant compounds with flavonols, flavonols, anthocyanins as their types that trap and absorb the UV radiation.

Carotenoids: Carotenoids, often found as the yellow, orange and red pigments in plants as secondary metabolites, are composed of carotenes and xanthophylls. The

carotenes – alpha – carotene, beta – carotene, lycopene and xanthophylls – Lutein, Zeatin, Violaxanthin are the common part of carotenoids that absorb uv - radiation.

Phenolics: Phenolics are composed of phenolic acids – Cinnamic acids, ferulic acids, sinapic acid, flavonoids like quercetin and kaempferol, lignin's absorb UV radiation.

Hydroxycinnamic acids:

Class of phenolics compounds that absorb uv radiation. Existing in various types like p-coumaric acid, caffeic acid, ferulic acid and sinapic acid, they are found in various plants turning their defense to high solar radiation.

When we look deeply as to why the accumulation of UV-absorbing compounds, we find answers in their ways of defense like:

- UV screening – Reduction of the amount of radiation that is incident on the plant tissues.
- Antioxidant activity – Presence of antioxidant properties that protect the plants against the oxidative damage that are a result of incidence of high light intensity.
- Signaling and regulation - The secondary metabolites play a major role in coordinating the plant responses to UV radiation.

2. Structural protection

Also known as physical mechanisms, they comprise of changes in physical structures in order to reduce the amount of light absorption in the tissues. Cuticle being a waxy layer reflect the excess light energy, absorb the UV radiation and regulate the photosystem. Scattering of light by the epidermal cells. Hairy leaves or stems reflect as well absorb the excess light energy. Leaf rolling in plants to reduce the surface area of the leaf that is exposed to sunlight.

3. Antioxidant defense:

Reactive oxygen species are formed as a result of UV radiation. These ROS have the capability of damaging the cellular components. As a counteract mechanism plant find solace in the antioxidant defense through enzymatic antioxidants which include the enzymes – super oxide dismutase (SOD), catalase, peroxidase which are involved in the ROS neutralization through chemical reactions.

The mechanisms include scavenging of free radicle where the ROS are neutralized by donating electrons to stabilize the free radicals. It is then followed by ROS detoxification where ROX is converted into water and oxygen. Redox regulation is another mechanism where the antioxidants are involved in the maintenance of the balance between oxidized and reduced molecules.

4. Photorespiration:

Photorespiration, a metabolic pathway which is a complex process that is said to occur in plants in the presence of light, oxygen and chloroplasts. A prominent conversion of Ribulose-1,5 bisphosphate (RuBP) into 3 - Phosphoglycerate (3 – PGA) and 2 – Phosphoglycerate (2 – PG) with the release of carbon dioxide and ammonia is clearly evident. It reduces the oxidative stress with the consumption of oxygen and CO_2 produced and the formation of ROS in turn.

With the dissipation of the excess energy from the incident light, the role of photo - oxidative damage can be reduced and the cellular components and photosynthetic pigments damage is minimized.

Apart from it, it plays a key role in the protection of the photosynthetic damage of apparatus with the help of reduction of amount of energy available for photosynthesis.

It ensures CO_2 assimilation even under conditions of high light intensity by recycling of the CO_2 released during photorespiration.

Impact of UV Radiation:

UV radiation shows significant impact on plants, at various levels like molecular, cellular and physiological apart from hindering their growth, development and productivity. Ranging from stunted growth, damage of leaf with necrosis, blotching, leaf structure changes with its pubescence, density and leaf thickness, to effects in the time of flowering, flower morphology and seed production, UV Radiation leaves behind many detrimental effects.

The high light intensity severely damages the highly sensitive photosystem – II (PS – II) which serves as a crucial component of the photosynthetic apparatus aiding in the conversion of light energy to chemical energy.

The mechanisms involved in the PS II damage include excessive energy absorption resulting in an overload of electrons in the electron transport chain, production of ROS like superoxides, hydroxyl radicals that have the ability to cause impairments in the PS II proteins and pigments.

The other severe mechanism is photoinhibition where the PS II reaction centre is completely inactivated thereby decreasing the efficiency of photosynthesis.

Ozone depletion:

It's a known fact that ozone depletion is a complex process and a severe issue in the recent times with the growing intensity of UV Radiation. The release of halons, greenhouse gases, chlorofluoro-carbons, methyl bromide are the leading sources of ozone depletion. The UV Radiation, most specifically UV – B and UV – C are involved in the breaking down of the CFC's and the other ozone depleting substances.

Ozone is present in the stratosphere whose depletion is a result of the anthropogenic activities in turn increasing the incidence of UV – B Radiation at the earth' surfaces.

The mechanism involved includes the release of CFC'S and halons into the atmosphere and their rise to the stratosphere where they are broken down as a result of uv radiation. The breakdown of CFC's and halons increases the concentration of the highly reactive chlorine and bromine atoms which react with O_3 molecules leading to their breakdown into)3 molecules results in the advancement of ozone depletion which in turn allows more amount of UV radiation to reach the earth's surface.

UV-B radiation

With its high energy as compared to uv -A radiation, UV-B radiation is found to show specific effects of plants, rendering the plants photo protective mechanism defenseless on a long term exposure. As a result of UV-B radiation, photodissociation of O_2, formation of ozone and catalytic destruction of ozone are prominent. In case of UV - B radiation impact on plants, it serves as the driving factor for the damage of DNA, photosynthesis inhibition generation of ROS, oxidative stress and disruption of plant water relation. They also have a positive effect with its influence on the morphology of the plant, plant morphogenesis, defense responses, production of UV-protective compounds and genes related to defense. It also enhances nutrient uptake and its utilization within the plant. They have the ability to regulate the development of plant, including the establishment of seedling, flowering and senescence apart from its influence on the plant morphology in terms of elongation of stem, expansion of root and its growth, expansion of leaf and its growth. Hence it is both useful and detrimental to plants at the same time

DNA damage and mutation

UV radiation results in the damage of DNA which turns out to be of great concern due to its impact in the plants growth and development and its productivity, genetic instability and mutation. Analyzing the type of damages it could cause, it was found that the UV radiation led to formation of cycle butane pyrimidine dimers often called CPDs, the covalent link that exists between the adjacent pyrimidine bases. They further led to the production of photoproducts - pyrimidine (6-4)pyrimidine photoproducts commonly written as 6-4 pps. The other possibility could be the oxidative damage of DNA with the formation of 8- oxoguanine and associated oxidized bases. Directly UV radiation induces the formation of CPDs and 6-4 pps and indirectly if generates the ROS who are capable of oxidizing the DNA bases. Looking through the mutation that are a result of the DNA damage are point mutations, chromosomal mutation and genomic mutations like changes in the size and structure of the genome. These mutations can also be a result of the error-prone repairs carried out on the damaged DNA.

Oxidative stress

Oxidative stress, a condition of imbalance that exists between the generation of the reactive oxygen species and the cells impaired growth and reduction in productivity. Oxidative stress is mainly due UV-B and UV -C radiation. They go on to generate ROS like superoxides, hydrogen peroxide and hydroxyl radicals as a result of the chloroplast damage. Oxidative stress causes lipid peroxidation which in turn results in damage to the membrane and disruption to the cellular processes. It changes the structure and function of the protein with its oxidation of protein

ROS

The generation if the ROS is a result of the interaction of UV radiation with the cellular components. The process is initiated either the absorption of the UV radiation by the DNA ,proteins and lipids .It is followed by the excitation of electrons and the transfer if the electrons to the oxygen molecules leading to the formation of superoxide radicals which are converted into hydrogen peroxide when the enzyme superoxide dismutase (SOD) acts on it. Fenton reaction, an interaction of UV radiation with its cellular components leads to the conversion of the hydrogen peroxide into hydroxyl radicals. Apart from these, other ROS like ozone and singlet oxygen are also generated.

Signal transduction

Signal transduction, the process of conversion of extracellular signals

(hormones, environmental stimuli, growth factors) into intracellular signals with molecular interactions. The UV radiation is sensed through the photoreceptors that trigger the complex signaling cascades. The UV-B photoreceptors like UVRs perceive UV-B radiation and UV-A photoreceptors like cryptochromes perceive UV-A radiation. UVRs photoreceptors detects the UV-B radiation and initiates the protective responses with transcription factor that is involved in the regulation of UV induced gene expression and antioxidant defenses. UV signaling interacts with various pathways that are significant in the plant like the ones that involve defenses. UV auxin, abscisic acid and jasmonic acid and help with the modulation of growth and stress. It further goes on to activate the UV responsive genes that help in the synthesis of protective compounds and repair enzymes.

Cross-talk pathway

Cross -talk pathways, the interaction and communication that takes place between the different signaling pathways that exist within a cell. It is these interactions that allow the integration of multiple signals and respond appropriately to its environment. The UV -B radiation influences the receptor-ligand interactions, protein -protein interactions, post -transcriptional modification like phosphorylation and ubiquitination while regulating the transcriptional activity. The various cross-talk pathways involved with UV-B radiation are:

- ✓ UV-B and ethylene signaling that regulate plant growth and development.
- ✓ UV-B and ethylene signaling which is involved in the regulation of stress responses and senescence.
- ✓ UV-B and jasmonic acid signaling which regulates the stress tolerance and defense responses.
- ✓ UV-B and salicylic acid signaling involved in the regulation of defense responses and systemic acquired resistance.

Conclusion

The UV radiation study and exploration draws a conclusion to the special physiological processes naturally present in the plant and the need for them in the today scenario where the intensity of light and solar radiation keeps increasing leading to ozone depletion. It also calls for more on UV radiation and its effects on plants and ecosystems. It is necessary we go for breeding crops for tolerance to UV in order to improve agricultural productivity and food security. It's important we go for practices that are sustainable for the environmental conservation as ways of mitigation to the impacts of UV radiation. Thus, the exploration concludes on the stress the plants undergo when exposed to high intensities of UV, mainly UV-B and UV-C and all the processes that the plants undergo in response to the created stress in order to protect the plant from damage and repair mechanisms of damaged

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FROM RITUALS TO REVENUE

THE SIGNIFICANCE OF BETEL LEAF (GREEN GOLD) IN ODISHA

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Betel vine (*Piper betle* L.), locally called paan, has been cultivated in Odisha for centuries and remains an integral part of the social, cultural, and economic fabric of coastal districts such as Cuttack, Puri, Khurda, and Ganjam. The state is among the major producers in India, and thousands of farm families depend on betel vine cultivation for year-round income and employment.

Cultural and medicinal significance

Betel leaf holds deep cultural and spiritual value in India, especially in Odisha, where it is offered in rituals, weddings, and festivals as a symbol of purity, prosperity, and goodwill. Beyond tradition, Ayurveda and folk medicine recognize its medicinal importance—it aids digestion, freshens breath, heals wounds, relieves cough and congestion, and acts as a natural antiseptic. Rich in bioactive compounds, betel leaf combines ritual significance with therapeutic benefits, making it both sacred and medicinally valuable.

Scope and livelihood significance

Betel vine offers a short harvesting cycle, with plucking every few days, ensuring continuous cash flow unlike seasonal field crops. Women and youth are actively engaged in training vines, plucking, sorting, and marketing, making the crop a pillar of livelihood security in coastal villages. Local and inter-state demand for fresh leaves in markets like Bhubaneswar, Kolkata, and Hyderabad ensures strong trade opportunities. With value addition—such as graded premium leaves, eco-friendly packaging, and herbal extracts—the scope of betel vine is expanding further.

Problems in cultivation

However, betel vine is a climate-sensitive crop. Farmers face frequent losses from:

- Cyclones and strong winds, which damage trellises and uproot vines.
- Heavy rainfall and waterlogging, leading to leaf rot and reduced quality.
- Rising temperatures and low temperature with cold wind which stress the delicate vines.
- Disease outbreaks like foot rot and leaf spot, aggravated by high humidity.

- As it is a perishable product that require quick marketing.
- Less scope and area for processing, pharmaceutical and industrial use.
- Low market price during off season.
- These risks often wipe out months of investment, leaving growers vulnerable.

Dependence and economic risks

In many coastal pockets, families depend almost entirely on betel vine income. A single cyclone can cause losses worth lakhs of rupees in a cluster, triggering debt cycles. Climate change has made such events more frequent, worsening insecurity.

Betel leaf in Odisha during COVID-19

The COVID-19 pandemic hit betel leaf farming in Odisha hard. With markets closed and transport restricted, the highly perishable leaves could not reach consumers, causing wastage and price crashes. Farmers who rely on daily sales suffered heavy losses, and women engaged in plucking and packing lost wages. Although vehicle passes were issued by government for farm produce, social demand remained low as weddings, festivals, and shops were shut. The crisis exposed the sector's vulnerability, highlighting the need for better storage, transport, and new avenues such as pharmaceuticals, herbal products, and disinfectants to safeguard farmers' livelihoods.

Government assistance in promoting betel vine in Odisha

Assistance for establishing new pan Baroj Unit and also maintenance under State Plan Scheme.

Input subsidy assistance to affected farmers during Cyclones and natural disaster.

The way forward

To safeguard livelihoods, there is an urgent need to:

- Promote climate-resilient structures like shade nets and raised beds.
- Strengthen insurance and disaster relief packages for vine growers.
- Explore pharmaceutical and industrial applications of betel leaf extracts—such as antimicrobials, natural preservatives, and herbal formulations—to create alternative value chains.

Conclusion:

Betel leaf is more than just a traditional crop—it is a vital link between culture, health, and livelihood. In Odisha, it not only sustains rural economies through continuous income but also carries immense cultural and medicinal significance. However, climate risks, market fluctuations, and health concerns associated with its use alongside arecanut and tobacco challenge its sustainability. Strengthening climate-resilient cultivation practices, improving storage and marketing infrastructure, and diversifying into pharmaceutical and industrial applications can unlock new opportunities. With proper support and innovation, betel leaf has the potential to remain "green gold" for Odisha, preserving its heritage while ensuring economic security for future generations.

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PEARLS OF SUSTAINABILITY

THE MANWANI'S JOURNEY FROM PASSION TO ECO-FRIENDLY INNOVATION

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Ashok Manwani, an innovative farmer from Maharashtra, has pioneered eco-friendly freshwater pearl farming in India, transforming a traditionally niche practice into a sustainable and scalable enterprise. With over 28 years of experience, he, along with his partner Kulanjan Dubey Manwani, developed techniques to cultivate pearls without harming mussels, using natural feeds and harvesting only from naturally deceased shellfish. Supported by government schemes like RKVY-RAFTAAR, Ashok established Manwani Innovative Pearl Culture LLP, housing mussel species collected from 12 regions. His innovations include the development of tools for safe mussel handling and the creation of designer pearls in the shapes of religious symbols. His model integrates pearl and fish farming, ensuring good returns, and has been shared through over 400 workshops across 18 states. With a mission-driven approach rather than commercial intent, his work has promoted organic aquaculture, and inspired thousands of farmers to adopt sustainable pearl farming practices.

Pearl known as moon stone (the second precious gem after Diamond) is produced by a living organism called mussels. Pearl farming in India is evolving into a sustainable and income-generating enterprise, thanks to pioneering individuals like **Ashok Hasanda Manwani** and **Kulanjan Dubey Manwani**, founders of *Indian Pearl Culture LLP*, based in Ulhasnagar, Maharashtra. With over 28 years of dedicated work in freshwater pearl farming, the couple has developed a model that is both eco-friendly and replicable, even by small-scale farmers.

Early challenges and passion for pearl cultivation

Ashok, born into a farming family in Akola district, Maharashtra, discovered freshwater pearl farming through articles during his college years. Initial attempts at collecting mussels from the Morna River ended in failure, but his passion remained undeterred. In 2000, he underwent formal training at the Pearl Culture Institute in Bhubaneswar, which laid the foundation for his technical expertise. In 2003, he met Kulanjan at a pearl cultivation training event. The two not only partnered in life but also in their mission to make natural pearl farming accessible and sustainable. Early on, they faced significant challenges: skepticism from the public, lack of awareness, and even living in forests during fieldwork. However, they persevered

through hardships and countless failed experiments.

Innovation and sustainable practices

The Manwani's have always prioritized natural and organic methods. They feed mussels a diet of curd, rice bran, jaggery, and algae. Rather than killing mussels to extract pearls, they wait for mussels to **die naturally**, aligning with their commitment to environmental sustainability.

Their unique innovations include:

- Custom mussel-opening tools and wooden mussel stands that avoid harming the shellfish.
- Techniques to extract up to six pearls per mussel, as opposed to the traditional two.
- Use of recycled plastic bottles in pearl culture, for which they received a national award.
- More than 300 innovative handicrafts made from the shinning dead mussels.
- Shell-craft-based patent, promoting value-added artisanal products.
- Designing pearls into sacred and custom shapes.
- India's first Kissan Portable Mobile Institute (PMI) which can be taken anywhere in the village chaupal, farmer's field, Panchayat, etc. & the farmers can be given practical training on Pearl Culture. This PMI is charged with solar technology. It contains a seating for one person in it.
- Their model is considered the world's first fully eco-friendly pearl farming system using naturally dead mussels, contributing to clean water ecosystems—since mussels filter 30 to 300 liters of water daily.

Innovating tradition: Designing pearls

One of the most distinctive innovations introduced by Ashok and Kulanjan Manwani is the development of techniques to cultivate pearls in customized shapes, including religious icons and sacred symbols. By skillfully manipulating the nucleus inserted into mussels, they have successfully produced pearls shaped like deities,

such as Lord Ganesha, lord Shiva, Om, Sai baba, Christian cross and other symbols which are then crafted into pendants, lockets, and jewellery. Moreover, the ability to shape pearls naturally without harming the mussels reflects the Manwanis' broader commitment to eco-friendly and ethical farming practices.

Growth, Expansion, and Institutional Support

In 2019, they officially registered Manwani Innovative Pearl Culture LLP. During the period of 2020-2023 (COVID-19 lockdown), they secured funding of ₹25 lakhs through RKVY-RAFTAAR (Rashtriya Krishi Vikas Yojana – Remunerative Approaches for Agriculture and Allied Sector Rejuvenation), a flagship scheme by the Government of India supporting agri-startups. They contributed an additional ₹35 lakhs of their own investment toward research and infrastructure development.

Currently, their pearl farming start-up operates within the Banaras Hindu University (BHU) campus under the RKVY-RAFTAAR Agribusiness Incubator (R-ABI) program. Their project is among 40 agri-startups currently supported under this scheme.

The couple manages a 1.5-acre pearl farm, housing mussels from 12 different regions. With a capacity of up to 50,000 mussels in half an acre, the farm supports 4 full-time staff and 16 seasonal workers. They actively train the staff and conduct performance evaluations through observation and mentorship.

Outreach, impact and recognition

Over the last two decades, the Manwanis have:

- Conducted over 400 training sessions and awareness workshops across India.
- Promoted pearl farming in 18 states, including Maharashtra, Gujarat, Karnataka, Bihar, Madhya Pradesh, Uttar Pradesh, and Chhattisgarh.
- Worked in partnership with state agriculture departments to reach grassroots-level farmers.
- Received 8 national awards and over 70 regional and institutional honors, including the Central Institute of Freshwater Aqua-culture's (CIFA) Progressive Farmer Award.

Their efforts have helped popularize pearl farming among farmers, students, artisans, and small entrepreneurs. Stakeholders involved include net makers, shell decorators, and local craftsmen.

Lessons from Experience

Ashok and Kulanjan Manwani emphasize that success in pearl farming requires sustained effort, hands-on learning, and innovation. Drawing from their extensive field experience, the following key strategies are recommended for individuals looking to enter or scale up in pearl farming:

1. Build a Strong Knowledge Base

Begin by acquiring practical knowledge in aquaculture, pond management, and fishery science. Understanding the biological and ecological aspects of mussels and pond systems is essential for establishing a productive setup.

2. Start Small and Scale Gradually

New farmers should begin with small-scale operations to gain experience and reduce risk. As technical proficiency and confidence grow, they can gradually scale up for greater profitability.

3. Implement Integrated Farming Models

Combining pearl cultivation with fish farming enhances income potential and optimizes resource use. This approach typically yields returns within six months and supports diversified farm income.

4. Choose Locally Adapted Mussel Species

Selecting mussel species suited to the local environment improves survival rates and pearl quality. Understanding species compatibility is crucial for success.

5. Adopt Ethical and Sustainable Practices

Use natural and eco-friendly methods, such as feeding mussels organic materials and harvesting only from naturally deceased mussels. Avoid harmful extraction practices to preserve aquatic biodiversity.

6. Leverage Government Schemes and Support

Farmers are encouraged to explore initiatives like the **Pradhan Mantri Matsya Sampada Yojana (PMMSY)**, which offers many subsidies like up to **60% for women**, and **RKVY-RAFTAAR**, which supports agri-startups. These schemes can significantly reduce initial investment burdens.

7. Engage in Continuous Learning

Participation in workshops, training programs, and research collaborations enhances technical skills and keeps farmers updated on best practices. Collaborating with experts, institutions, and experienced practitioners is vital.

8. Build a Network of Stakeholders

Forming connections with fellow farmers, researchers, artisans, and support organizations helps in exchanging ideas, solving challenges, and accessing markets.

By integrating these principles, aspiring pearl farmers can move toward a natural, innovative, and economically viable model of aquaculture that aligns with both environment sustainability and rural livelihood development.

Business Philosophy and Future Vision

Despite their success, the Manwani's are not driven by profit as they stated that "Our mission is to ensure that even the poorest farmer can earn through pearl cultivation. It can be done alongside traditional farming and offers an excellent way to supplement income. There are no shortcuts, only a continuous process of experimentation, adaptation, and knowledge-sharing can lead to success."

This successful pearl farmer is open to queries, discussion and guidance to any young farmer who wants to start pearl farming.

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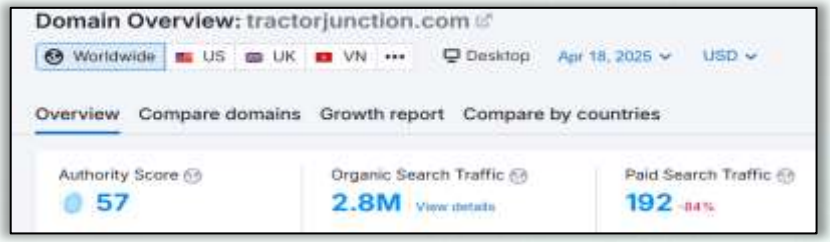
India’s Most Visited Agri-Websites

A quick comparison of the top-performing agriculture websites based on monthly organic search traffic.

Tractor Junction



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