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Strengthening India's Food Security

The Crucial Role of Crop Protection

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SECURING FARMER PROSPERITY THROUGH RESPONSIBLE CROP PROTECTION

India's agriculture sector stands at a pivotal juncture, where productivity must be balanced with sustainability and global competitiveness. Among the many levers that influence farm output and food security, crop protection remains one of the most vital.

Over the years, crop protection practices in India have evolved remarkably—transitioning from traditional, preventive methods to an era powered by scientific innovation, synthetic chemistry, and more recently, biological solutions. The industry has made critical contributions in reducing crop losses, which, even today, can be as high as 20–25% annually due to pests, diseases, and weeds. Without timely interventions, these losses would not only compromise farmer incomes but also threaten national food security.

That said, the sector is facing a new set of imperatives. On one hand, Indian manufacturers have emerged as strong global suppliers of active ingredients, formulations, and generics, holding an important space in international markets. On the other hand, mounting concerns over environmental sustainability, residue management, and farmer safety are reshaping expectations. The emphasis now must be on developing eco-friendly formulations, promoting integrated pest management (IPM), and responsibly introducing biological alternatives alongside conventional molecules.

Equally pressing is the need to strengthen regulatory frameworks and ensure quicker approvals for novel chemistries, while tightening monitoring to curb spurious products that erode farmer trust. Education and extension, too, are critical. Indian farmers—many of them smallholders—must be trained to use crop protection products judiciously, with an eye on optimal dosage, correct timing, and safe practices.

India's crop protection sector is driven by innovation, export opportunities, and digital technologies such as precision spraying, yet bound by the urgency of sustainability and farmer welfare. Our nation's crop protection industry is playing a pivotal role in safeguarding harvests and is also contributing meaningfully to the resilience of our entire food system.

As we engage with these changes, we bring you the September edition of our magazine focused on the crop protection sector. Please enjoy reading the edition that fosters informed dialogue, highlights innovation, and champions responsible growth for the benefit of farmers and the nation alike..

Rajni Shaleen Chopra

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Presenting

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From the CEO's desk

Crop Protection in India

Strengths, Challenges, and the Road to Sustainable Growth

India's crop protection sector has emerged as a pivotal force in ensuring food security and driving agricultural sustainability. As the world's fourth-largest producer of crop protection chemicals, India is well positioned for further growth, innovation, and global competitiveness. The industry plays a fundamental role in safeguarding crops from biotic stresses, such as pests and diseases, which can account for losses up to 40%. The increasing demand for food due to population growth, along with finite agricultural land and water resources, has made crop protection chemicals essential for improving yields and optimizing resource use.

Several strengths underpin the sector's success. Indian companies are engaged in robust product innovation and local manufacturing, making the country the second-largest exporter of agrochemicals globally, with exports touching $5.5 billion in 2022. There is vibrant competition between domestic and multinational firms, driving rapid advancements in research and development and supporting the introduction of new crop protection solutions. Regional leaders in crop protection have emerged in different parts of the country, benefiting from strong supply chains, farmer awareness, and links to export-oriented horticulture. The ongoing shift toward biologicals, integrated pest management, and precision technologies highlights India's potential to become a global hub for sustainable crop protection.

However, the industry faces serious challenges. Heavy dependence on imported raw materials leaves the sector vulnerable to global supply shocks. Cumbersome and outdated regulatory frameworks inhibit innovation and delay product approvals. High GST rates and import duties make quality crop protection expensive for farmers. The proliferation of substandard and counterfeit products due to insufficient regulatory enforcement continues to jeopardize farmer welfare and environmental safety. Policy gaps and limited support for domestic manufacturing also hamper the 'Make in India' vision for agrochemicals.

To realize its potential, India must undertake strategic reforms. Modernizing regulatory systems, expediting approvals for new and environmentally friendly agrochemicals, and incentivizing domestic manufacturing are critical

steps. Digital transformation in laboratory testing and stronger crackdowns on counterfeit products should become priorities. Public-private partnerships can foster knowledge dissemination, farmer education, and adoption of safe, sustainable practices. Increased investment in R&D, especially for climate-resilient and biological solutions, will enable India to address evolving pest challenges and embrace sustainability.

India's crop protection sector stands at a crossroads. Leveraging its strengths, addressing persistent challenges, and charting a forward-looking, sustainable path will be crucial for transforming Indian agriculture, ensuring food security, and securing a resilient future..

Haris Khan

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(7 AUGUST 1925 – 28 SEPTEMBER 2023)

Agriculture Today Group Salutes Prof. M.S. Swaminathan

THE GREEN REVOLUTIONARY WHO REIMAGINED INDIA'S FUTURE

PROF M.S. SWAMINATHAN

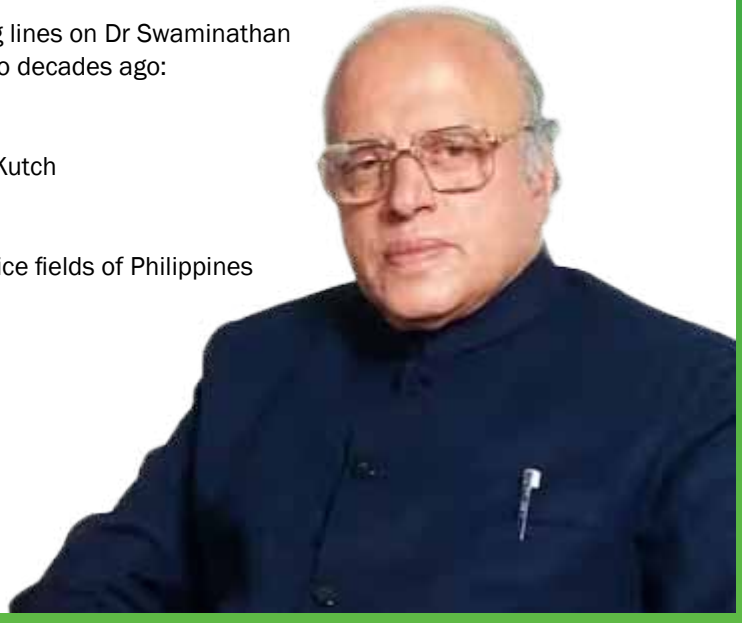
HEART OF BUDDHA AND HEAD OF EINSTEIN

Prof Mankombu Sambasivan Swaminathan (7 August 1925 – 28 September 2023), a geneticist and plant breeder, was a global leader of the green revolution. He has been called the main architect of the green revolution in India for his leadership and role in introducing and further developing high-yielding varieties of wheat and rice.

Prof. Swaminathan powerfully advanced the belief that genuine agricultural advancement is only realized when it preserves the harmony of our planet's ecosystems and upholds the honour, well-being, and dignity of every farmer. He envisioned a future where scientific innovation and human compassion blend to foster a sustainable Earth and ensure that the stewards of our fields thrive with respect and pride.

Padmashri Dr MH Mehta wrote the following lines on Dr Swaminathan after long farm visits with him more than two decades ago:

Swaminathan
Among the farmers of earthquake ravaged Kutch
or the Tsunami affected
fisher women and men
for the luster green farms of Punjab or the rice fields of Philippines
With stars in his eyes
Tools of new knowledge in hands
and God's message of hope in the heart
Moves a man
Combining the heart of Buddha
and head of Einstein -
MS Swaminathan.



Trump Tariff and the Test of India's Agricultural Resilience

In the global marketplace, those who stand tall in the wind will harvest the future

In the high-stakes arena of global agricultural trade, the imposition of 25% tariffs by the United States on select Indian farm exports-announced with characteristic drama by President Donald Trump-is less a catastrophe and more an opportunity in disguise. If handled with foresight and firm resolve, these tariffs could catalyse a strategic reset in India's agri-trade orientation.

The Trump administration, both past and present, has displayed a tendency toward transactional diplomacy – often clouded by spectacle and short-term optics. The latest tariff moves, wrapped in rhetoric about "protecting American farmers" and peppered with dismissive remarks about India's competitiveness, is not a verdict on the health of Indian agriculture. Rather, it is a reminder that global food and commodity markets are increasingly shaped by political noise.

India's agricultural sector - rooted in diversity from Basmati rice to buffalo meat, from fish to fresh and from spices to cotton - is far more resilient than what is captured in tariff schedules. The immediate impact will be felt in certain export lines: rice, processed foods, spices, aquaculture, and some horticulture products.

But the deeper story is one of adaptation Buyer Seller Meets (BSM)

About the **AUTHOR**

Dr. MJ Khan is Chairman of Agriculture Today Group and Special Advisor to the Board, World Agriculture Forum

From Tariff Shock to Trade Pivot

What Indian agriculture needs is not panic, but a pivot. Tariff disruptions must be treated as the price of transition - a stepping stone toward expanding agri-export markets, diversifying product portfolio, upgrading processing and quality standards, and reducing dependence on any single buyer nation.

Just as farmers diversify crops to reduce risk, India must diversify trade partners-strengthening links with Africa, the Middle East, Southeast Asia, and Latin America. Bilateral and regional trade pacts, combined with active agricultural diplomacy, can ensure that temporary storms do not uproot long-term growth. The India-UK CEPA (Comprehensive Economic Partnership Agreement) kind of accords with key nations would give fresh boost to sustainable agro exports.

Rethinking Strategic Dependence in Agriculture

The way forward is *Atma Nirbharta* (self-reliance) in agricultural technology: investing in indigenous R&D, strengthening public–private breeding programs, and scaling affordable mechanisation for smallholders. Multi-sourcing from partners like Israel, Japan, Brazil, and France can further hedge risks. Substantial increase in MAI funds (Market Access Initiative funds provided by the Ministry of Commerce and Industry to support and boost exports) to Rs. 1200-1500 crores or more,

and APEDA (Agricultural and Processed Food Products Export Development Authority) budget to Rs 800-1000 crores will help in taking Indian agro brands to the world through BSM, RBSM (Reverse Buyer Seller Meets), Road Shows etc. Promotion of GAP certification in all export-oriented commodities, orienting our education and extension system to exports, QA (Quality Assurance) labs and logistics, and further strengthening districts as Export Hubs, aligning with the GOI-powered One District One Product (ODOP) initiative shall provide further impetus to these efforts.

Global Buyers: Partnership, Not Extraction

For decades, global agribusiness giants have benefited from India's agricultural capacity—sourcing raw commodities at competitive prices while investing comparatively little in local supply chain and value chain development or value-addition. Whether it is spice processors, grain traders or dairy buyers, the model has often been transactional or extractive, rather than partnership driven. This tariff moment should trigger a rethink. Global buyers who truly value India as a long-term sourcing partner must invest in infrastructure, traceability, and farmer training - not just marketing margins.

Global buyers who truly value India as a long-term sourcing partner must invest in infrastructure, traceability, and farmer training - not just marketing margins

Those swayed by "Trumpian protectionism" may find more comfort elsewhere, but they will also miss out on the unmatched scale and variety that India offers.

The Wider Strategic Landscape

Agriculture is both an economic lifeline and a diplomatic lever. Platforms like BRICS Agriculture Ministers' Forum, th-e International Solar Alliance's agri-energy initiatives, and India–Africa Seeds, Digital Agriculture or Farm Tech partnerships are arenas where India can lead. While geopolitical frictions remain with some countries, selective cooperation – on climate-resilient crops, sustainable fisheries, and digital agriculture – can build resilience into the global food system.

Russia, for example, continues to offer stable fertiliser supplies, & the Gulf is a reliable supplier of gases, reinforcing the importance of diverse relationships.

A Tariff Today, Food Security Tomorrow

In the final analysis, the Trump tariffs are more theatre than threat. They signal America's inward turn, not India's weakness. If U.S. policy remains protectionist, the long-term damage may be more to American importers and consumers than to Indian farmers.

For US demand for market access for its dairy and farm produce, Prime Minister Modi has taken firm stand to protect lives and livelihoods of millions of dependant farmers and their families, than transacting the trade. India's response is calm but assertive: invest in trade diversification, modernise agricultural supply chains, invest in value addition, and deepen South–South cooperation.

In the face of noise, agriculture's roots must grow deeper. Tariffs are storms; resilience is the soil. And in the global marketplace, those who stand tall in the wind will harvest the future.

PROFESSOR SWAMINATHAN AND HIS VISION FOR PLANT PROTECTION, HEALTH, AND SUSTAINABILITY

To most of us, Prof. Swaminathan was a great scientist, humanist, and true global leader. I am blessed to have been associated with Prof. Swaminathan for a long time. Recently, there was an international conference in his honour, and glowing tributes were paid by all.

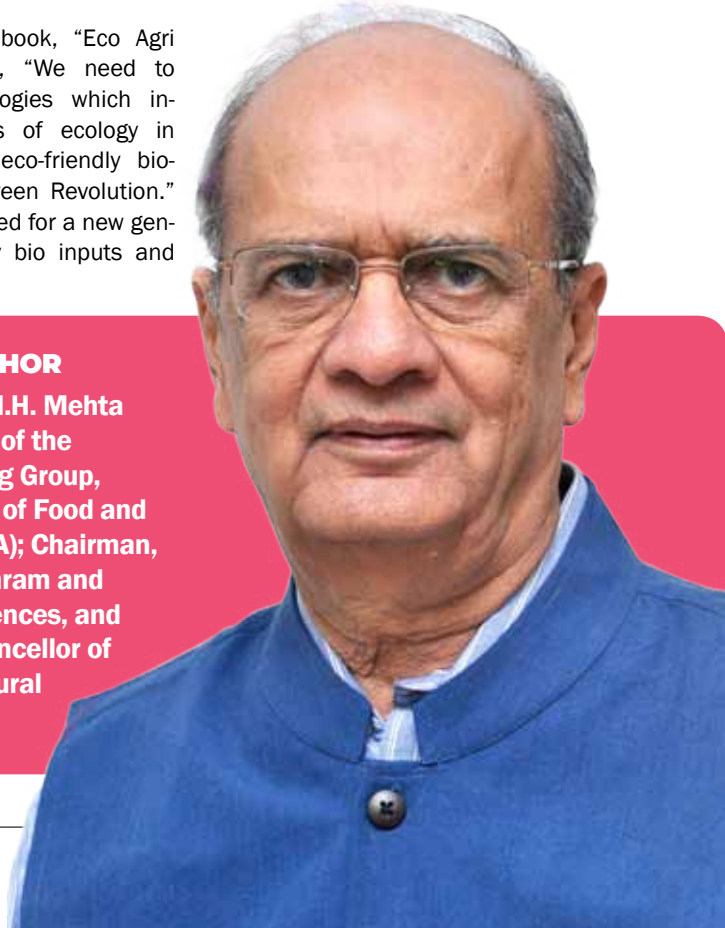
From a brilliant scholar to a visionary global leader, he continuously moved to higher and higher levels of achievement. The nine decades of his life can be divided into four phases – brilliant and dreamy student, devoted scientist and science manager, a visionary and missionary solving the hunger problem, and a global citizen and humanist.

Crop Health – Crop Protection And Biological Software

Prof. Swaminathan's global vision was for an Evergreen Revolution. While encouraging me to write a book—in his foreword for my book, "Eco Agri Revolution"—he wrote, "We need to promote eco technologies which integrate the principles of ecology in technology and use eco-friendly biologicals for the Evergreen Revolution." He emphasized the need for a new generation of eco-friendly bio inputs and said:

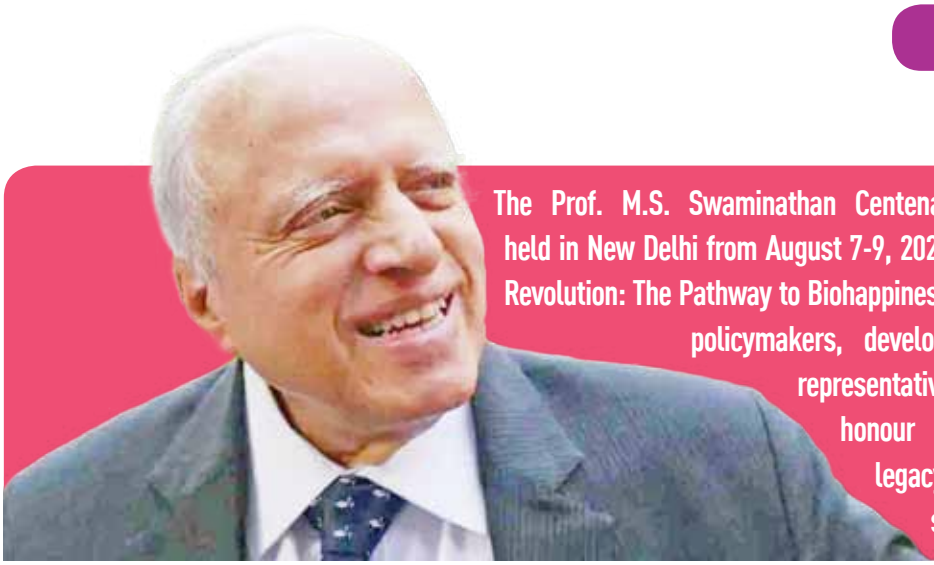
"We have entered the Anthropocene era, where human action will play an important role in shaping the course of development and ecological well-being. Therefore, this is a timely one. We need to promote ecotechnologies which integrate the principles of ecology in technology development and dissemination. We also need to promote the production and use of biological software for sustainable agriculture and food security. Dr. Mehta has shown the way for how we can achieve advances in productivity in perpetuity, without ecological harm."

I entirely agree with you that the Eco Agri Model is the most suited for small farmers. This is also the aim of our bio-



About the **AUTHOR**

Padmashri Dr. M.H. Mehta is the Chairman of the National Working Group, Indian Chamber of Food and Agriculture (ICFA); Chairman, The Science Ashram and Gujarat Life Sciences, and former Vice Chancellor of Gujarat Agricultural University (GAU)



The Prof. M.S. Swaminathan Centenary International Conference, held in New Delhi from August 7-9, 2025, under the theme "Evergreen Revolution: The Pathway to Biohappiness," brought together scientists, policymakers, development partners, and farmer representatives from around the world to honour Prof. Swaminathan's life and legacy and to chart pathways for sustainable farming.

village paradigm of sustainable rural livelihood and ecological security.

Dr. M.S. Swaminathan's World Vision – From Green to Evergreen Revolution

Professor Swaminathan's views and actions for UN Millennium Development Goal No. 1 (MDG), i.e., reducing/eliminating hunger and poverty, were indeed guiding lines. Today, nearly a billion people go to bed partially hungry. For a country like India, a large percentage of children under five are underweight and stunted. Therefore, while talking about "The Future of Agriculture" (Combating Hunger, Cambridge Univ. Press – 2016), he emphasized six areas of urgent action: soil health, water health, eco-friendly bio inputs, appropriate credit and insurance support for farmers, remunerative marketing, and economy of scale for farmers through cooperatives and FPOs. Therefore, he asked me to lead a working group in ICFA. Naming the working group "Eco Agri Revolution for Evergreen Revolution," inspired by his vision, we initiated a roadmap and action plan for the Eco Agri Revolution involving scientists, industries, government and non-government bodies, and farmer groups to take up this mission.

Messiah Of Farmers & Eco Agriculture

During the devastating earthquake in Kutch, he gave confidence and support to new ideas of agricultural rehabilitation. When he personally visited and moved through the farms in Kutch with us—talking to the farm women and men with great love and understanding—we all learned what many years of schooling will not teach. Together, we published our experience in a booklet (Rehabilitation in Earthquake Affected Gujarat—M.H. Mehta & M.S. Swaminathan, GAU Publication 2002), which later became a very useful guide during earthquakes in Nepal and Indonesia.

The nine decades of his life can be divided into four phases – brilliant and dreamy student, devoted scientist and science manager, a visionary and missionary solving the hunger problem, and a global citizen and humanist.

His concept of moving from the Green to the Evergreen Revolution—implying higher productivity without environmental harm—became a guiding light for the policy planners and scientists of the world. The ideas of moving from 'Know-How' to 'Do-How' and "Do Ecology" have become key words. Dr. Swaminathan's deep faith in the Gandhian approach of 'an ounce of action is better than tons of advice' was reflected in his calls to action at the famous Rio Conference: 'Actions Today, Not Promises of Tomorrow.'

Even at an advanced age, his zeal and sense of urgency were amazing. A true 'Bharat Ratna', Prof. Swaminathan's life will inspire present and future generations forever.

Revolutionizing INDIAN DAIRY

Innovations for Productivity, Health, and Environment

Agriculture, the backbone of our economy, is at a critical juncture. Traditional practices, while foundational, are no longer sufficient to meet the demands of a growing population. Degrading natural resources, and a rapidly changing climate are posing further challenges.

This certainly calls for taking steps so that agriculture sector is transformed

About the **AUTHOR**

Dr Meenesh Shah is Chairman, National Dairy Development Board (NDDB)

from input intensive to knowledge intensive, from extractive to regenerative and from isolated efforts to integrated ecosystems.

In this context, the dairy sector which is a vital part of Indian agriculture, must also evolve, and we at National Dairy Development Board (NDDB) are deeply aware of the responsibilities we share in addressing the evolving challenges of sustainability, food security, and climate resilience.

Over the years, we have redefined dairying to align with broader goals of environmental sustainability and resilience. I would just quickly point out a few aspects.

Promotion Of Scientific Breeding Methods

With land becoming increasingly scarce, the focus of Indian dairying must shift from increasing animal numbers to enhancing productivity. NDDB, in collaboration with the Government of India, is driving this change by promoting scientific breeding methods such as genomic selection, sexed semen, and advanced embryo technologies like OPU-IVEP.

Improving animal nutrition is also crucial. NDDB's Ration Balancing Programme (RBP), which has reached 2.8 million animals, helps reduce methane emissions and improves milk yield. Digital tools like the 1962 Farmer App, crop residue management, Fodder Plus FPOs are supporting small farmers in adopting balanced feeding and better fodder practices.

The indiscriminate use of antibiotics in livestock is contributing to antimicrobial resistance (AMR), a serious public health threat. To address this, NDDB is promoting Ethno-Veterinary Medicine (EVM), a cost-effective and traditional approach using locally available ingredients to treat around 30 common bovine ailments. EVM significantly reduces antibiotic use, helping to combat AMR. Additionally, India's NADCP aims to control diseases like FMD and Brucellosis.

We are also tackling climate challenges through innovative manure management and clean energy solutions. NDDB has installed over 27,000 small flexi biogas plants under the Zakariyapura Model and launched large-scale plants in Varanasi and Banaskantha. These efforts not only provide clean energy and organic fertilizers but also reduce greenhouse gas emissions.

Through extension and education, the dairy farmers are being continuously oriented on the field application of scientific animal husbandry and dairying practices. Training and capacity building have remained and will remain a critical input for sustainable growth in dairy sector

In alignment with India's climate goals, NDDB has initiated pioneering efforts to integrate dairy farmers into carbon markets, thereby enabling them to benefit directly from their climate-positive actions. Under one such unique initiative, carbon credits generated from over 1,000 household-level biogas plants have been successfully transferred directly to farmers' accounts, marking a transformative step in climate finance inclusion for smallholders.

Digital Infrastructure to Support Livestock Management

Under the National Digital Livestock Mission (NDLM), Government of India and NDDB is building digital infrastructure to support livestock management through animal ID, health records, and integrated services.

Investment in affordable, reliable, and clean energy infrastructure is crucial for sustainability in the dairy sector. NDDB is actively promoting the use of solar energy across the dairy value chain, including solarisation of Village Dairy Cooperative Societies (DCS), and use of solar PV and Solar Thermal Energy for milk chilling and processing. Technologies like Concentrated Solar Thermal (CST) are helping dairy plants across India reduce energy costs and environmental impact.

Through extension and education, the dairy farmers are being continuously oriented on the field application of scientific animal husbandry and dairying practices. Training and capacity building have remained and will remain a critical input for sustainable growth in dairy sector.

Redefining agriculture and dairying require collective action. NDDB remains committed to building a climate-smart, nutrition-sensitive, and resilient dairying system—but this transformation needs participation from scientists, policymakers, entrepreneurs, and most importantly, farmers. I am sure deliberations in this conclave will provide critical inputs in this regard.

Together, let us build a future where agriculture and dairying are not just productive, but sustainable and one that nourishes both people and the planet.

BIOPESTICIDES, BIOTECHNOLOGY, AND BEYOND

NEW FRONTIERS IN CROP PROTECTION

About the **AUTHORS**

Dr Ch Srinivasa Rao, Director, ICAR-Indian Agricultural Research Institute, with Dr M S Saharan, Dr M K Dhillon and Dr Pankaj of IARI

Agriculture has been the mainstay of the Indian economy for centuries, providing livelihood support to millions of people across the country. India's population increased by a factor of 4.33 while its food production rose by a factor of 6.61 between 1947 and 2023, which indeed speaks volumes about the global success of the Indian agricultural production system—thanks to appropriate government policy support and the hard work of farmers and scientists. There is no denying the fact that crop protection has played a major role in the success story of food self-reliance. Among the various options to improve the per unit yield of crops, successful management of the large array of pests and diseases stands out. Protection of crops from pests and diseases is expected to increase crop yield manyfold compared to the increments that can be expected from advanced technologies, including genetic improvement through conventional and non-conventional approaches, as the crop loss protected is yield gained.

A recent global-level study on crop losses in the main food security hotspots (including the Indo-Gangetic plains) for five major crops showed significant losses due to pests (weeds excluded): 10.1–28.1% for wheat, 24.6–40.4% for rice, 19.5–41.1% for maize, 8.1–21% for potato, and 11–32.4% for soybean. It is projected that losses to insect pests and pathogens will increase with global warming. The 'arms race' between pests and hosts is real.

New Biotic Stresses

Changing situations, including shifting farm practices, are inadvertently inviting new biotic stresses that again limit productivity. The traditional approaches of exclusion, eradication, sanitation, chemical/biological control, or even host resistance may not be useful in their ritual formats, but the same principles, though still applicable, must be suitably modified to meet the current challenge of pests and diseases.

In the post-Green Revolution era, the pest scenario of crops has undergone drastic changes. Pest problems in terms of the number of species, frequency of outbreaks, and entry of invasive species have intensified. Crop protection is crucial to food and nutritional security and plays a major role in achieving production targets. The task becomes even

more challenging in the current scenario of climate change, globalization of agricultural trade, and continual emergence of new pests and diseases.

In the last two decades, nearly 15 pests and diseases have either entered India or minor pests have become silent killers of crops. Control of crop losses due to insect pests requires a suite of different management measures, including chemical insecticides, which have thus become important tools. Currently, the global chemical pesticide market is about $50 billion and is growing at 3.5% annually. The biopesticide market, however, is about 4–5% of the chemical pesticide market but is growing at a faster rate of about 15%.

Additionally, insect- and disease-resistant varieties have been deployed as a principal method of pest control in several parts of the world, but progress has been slow. Current strategies of crop protection, though they vary widely between the inflicting agents, primarily encompass conventional methods such as quarantine systems to check the entry of insect pests and pathogens, sanitary measures like clean cultivation, crop rotation to restrict plant-to-plant flow or survival of propagules, use of resistant crop cultivars, and chemical and biological control agents.

Crop Protection Strategies

Given the current compelling challenges, crop protection interestingly presents many dynamic opportunities for novel management of biotic stresses. Pest and disease management is an evolving systems approach that accommodates all need-based innovations, concepts, and policies regarding various management practices. Fortunately, advances in plant protection sciences—such as biotechnology, molecular biology, digital science, mechanization, and new, safer chemistry products in the 21st century—have opened several avenues for strategic deployment of novel technologies for crop protection in the field.

While chemical control and transgenics have long dominated crop protection, advocates of non-chemical and non-transgenic approaches are promoting organic crop health management. The judicious use of pesticides must be ensured to produce safe and quality food, prevent environmental contamination, promote exports, and reduce the cost of production, thereby increasing farmer income. Increasing concern for safer chemicals has led to priority registration and use of new-generation chemicals. Likewise, conservation and enhancement of natural bioagents for pest suppression should be an essential approach.

In the future, farmers will have access to resistant cultivars for planting and new tools to manage pests and diseases. For most farmers, cost-effectiveness and compatibility with existing practices are key factors determining adoption

Biomolecule-Nanomaterial Complexes

To augment such natural management strategies, large-scale production of biocontrol agents through entrepreneurship development is urgently required. Furthermore, discoveries in molecular biology and nanotechnology (as carrier molecules) have resulted in products that can be used for topical applications of dsRNA on crop plants. The concept of biomolecule-nanomaterial complexes could herald the next generation of agrochemicals for pest management, as they would be pest-specific and have minimal ecological and environmental impacts. Pre-import and post-entry quarantine require need-based international cooperation and collaboration to address exotic pests and pathogens.

With new communication systems, precise detection and diagnosis alerts of any pest at one location in the country can be transmitted within minutes throughout the crop area. Chemical communication among insect pests via pheromones, AI, IoT, and ML are some of the new technologies transforming crop protection. Next-generation climate-resilient protection technologies—such as antimicrobial peptide formulations, recombinant antibodies, dsRNA, gene silencing, and CRISPR-Cas editing—are revolutionizing genetic transformation beyond Bt technology.

JOINT VENTURE OF INDIAN FARMERS FERTILISER COOPERATIVE LIMITED AND MITSUBISHI CORPORATION (IFFCO-MC)

A DECADE OF DEDICATION TO INDIA'S FARMERS

10 Years of Growing Together

In the heart of every Indian farmer lies a dream of a prosperous harvest, a healthy field, and a secure future for their family. It is with this dream that IFFCO-MC began its journey in 2015, from the collaborative spirit of Indian Farmers Fertilizer Cooperative Limited (IFFCO) and Mitsubishi Corporation, Japan. IFFCO-MC was founded with a singular purpose: "To empower India's farmers with access to high-quality, affordable crop protection solutions".

As the company celebrates 10 years of unwavering service to Indian Agriculture, its story is not just about business growth but about nurturing hope, strengthening rural communities, and walking hand-in-hand with millions of farmers across the nation.

Founding Philosophy & Vision

At the core of IFFCO-MC lies a vision as grounded and purposeful as the soil.

About the **AUTHOR**

Mr Manoj Varshney is the Managing Director and Chief Executive Officer (MD and CEO) of IFFCO-MC

Vision

"To enhance farmer income by providing good quality crop protection products at reasonable prices."

This philosophy remains the anchor of all strategic decisions, from product development to distribution. The company believes that real transformation happens when farmers can rely on scientifically proven, yet economically viable solutions.

Mission

a. To develop a channel for farmers to access genuine products and knowledge with a focus on safety, health and environment.

b. To identify and provide a new generation of crop protection products for farmers.

Strengthened Product Portfolio Including New Category of Agri Biologicals

IFFCO-MC's product strength lies in its comprehensive portfolio of over 85 agrochemical solutions, designed to address the evolving needs of Indian farming. The range spans:

- Insecticides
- Herbicides
- Fungicides

Plant Growth Regulators (PGRs)

A BRAND THAT CARES – FOR TODAY & TOMORROW

IFFCO-MC is not just riding on its past achievements it's looking ahead with resolve. As the Indian agriculture sector faces climate uncertainty, pest resistance and productivity pressures, IFFCO-MC is evolving in real-time to be a resilient, responsive force.

By investing in biologicals, digital precision, and community impact, the company continues to earn not just revenue but respect and gratitude from the people who matter most: India's farmers.

Biologicals (New & Expanding Category)

The Biologicals category marks a visionary step toward sustainable and residue-free farming. Rooted in eco-friendly practices and Japanese precision, these biologicals are developed to enhance soil health and ensure long-term agricultural sustainability. With this, IFFCO-MC is not only delivering protection but also nurturing the land for generations to come.

Distribution Reach – Nationwide, Reliable, and Farmer-Friendly

IFFCO-MC's distribution strategy is as inclusive as its mission. Its supply chain ensures genuine, timely access to products via:

- IFFCO Bazaar, Cooperative Society, IFFDC
- Farmer Service Centers (FSCs), CSC VLEs etc.

4. Fixed MRP Policy – Ensuring Trust Through Transparency

IFFCO-MC follows a Fixed MRP policy across India, ensuring every farmer be it in Punjab or Tamil Nadu pays the same transparent and fair price.

This approach:

- Protects farmers from market exploitation
- Builds trust through consistency
- Ensures equal access to quality crop solutions

Farmer Welfare – Kisan Suraksha Bima Yojana (KSBY)

Every purchase of an IFFCO-MC product is accompanied by Kisan Suraksha Bima Yojana (KSBY), a free accidental insurance cover of max Rs. 1 Lakh on the purchase value of Rs. 15000 by Indian farmers.

In 2025–26 alone:

More than 100 claims were honoured across 11 states. Since inception, Rs.2.37 crore has been disbursed to 239 families who faced the loss of their loved ones.

This integration of products with protection reflects a deeper empathy where a brand doesn't just support productivity but also shields livelihoods in their most vulnerable moments.

India-Japan Synergy for Smarter Farming

The IFFCO–Mitsubishi partnership blends IFFCO's grassroots agri-expertise with Mitsubishi's global innovation and precision.

Together, we deliver next-gen, sustainable agro-solutions that meet today's challenges and prepare for tomorrow's needs.

Impact Over a Decade – Touching Millions

Over 10 years, IFFCO-MC has:

- Earned the trust of millions of farmers
- Built strong ties with 28,00+ PACs – As trusted channel of more than 12000 business partners.
- Achieved nationwide crop coverage
- Fostered loyalty through quality, consistency, and care
- Made presence in almost every climatic zone & 18 states

CSR Commitment – More Than Business

IFFCO-MC believes growth means uplifting everyone. The company has been delivering impactful CSR programs that made a tangible difference:

Medical Camps in Haryana, Punjab & MP benefiting 3,000+ individuals

Water Coolers & Filters installed in high-footfall rural areas in the state of U.P.

NGO Support for food, shelter, medical aid for senior citizens and vulnerable groups

These are not just corporate gestures they are acts of compassion, reinforcing the company's connection with the grassroots.

Future-Ready Roadmap

IFFCO-MC's future vision is ambitious yet rooted in farmer-first values. The company aims to grow its market share from 1% to 5%, guided by:

Expansion of Biologicals and eco-friendly solutions

Integration of digital farming tools

Crop-specific formulations to combat resistance

In the time to come, with investments in R&D, on-ground trials, and agronomic support, IFFCO-MC is evolving from a product provider to a full-spectrum farming solutions partner.

Governance & Leadership

IFFCO-MC is steered by a professional team blending agricultural expertise with business strategy. With leadership drawn from both parent organizations, decision-making is focused on cost efficiency, farmer welfare, sustainable development and market-responsive innovation.

Their collective experience ensures IFFCO-MC remains agile in a rapidly changing agro-economic landscape.

A Promise That Grows with the Soil

A decade is not just a measure of time, it's a testament to trust, purpose, and impact.

For IFFCO-MC, these 10 years reflect a deep-rooted journey of standing shoulder to shoulder with India's farmers, through every season, every challenge, and every victory.

As the company moves into its next chapter, it carries with it:

- A commitment to innovation that is both cutting-edge and accessible
- A vision for inclusive growth that uplifts every stakeholder, primarily farmers
- And a soul deeply connected to the soil it serves. -

FERTIS The Progressive Farmer's Choice

Proprietary Crop Management Program
designed to Maximize Farmer's Income and Produce Quality
Pro Rise

Rise through ProRise

Fertis is a fast growing technology company focused on Research, Development, and Commercialization of Novel Crop Nutrients, Microbes and Protectants.

Fertis is a culmination of over two decades of Research in Organic and Inorganic Molecular formulations, aimed at enhancing Crop Yields, Quality, Reducing Pesticidal Residues and enhancing Nutritional Value in the Produce Quality.

The company has several patents in these areas both in India and Globally

act ACTIN

Proprietary endophyte and soil microbial formulation (crop probiotics)

Multiple fungal and bacterial diseases occur at different stages during the cropping cycle requiring multiple applications of varied Pesticides.

Pesticide residue causes serious health implications to human and environment, which drides demand for low residue produce. It is known fact that by merely reducing pesticide usage would result in crop losses and affect the quality of produce.

act imphact

Proprietary Soil and Nutrient Activator

drip drenching

Rapid nutrient losses in the applied fertilizers and nutrient availability in saline alkali soil limits the yield

Rapid nutrient losses and nutrient fixation in soil results to low fertilizer use efficiency.

Imphact improves cation exchange capacity, corrects pH of alkaline soils, Reduces soil salinity and increases nutrient use efficiency. Increases water penetration capacity of soil and also helps unclog drip lines in drip irrigation.

ZETOL SELECT

Crop Specific, Stage Specific Water Soluble Fertilizer for Fertigation & Foliar

ZETOL SELECT are crop and stage specific and developed specifically for high yielding crops to meet the demands of nutrients at each stage of crop growth. They contains a full spectrum of 100% premium water soluble nutrients.

tracs Tracssure

Proprietary and Full Spectrum Essential Micro Nutrient (Soil & Foliar) Formulation

Increasing micronutrient deficiencies are impacting crop yields and quality. Micro and Secondary nutrients required for high yielding crops are fundamentally different in number and volume from low yielding varieties and hybrids.

ECOL AID MICROCYTE

Reduces **BIOTIC STRESS**

- Enhanced Nutrient Use Efficiency
- Shield against disease causing soil borne pathogens and nematodes
- Superior Yield with Quality.
- Use along with **IMPHACT** to maximize crop yields and produce quality of root zone.

ECOL AID NITROCYTE

Activates Cuticle & Cell Wall Synthesis

- **Activates plant defense genes** that get suppressed due to nitrogen fertilizer use.
- **Strengthens the plant's outer layer** (cuticle and cell wall), making it tougher and more resistant.
- **Reduces sucking insects and disease attacks** by forming a strong physical barrier, resulting in less number of Pesticide applications.
- **Improves yield and quality** by protecting crops from abiotic stresses like: Drought, High or low temperatures, Damage from strong winds or heavy rains, Moisture loss due to transpiration and Harmful UV rays.

dormulin

5th Generation Nutrients

Multiple fungal and bacterial diseases occur at different stages during the cropping cycle requiring multiple applications of varied Pesticides.

Pesticide residue causes serious health implications to human and environment, which drives demand for low residue produce. It is known fact that by merely reducing pesticide usage would result in crop losses and affect the quality of produce.

trail Trail Blaze

Advanced Seed Fertilizer

Full Spectrum, High Performance, Proprietary Seed Fertilizer.

- Ensures uniform and superior germination of seeds
- Unique patented formula helps in enhanced growth & vigour of the seedling
- Better Root & Shoot growth
- Improves the Seed & Seedling performance
- Better crop stand ultimately results into higher yields

ZETOL SURE

Stage Specific Water Soluble Fertilizer for Fertigation & Foliar

Provides the World's Most Advanced, Efficacious, Fast Acting, Easy to Use and complete water soluble fertilizers solutions designed to meet the nutrient demands at each stage of cropping cycle to maximize crop yields and returns.

FERTIS INDIA PVT. LTD.
Toll Free No. 1800 20 35 350 | Email: marketing@fertis.in

NAGARJUNA GROUP

ACCELERATING INNOVATION FOR GLOBAL FOOD SECURITY

About the **AUTHOR**

Mr Feroz Sheikh is Chief Information & Digital Officer, Syngenta Group

We are at a technological inflection point for agriculture. It has been driven by the emergence of new digital technology (particularly AI) on one side and increasing pressures on the global agricultural food system on the other. These are things like climate change, geopolitical instability as well as the urgent need for increased yields that don't require further inputs that can have damaging environmental effects.

Despite significant advancements in agricultural technology and rapid change in recent years, the transformative impact of these developments often seems just out of reach. What triggers such inflection points? Consider a pivotal moment in Indian agriculture: a legislative change that allowed the widespread use of drones. This wasn't an innovation born solely from within the sector; rather, it was the convergence of available technology with new regulations. Suddenly, vast areas were opened for drone usage, enabling countless farmers to employ these devices for precision spraying, weed detection, and land scouting. This example underscores how external factors, like policy shifts, can catalyse profound advancements in agriculture, leading to substantial and practical benefits for the farming community.

Transformation Through Technology

There is so much sophisticated technology in the agricultural sector that could well be transformative, and while we respond to shifts in politics and policy, we must prepare for other potential sources of what might catalyse the inflection point. Technology companies like Syngenta have a crucial role to play. First Syngenta's scale and capacity mean that we don't need to chase hype but can test new technology carefully and strategically, scaling up innovations that offer good business options as well as value and – most importantly

–precise advice and actionable insights for our growers.

Secondly, we have a vast amount of data that can be used to improve our current digital services, and this is something that has driven our work as a technology company for many years now. The crop-wise digital platform is a world-leading agronomic brain, and the new tools of AI and ML mean that it is easier than ever to interact with that brain.

Thirdly, we can focus on partnership. As I say again and again, when you are working on the world's biggest and most complex problems you can never do it alone. When it comes to finding new tools, we can't just think of ourselves but must proactively build the ecosystem of new technologies that allows for access, adoption and scalability on a global scale. This means taking a holistic view of what is needed by growers.

Higher Productivity With Sustainability

A key word for discussions of ag-tech is autonomy – but this isn't just about autonomous technology or farming equipment, but empowering growers to be autonomous, to find new and effective ways of maximizing their yields and improving the sustainability of their farms.

Our modern agriculture platforms in China and Southeast Asia are helping farmers make better decisions when it comes to the use of inputs – seeds, chemistry, biologicals, or even deploying the right kind of robotics and agronomy protocols. Each of these MAP centers acts as a hub for providing access to the latest technology – AI, digital and data.

If I take a step back and talk about the problems that agriculture faces today, the prime issue is that humanity does not have enough food to put on the table for everybody. By 2050, we will need 600 million hectares of additional land. That is almost four times the agricultural land in Europe. We need all of these kinds of innovations – robotics, vertical farming, drones – to really change how agriculture works. How farmers globally - smallholder farmers in China, Southeast Asia as well as large

The Cropwise digital platform is a world-leading agronomic brain, and the new tools of AI and ML mean that it is easier than ever to interact with that brain

farms in the West – pursue agriculture. One of the key technologies there is drones so that the farmers can make better decisions.

Syngenta is an innovation company. What we do at the lab is look at the next

blockbuster molecule, the next medicine that can help the plants fight emerging diseases or fight the effects of climate change. This applies to chemistry – discovering new molecules, looking at the efficacy of that molecule, and what it would take to build something like that. Or genetics - analyzing the traits for the next seed variety that is going to be more heat tolerant. Which traits do we need to promote, what kind of gene editing protocols to follow to really help bring that kind of innovation forward.

Almost our entire R&D pipeline is accelerated through AI. Helping reduce the time it takes to bring these new genetics, new chemistry, in the hands of the farmers.

AI is going to be a fundamental leveller of access to technology. The average age of a smallholder farmer is 68 years. When you look at China, Japan, South-East Asia, you have small farms, aging population, lack of access to technology. What a 1000-hectare farm in the US can afford is not comparable to what the smallholder farms can do. That is where I think that AI can really act as a leveler. An agronomy co-pilot can give the best answer to a farmer who can't afford a hire a specialist agronomist. That's one of the areas which I feel very positive about – the impact of AI on smallholder farmers in the South-East Asian region. In this region, agriculture will make a big leapfrog powered by AI. Simple advice can really help improve the yield for these farmers. Imagine the power of AI in their hands, in their native language – is a game changer.

EMERGING TECHNOLOGIES IN CROP PROTECTION

GOVT INITIATIVES AND SUPPORT

Crop protection technologies are critical for boosting India's agricultural productivity as envisaged under the government's efforts for doubling farmers' income. This is also important for achieving the government's vision of "Atma Nirbhar Bharat" and "Viksit Bharat."

The New Age of Crop Protection

The emerging technologies in the crop protection domain are primarily based on biotechnologies, nanotechnologies, AI, and drone technologies.

Biotechnology and Genetic Engineering: The most important technology under this category is gene editing through CRISPR-CAS9, which involves precise modification of the plant genome to impart disease and pest resistance. Plants can also be engineered to produce antimicrobial peptides and compounds, providing in-built

About the **AUTHOR**

Dr Jitendra Kumar is Managing Director, Biotechnology Industry Research Assistance Council (BIRAC)

resistance against pests and diseases. The third category is biological solutions such as bio-pesticides, bio-stimulants, and microbial inoculants, which improve soil health, build plant resilience, and lower chemical residues in food chains. At the same time, advanced seed treatments are extending early-stage protection, enabling stronger crop establishment.

Nanotechnology-based solutions: Nanomaterials can be used to deliver pesticides more effectively, thereby reducing the amount of pesticides used, and novel nanomaterials are being discovered that can act against pests and pathogens.

AI and Drone Technologies: Solutions under this category are also revolutionizing crop protection. Drone-based spraying and surveillance improve precision, reduce wastage, and minimize farmer exposure to chemicals. Similarly, AI and machine learning are being used to predict pest outbreaks, analyze field data, and guide targeted interventions. Robotics, such as IIT Kharagpur's mobile pest-management robot, showcase how automation can bring precision to farming.

Emerging Technologies

Other innovations include satellite and geospatial technologies for sowing and pest monitoring, and real-time AI-IoT disease detection systems like the one developed by IIIT-Allahabad. Gene editing and bioengineering are further creating pest-resistant seed varieties, reducing long-term dependency on pesticides. Collectively, these technologies are driving a paradigm shift from reactive protection to proactive and predictive management.

India's Policy and Program Support

The Bio E3 policy initiated in 2024 envisages a transition from chemistry-based solutions to those based on bio-based solutions. This means the Government's increased support to encourage innovations leading to bio-based agrochemicals and fertilizers as far as crop protection in agriculture is concerned. One of the objectives under this policy is also to support the creation of biomanufacturing hubs and bio-foundries, including Bio AI hubs. It is expected that many start-ups working on innovations in crop protection can use this infrastructure to scale up their innovations, which is currently a major bottleneck in the success of start-ups in the country.

Emerging crop protection technologies gravitate towards environmental sustainability and the circular economy, which aligns well with GOI's recent announcement of the Bio E3 policy

Recognizing the potential of AI and robotic technologies, the Government of India has rolled out a series of programs to encourage adoption. The Digital Agriculture Mission (2021–25) integrates AI, drones, blockchain, and IoT into mainstream farming. Under this, platforms like AgriStack and the Krishi Decision Support System provide farmers with real-time advisories using data on soil, weather, and crops.

Innovation-driven entrepreneurship is being promoted through the RKVY-RAFTAAR programme, under which more than 1,700 agri-startups have been supported, including those in crop protection. The recently launched Agri Accelerator Fund adds further encouragement to this ecosystem.

Important Govt Initiatives

On-ground deployment is being accelerated by the government's drone schemes, including Namo Drone Didi, which equips women self-help groups with drones for agricultural services. Subsidies under the Sub-Mission on Agricultural Mechanization (SMAM) also ensure affordability.

For surveillance, the National Pest Surveillance System (NPSS) leverages AI/ML tools to detect and manage outbreaks. Complementing this are grassroots networks like Krishi Vigyan Kendras (KVKs), which serve as conduits for technology transfer to farmers.

In research and breeding, the Union Budget 2025 pledged investment in gene editing, creation of pest-resistant varieties, and expansion of India's gene bank. Longstanding initiatives such as Neem-coated Urea, Soil Health Cards, and climate-resilient agriculture programs add further depth to this framework.

Support Through BIRAC

The Department of Biotechnology, through its PSU Biotechnology Industry Research and Assistance Council (BIRAC), has since its inception in 2012 supported innovations in the deep-tech area of biotechnology, including agritech. Its flagship programme is the Biotech Ignition Grant (BIG), which supports innovations through grant funding. This grant is meant to establish proof of concept. BIRAC has also created a whole battery of funding support programmes to take technologies from the proof-of-concept level to commercialization. For instance, the Small Business Innovative Research Initiative (SBIRI) and the Biotechnology Industry Partnership Programme (BIPP) are geared towards taking technologies to TRL level 7.

BIRAC also has a Product Commercialization Programme (PCP) to fund innovations to reach commercialization stages. In addition, BIRAC has funding schemes based on equity sharing to encourage risk funding. Many start-ups working on technologies for crop protection have been funded under these schemes. BIRAC has also partnered with the Bill and Melinda Gates Foundation to establish the Grand Challenges India programme to fund innovations having social impact, including those in agritech. At the heart of BIRAC's innovation ecosystem is the BioNest incubation support, through which close to 100 plug-and-play facilities have been established to provide incubation support to start-ups. Many of these BioNest centres are established in agricultural universities, which nurture innovations in agritech, including those working on crop protection.

Recent policies and programmes of the Government can potentially propel India onto the global innovation map, including in the areas of crop protection.

About the **AUTHOR**

Mr Rajesh Kumar Aggarwal is Managing Director, Insecticides (India) Ltd

BOOSTING INDIA'S CROP PROTECTION WITH POLICY AND INNOVATION

Standing at the crossroads of climate uncertainty and rising food security demands, India's agricultural sector is experiencing a significant shift, driven by a robust policy push and technological innovations aimed at ensuring enhanced crop productivity and resilience. The Government of India has made notable strides in the past years through a series of forward-looking schemes and sectoral advances that are reshaping the agricultural landscape. These developments offer both an opportunity and a responsibility to innovate, support, and partner with India's farmers in this new era of sustainable agriculture.

Policy Push: Government as an Enabler

The Union Budget 2025–26 set a definitive tone for India's agricultural vision, resilient, tech-enabled, and farmer-first. Schemes like the revamped Pradhan Mantri Fasal Bima Yojana (PMFBY) and the extension of Weather-Based Crop Insurance Schemes have helped de-risk farming, especially for small and marginal farmers vulnerable to erratic weather and pest outbreaks. As the scheme enters its ninth year, the renewed focus on faster claim settlements and mobile-based enrolments is fostering greater trust and wider adoption.

Another key initiative is the rollout of the New Agricultural Policy 2025, which

emphasizes climate-smart agriculture, sustainable crop protection, and digitally driven decision-making. This is first policy to bring crop insurance, soil health management, and precision pesticide use under a common framework, incentivizing farmers to adopt integrated practices. This reform aims to transition 30% of the nation's farms to sustainable practices by 2030.

Additionally, schemes under the National Mission on Sustainable Agriculture (NMSA) and state-level Integrated Pest Management (IPM) programs are being aligned with PM-Kisan and Kisan Drones initiatives, creating a policy ecosystem where subsidy, training, and market linkage are interwoven.

With over 86% of Indian farmers being smallholders, access to affordable, safe, and effective crop protection needs to be central to all policy and industry efforts aimed at enhancing agricultural resilience and productivity. Recent government schemes like PM-Kisan Samman Nidhi, Agristack development, and Credit Access Reforms have improved the purchasing power and digital accessibility of these farmers, making it easier to adopt better crop protection solutions. In this backdrop, the role of agri-input companies has also evolved. We are no longer just manufacturers; we have evolved into educators, enablers, and ecosystem partners.

Fuelled by Government policies and technological innovations, India's agriculture sector is undergoing a much-needed evolution

The Ministry of Agriculture has actively promoted bio-rational pesticides, next-generation insecticides, and IPM practices in collaboration with the industry. These policy frameworks are helping shift the narrative from conventional, blanket pesticide use to data-driven, crop-specific, and environmentally safer protection methods.

For instance, under the Plant Protection/IPM Scheme, states like Meghalaya have reported significant improvement in yield in pilot clusters where IPM techniques, including the use of bio-pesticides and pheromone traps, were implemented. The Centre has now encouraged other states to scale similar programs, with the private sector playing a pivotal role in research, formulation, and farmer outreach.

Technological Advances: Precision, Biologics, and Digital Inclusion

One of the most promising developments in 2025 has been the integration of digital tools in crop protection. From satellite-based crop monitoring to AI-powered pest prediction models, the future is about precision and proactivity. Government-backed weather forecasting tools are being integrated into mobile apps, enabling real-time alerts on pest outbreaks or disease likelihood.

Rapid advances in technology and product development, spurred by policy and market demand, are opening new horizons for farmers:

Genome-Edited and Climate-Resilient Crops: ICAR's release of CRISPR-based rice varieties in 2025 (such as DRR 100 Kamla) delivers 10–15% higher yields while using 20% less water, a critical adaptation with direct benefits for rice-dependent states facing climate stress.

AI, Satellite, and Sensor-Based Agriculture: The scale-up of AI-driven crop monitoring, digital weather advisories, and data-driven soil health analysis is ushering in a new era of precision agriculture. By reducing input wastage and optimizing protection schedules, farmers can now more confidently maintain high productivity and resilience, even in uncertain conditions.

Sustainable Crop Protection Solutions: The market for biological crop protection products is expected to grow at a 16% CAGR in 2025, reflecting both regulatory incentives and rising farmer awareness of eco-friendly alternatives. This shift not only addresses market demands for residue-free exports but also ensures lower input costs and improved field health over time.

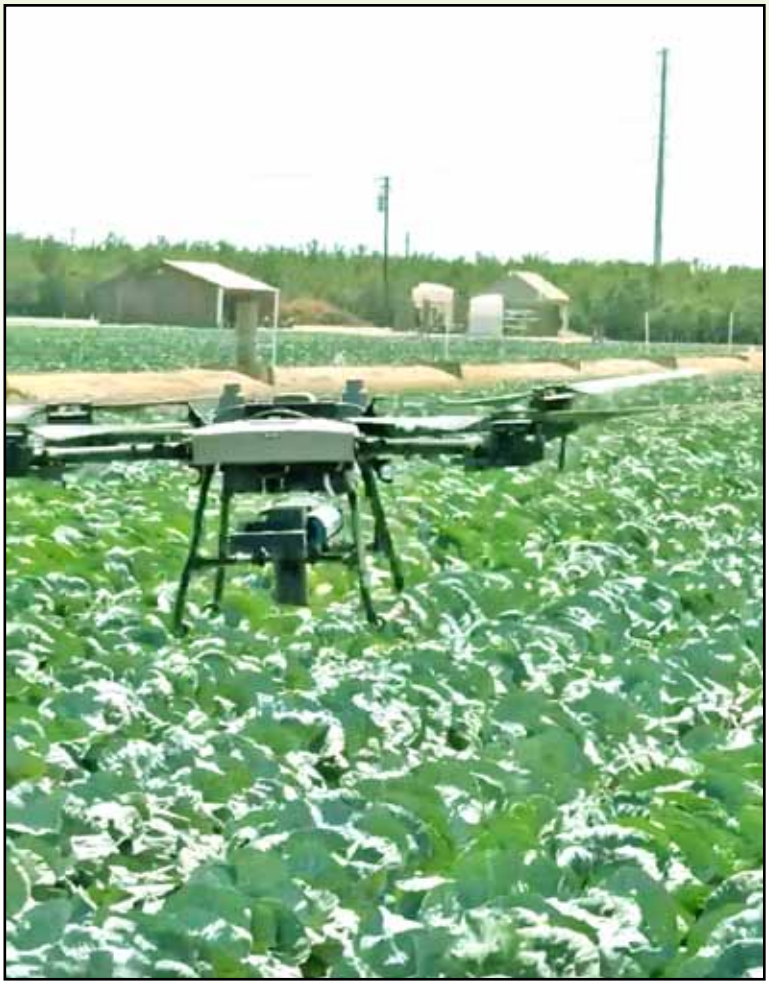
Drone Technology and Digital Marketplaces: Ongoing regulatory support, including continued approval for drone-based agrochemical application, is set to expand this critical technology's accessibility. Digital platforms for input purchase, advisory services, and product sales are accelerating the democratization of agritech.

Looking Ahead

2025 marks a watershed moment for Indian agriculture. Fuelled by Government policies and technological innovations, India's agriculture sector is undergoing a much-needed evolution from input-intensive to knowledge-intensive, from risk-prone to resilience-driven, and from generalized policy to hyper-localized execution. As the country eyes climate resilience and food security, the alignment of public policy, private innovation, and farmer aspirations will be key. By working hand in hand with farmers, scientists, and policymakers, we should aim to co-create solutions that are sustainable, scalable, and suited to the Indian farmer. We look forward to a proper implementation and monitoring of these schemes so that the benefits reach the last farmer.

INDIA'S GLOBAL DISRUPTION IN MATING DISRUPTION

ATGC's Pheromone-Led Revolution



In an age of growing climate concerns, pesticide resistance, and global demand for sustainable farming, ATGC Biotech Pvt. Ltd. stands as a pioneering force behind a silent revolution in agriculture transforming pest control with precision pheromone-based technologies. Born in the innovation corridors of Hyderabad Genome Valley and rooted deeply in India's scientific excellence, ATGC is now a global benchmark for bio-manufacturing-driven, net-zero crop protection.

What began as an ambitious experiment to decode insect communication has evolved into a 50 + product-strong, IP-backed, and internationally validated ecosystem spanning Israel, the United States, Brazil, Mexico, Africa, and beyond. ATGC's field-tested formulations are empowering farmers from smallholder cotton growers in India to large gypsy moth area wide management in USA by aiding insecticides with smarter, residue-free biological alternatives.

A Science-Backed, Farmer-First Mission

The global agricultural industry loses over $450 billion annually to internal borers, subterranean feeders, and pesticide-resistant pests. Tradi-

About the **AUTHOR**

Dr. Markandeya Gorantla is CMD, ATGC Biotech Pvt. Ltd.

tional pesticides have plateaued in effectiveness. The world is now ready for a new science.

ATGC's answer is deceptively simple, yet technologically sophisticated: "Insect Family Planning" through mating disruption. Instead of killing pests indiscriminately, ATGC's formulations confuse them, disrupting their reproductive cycles and reducing chemical usage by over 90%.

- CREMIT PBW, CREMIT BFSB, CREMIT FAW, Akarsh ME, CREMIT FCM, CREMIT DBM, CREMIT TUTA, CREMIT Verbenone are the world's first smallholder-friendly mating disruption product for pink bollworm, Brinjal Fruit and Shoot borer, Fall Army worm, Fruit fly, false condling moth, Carob Moth, Gypsy Moth and Coleopteran control is now India's flagship global solution IPM programs.
- Powered by 26+ patents, ATGC's pipeline spans pheromone glue formulation, controlled-release tablets, sprayable emulsions, and underwater dispensers each tailored for high precision and farmer ease.
-

Small Chemistry, Big Impact: The 5-Gram/Month Revolution

At the core of ATGC's innovation is a bold and disruptive principle: "One acre, one gram per week." This 5-gram/month chemistry model is waterless, residue-free, non-toxic, and yet powerful enough to disrupt the mating cycles of the world's most destructive pests.

Rather than blanket spraying fields with liters of broad-spectrum insecticides, ATGC's approach targets insect communication. Through controlled-release dispensers—whether glue, tablets, or sprays—the pheromones mimic the insect's own mating signals, confusing males and preventing successful reproduction.

This ultra-low-dose approach brings 3 unmatched benefits:

- Ecological Compatibility: No harm to beneficial organisms or soil health.
- Farmer Safety: No re-entry intervals or toxic exposure.
- Scalable Simplicity: Ideal for both smallholder and industrial farms.

This isn't just a formulation. It's a systems change from "kill" to "confuse," from chemical warfare to ecological balance.

What makes ATGC different is its ability to scale scientifically, commercially, and geographically. Unlike most academic innovations, ATGC's pheromone systems are already deployed over 100,000+ acres globally, including aerial treatments across large geographies.

Across continents

- Israel: With Semiophore, 18 pheromone products are licensed, ranging from Tomato Leaf Miner to Vine Mealybug.
- United States: EPA-approved products for Carob Moth, Citrus Leaf Miner, Verbenone, Gypsy Moth and other with ongoing programs under the USDA's "Slow the Spread" initiative.
- Brazil, Mexico, Latin America: Field trials for Fall Armyworm, Tuta, Thrips and DBM are leading to national approvals.
- Africa & MENA: Validated products like Akarsh ME, CREMIT FCM, and Carob Moth glue formulations are in advanced regulatory stages.
- Europe & Australia: Vineyard, citrus,

tomato, and forestry pests are now being addressed under CREMIT and Akarsh platforms.

All these are underpinned by a unified principle: high efficacy, low dosage, no water, and zero residues.

Platform Innovation: Where Synthetic Biology Meets Farmer Realities

ATGC's success is not just a result of formulation it is the intersection of synthetic biology, materials science, and agronomic insight:

- Bio-transformed pheromones made via enzymatic synthesis from oil crops.
- Controlled-release systems using mesoporous and nano-carriers, reducing field applications to just 3 sprays per season.
- Reusable biotransformation units that eliminate energy inputs, enabling net-zero pest control.

ATGC's pheromone systems are deployed over 100,000+ acres globally, including aerial treatments across large geographies

- Multi-format delivery (gel, solid, spray) for tailoring solutions across crops, climates, and cropping systems.

This diversity in platforms has allowed country-specific customization, ensuring both regulatory acceptance and farmer adoption.

Recognitions That Matter

ATGC's credibility is not self-proclaimed. It is built on rigorous validation by top-tier institutions:

- Technology Certification by ICAR (2025) presented during the 97th Foundation Day by the Union Minister of Agriculture.
- Innovator of the Year 2025, awarded by Agriculture Today and conferred by Shri Piyush Goyal.
- Global case study by the World Economic Forum (WEF) for advancing the bioeconomy.
- Presidential recognition at Rashtrapati Bhavan (2023) for scientific contributions.
- US NASEM nomination under the Indo–US Bioeconomy Collaboration.
- DBT-BIRAC Innovator of the Year (2017 and 2018), and Ministry of Agriculture Grand Challenge award 2019 a company to replace insecticides.

These honors not only validate ATGC's science but also cement India's leadership in pheromone-based biological agriculture.

Leadership, Policy, and the Path Forward

Led by Dr. Markandeya Gorantla and a team of 14 core scientists from the University of Hyderabad, ATGC blends technical depth with global vision. Supported by ex-IAS/IRS officers, deep-tech industrial collaborators, and an esteemed Scientific Advisory Board chaired by Prof. Arjula Reddy, the company is shaping India's BioE3 policy, mentoring next-gen synthetic biology deep tech, and redefining how nations approach crop protection.

With over 44 ready-to-commercialize products, global partnerships in place, and advanced R&D in peptide-pheromone hybrids, AI-integrated monitoring, and underwater dispensing systems, ATGC is not just keeping pace it is setting the pace.

India's Gift to Global Agriculture

ATGC's success is a symbol of India's rise as a leader in nature-positive innovation. By offering low-dose, high-impact, climate-resilient technologies, ATGC is helping countries abandon chemical warfare in agriculture in favor of precision ecological solutions.

"We are scripting a greener future—one pheromone at a time."

SML
Transforming Agriculture

Reap

Double Effect
Crop Perfect

- Effective control of stem borer
- Advanced DG formulation
- Prolonged absorption of active ingredients from SRT
- Greener, better tillers & balanced pH

Super S Protection Nutrition

SML Limited
(Formerly Sulphur Mills Limited)

THE FUTURE OF AGRICULTURE: A NEW PATH FORWARD

Agriculture is changing very fast. It is no longer just about old traditions. Today, farming is at a turning point. With the world's population expected to go beyond 9 billion by 2050, we need to grow more food using fewer resources. At the same time, we must protect the planet. Climate change, pollution, and changing consumer habits are pushing agriculture to think differently. The future depends on fresh ideas, smart technology, and responsible choices.

Farming has always been important, but now it plays an even bigger role in solving global problems. It is not just about feeding people – it is about protecting nature, supporting communities, and building a better future. Farmers, scientists, and leaders all have a part to play in making agriculture smarter, safer, and more sustainable.

Big Challenges Ahead

Farmers today face many tough problems. Weather is becoming more unpredictable -droughts, floods, and heatwaves are making it harder to grow crops. Seasons are shifting, and rainfall patterns are changing. These changes affect not only crops but also livestock and water supplies. Soil is losing its nutrients, water is becoming scarce, and many plant and animal species are disappearing. These issues are all connected and make farming more difficult.

On top of that, farmers also deal with rising costs, changing market demands, and pressure to reduce their environmental impact. Old methods of farming aren't enough anymore. To keep up, agriculture needs to become stronger, more flexible, and more sustainable. That means changing how we grow and protect crops, using science and technology, and caring more about nature.

Innovation Is Key

New technology is helping farmers in big

About the **AUTHOR**

Mr Sanjay Aggarwal is the Managing Director of Indogulf Cropsciences

As agriculture moves toward a more sustainable and technology-driven future, Indogulf Cropsciences is playing a vital role by combining innovation and efficient operations. Through advanced crop protection, biologicals, and digital engagement, the company is helping shape a resilient agricultural ecosystem that meets tomorrow's challenges with confidence and clarity

ways. Tools like satellites, drones, and sensors let farmers check crop health, soil quality, and weather in real time. These tools help farmers make better decisions and respond quickly to problems. Artificial intelligence (AI) helps predict the best times to plant, water, and protect crops. It can also help track pests and diseases before they spread.

Biotechnology is also making a difference. Scientists are creating seeds that can handle tough conditions like pests, drought, and poor soil. These seeds grow faster, use less water, and produce more food. New types of crop protection products are being made to work better and be safer for the environment. These changes are helping farmers grow more food while using fewer chemicals and less water.

Making Farming Sustainable

Sustainability means farming in a way that doesn't harm the planet. It's not just a trend—it's the future. Instead of focusing only on high yields, farmers are now trying to use resources wisely, protect nature, and keep farming going for generations.

Water-soluble fertilizers and plant growth boosters that work in tough weather are helping. These tools reduce waste, improve soil health, and make crops stronger. They also help farmers use less water and fewer chemicals. The best part is they can be used in many different places and types of farms, making sustainability possible everywhere.

Leading with Purpose

Good leadership in agriculture means thinking beyond profits. It's about making choices that help people, protect the environment, and grow the economy. This includes spending on research, pushing for helpful policies, and making sure small farmers aren't left behind.

Governments can help by creating rules that support sustainable farming and reward innovation. They can offer training, funding, and fair prices for crops. Businesses can help by being honest, fair, and focused on long-term goals. When leaders care about both results and values, real progress happens.

Leadership also means being open to change and willing to take risks. The future of farming depends on bold ideas and strong partnerships. With the right vision, agriculture can lead the way in solving global problems.

A Sector ready for Change

Agriculture is more than just growing food - it's a way of life for billions of people. It affects health, jobs, and the environment. The road ahead won't be easy. Climate change, competition for resources, and fast-moving technology will all play a role. But there's also a lot of hope.

Farming is becoming more advanced, more connected, and more thoughtful. It's not just about using new tools - it's about changing how we think. The goal is to build systems that are fair, strong, and good for the planet. Agriculture is ready to move forward, and the time to act is now.

Building Tomorrow's Agriculture Today

The future of farming isn't far away - it is already happening. Every choice we make, every new tool we use, and every value we follow is shaping what comes next. We need to be brave enough to try new things, smart enough to work together, and committed to doing what is right for the Earth.

As we move forward, the focus should be on farming that is productive, fair, and kind to nature. With strong leadership, smart science, and a shared vision, agriculture can meet today's challenges and build a better tomorrow for everyone.

Indogulf Cropsciences Ltd: Pioneering the Future of Farming

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SEEDS OF INNOVATION

New Age Crop Protection

Agriculture remains the backbone of India, employing approximately 54.6% of the population and contributing only 17-18% to the GDP in 2025, with over 86% of farmers holding less than 2 hectares of land. The sector is marked by diverse agro-climatic zones but faces persistent challenges such as fragmented land, monsoon dependency, labour shortages, and pest resistance. Whereas globally, agriculture in countries like the US, EU, Brazil, and Japan is characterised by large-scale industrial farming, advanced mechanisation, and rapid technological adoption. Farmland is consolidated, farm operations are high-tech and data-driven, and crop protection strategies incorporate cutting-edge science, from genomics to nanotechnology and computational modelling. These nations produce high volumes with enhanced efficiency and sustainability, driven by substantial R&D investments and robust regulatory frameworks. Larger farms overseas enable economies of scale, extensive mechanisation, and better integration of crop protection technologies compared to Indian marginal farmers, who rely increasingly on cooperative models and government-supported initiatives to access technology.

Agriculture in India: A Comparative Analysis

The agricultural output scale abroad dwarfs India. The combined agrarian sector of leading Western and Asian economies generates over $3 trillion annually, supported by mechanised farms with thousands of hectares, whereas Indian agriculture only contributes approximately 10% in this. To tackle these issues, the Indian agrochemical industry has become indispensable, with India's market valued at about $11.2 billion in FY 2025 and expected to reach $14.5 billion by FY 2028. India is among the top four global agrochemical producers and the second-largest exporter, with exports surpassing $5.5 billion. Increased adoption of herbicides, rising agrochemical consumption, and supportive government policies are driving sector growth, while innovation and sustainability remain key focus areas for meeting the country's food security and productivity goals and to triple this number by 2047.

Agricultural technology abroad is using precision agriculture techniques such as GPS-guided equipment, drone spraying, sensor-based monitoring, and AI analytics are standard overseas, enabling efficient input use and environmental stewardship. In India also, digital adoption is growing, with about 35% precision agriculture penetration by 2025. However, small farm sizes and cost barriers limit widespread uptake. Crop protection products in India are evolving, with major firms launching advanced herbicides and fungicides designed for local conditions. Yet, access to novel biopesticides and gene-based technologies is more limited.

Crop Protection in India

India has approximately 348 registered agrochemical molecules and about 746 formulations, compared to over 600 molecules approved in the European Union and over 500 in Japan. India's registration process is slower and more cumbersome due to stringent testing, limited data protection, and fragmented regulatory bodies,

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causing a lag in market overview of innovative products. Meanwhile, developed countries benefit from expected regulatory pathways, strong intellectual property rights, and streamlined multi-agency coordination, promoting faster deployment of sustainable and high-tech solutions.

At this juncture, we need key technological advancements in biopesticides, biocontrol agents, and novel green molecules derived from natural sources, Nanotechnology in Seed Coating and Priming, Genetically Modified Organisms (GMOs) and Genetic Engineering & Biotechnology and Computational Tools as the global shift towards sustainability is steering the crop protection industry towards the same.

Biopesticide Market

India's biopesticide market is growing rapidly, projected to expand at a 16% CAGR in 2025 with microbial pesticides, botanical extracts, and biofungicides increasingly adopted in crops like cotton, rice, and vegetables. Globally, large manufacturers invest heavily in biological formulations to reduce chemical reliance, enhance environmental safety, and meet consumer demands for residue-free food.

Nanotechnology

Nanotechnology also holds immense promise for crop protection. Innovative nanocoating and nano-priming of seeds enhance germination rates, improve seed vigor, and provide slow-release protection against pests and diseases. While developed countries are already exploring commercial adoption, India is making strides by integrating nanotech innovations in seed treatment and smart delivery systems, leading to improved crop establishment and yield stability.

India is set to evolve from a technology adopter to a global innovator in crop protection

GMOs and Genetic Engineering

GMOs and genetic engineering dominate crop protection abroad, offering crops with built-in resistance to insects, herbicides, and environmental stressors. BT cotton has revolutionised Indian cotton farming, but the adoption of newer GM crops like BT brinjal remains limited due to regulatory and social hurdles. In contrast, countries like the US, Brazil, and Argentina widely cultivate multiple GM crops, supported by streamlined regulatory approval and market acceptance. Gene-editing technologies like CRISPR are also in advanced stages globally, allowing targeted resistance traits and trait stacking to reduce pesticide use.

Biotechnology innovations such as RNA interference (RNAi) for pest and disease control are gaining momentum globally, with companies developing RNA-based sprays for targeted action. Computational tools leveraging IoT, big data, weather forecasting, and AI models enable precise timing and location for interventions, optimising pesticide use and reducing environmental impact. Indian startups and agri-tech firms are also increasingly deploying satellite imagery, drones, and machine learning algorithms for monitoring and advisory services, though adoption at scale remains uneven.

To bridge the technology and innovation gap in crop protection industry, India must prioritize digitizing agrochemical registrations, strengthening data protection and intellectual property rights, and encouraging collaborative research to develop India-specific biopesticides, nanoformulations, and climate-resilient biotech crops. Scaling precision and digital agriculture by making sensors, drones, AI platforms, and IoT tools accessible to marginal farmers through subsidies, training, and digital literacy will be vital. A push for nanotechnology in inputs and a transparent regulatory framework for GMOs and gene editing, paired with effective outreach, extension services, and infrastructure upgrades, will accelerate the sector's modernization.

Guided by the Viksit Bharat 2047's vision to make agriculture a $1.8-3.1 trillion sector, with investments over ☐1.75 trillion in 2025-26 and bold steps in integrated pest management, precision agriculture, digital platforms and rural capacity-building, India is set to evolve from a technology adopter to a global innovator in crop protection, forging a path to productivity, sustainability, and farmer prosperity.

NATURAL FARMING AND INDIA'S FOOD SECURITY

Going Back to Roots is the Way Forward

As India works to feed a growing population in a world shaped by climate change, it has become more important than ever to rethink how we approach farming. Food security today is not just about growing enough; it also means doing it in a way that's sustainable, nutritious, affordable, and better for the environment. In this situation, natural farming is proving to be a strong way forward.

The Current Crossroads

The Green Revolution was essential for our nation, but the use of chemical-based farming has started to create serious problems. Soil quality has gone down, water levels are falling, and many useful plants and insects have disappeared. There is also rising concern about the health effects of chemical traces left in food. Many small farmers now rely on expensive fertilizers and pesticides, which often puts them in debt.

Farming has also become harder because of climate change. Unpredictable rains, extreme weather, and rising temperatures are making it more difficult to grow crops. India now produces more food than before, yet many people still don't get enough nutrition. The way this food is

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being grown is putting pressure on the environment. Natural farming offers a clear and practical solution to many of these issues.

What is Natural Farming?

Natural farming represents a philosophy rooted in ecological harmony. It is not merely a chemical-free version of agriculture; it is a holistic method that encourages farmers to work with nature, rather than try to control or override it. It promotes the use of farm-based and bio-derived inputs such as fermented plant extracts, composted organic matter, and microbial-rich solutions that nourish the soil without depleting its life. The emphasis is on regenerating soil health, increasing biodiversity, and reducing reliance on market-bought synthetic inputs.

This approach relies on the natural rhythms and cycles of the ecosystem. It avoids aggressive tilling, monocropping, and synthetic pesticides, instead encouraging crop diversity, minimal soil disturbance, and the reuse of organic waste. Natural farming is, at its core, a closed-loop system, where what comes from the earth goes back to it, forming a self-sustaining cycle.

Link Between Natural Farming and Food Security

Food security today means more than just having enough to eat. It also depends on how nutritious the food is, whether farmers can afford to grow it, and whether the farming methods are safe for the environment. Natural farming supports all of these needs.

Crops grown naturally often have more nutrients because the soil they grow in is healthier. These crops also have fewer chemicals, which makes them safer to eat and matches what many people are now looking for—cleaner, healthier food. For farmers, natural farming reduces the need to buy expensive fertilizers and pesticides. This can help them save money and earn a better income, especially for those with small plots of land.

Natural farming also helps in dealing with climate change. It improves the soil's ability to store carbon and hold water, making farms more resistant to droughts and extreme weather. In today's changing climate, this kind of resilience is very important. Natural farming also uses waste from farms, animals, and even cities in a useful way. Instead of throwing this waste away, it becomes part of the farming process. This not only reduces pollution but also makes farming more efficient and sustainable.

Natural farming is not about holding on to the past; it's a practical and thoughtful approach that can help fix the growing problems in our current food system

Challenges and Opportunities

Despite its many benefits, natural farming cannot scale overnight. Transitioning from chemical-intensive farming requires not just training, but a mindset shift. Farmers need support during the initial phases when yields may fluctuate, and they need access to credible information, community-based infrastructure, and market recognition for the produce they grow naturally.

Government programs and grassroots movements in various parts of the country have demonstrated that this transformation is not only possible but practical. With the right institutional support, from public policy to farmer cooperatives, natural farming can become a viable mainstream model. It also opens up possibilities for rural entrepreneurship, especially in the development and distribution of bio-inputs, composting systems, and waste-to-resource technologies.

At its most effective, this model thrives when local knowledge is combined with scientific rigor, and when communities are empowered to take ownership of their soil, water, and food systems. As consumers become more health-conscious and environmentally aware, the market for naturally grown food is also steadily expanding, further reinforcing the viability of this approach.

The Way Forward

India's farming story has always combined new ideas with traditional methods. Natural farming can be the next step forward. It uses age-old techniques along with today's knowledge about healthy soil and the environment. This approach doesn't mean giving up on technology or big farms. It means using them in ways that protect nature instead of damaging it. If we want to make sure everyone has enough good food in the future, just growing more is not enough. We need to grow food in a way that is safer, healthier, and better for the planet. Natural farming helps us do that. It keeps the soil healthy, supports farmers, and gives people cleaner food. Choosing this way of farming is not about going back in time. It's about moving forward more smartly and responsibly, one that stays connected to the land that feeds us.

REVIVING SOIL HEALTH

THROUGH NUTRIENT EFFICIENCY AND PRECISION FARMING

India's agricultural journey over the past few decades has focused heavily on high-input, high-yield systems, aiming primarily at boosting production. Green Revolution played a critical role in achieving food security, but it also brought several unintended challenges — soil health has declined, biodiversity is under threat, and in many regions, farm productivity is beginning to stagnate.

According to a recent study by ICAR and the Desertification and Land Degradation Atlas of India, nearly 30% of India's total geographical area-about 97 million hectares, is affected by land degradation. This is no longer a theoretical risk but a tangible, nationwide crisis.

The National Bureau of Soil Survey and Land Use Planning highlights water erosion (45%), chemical degradation (32%), and physical degradation (8%) as the primary drivers of soil deterioration in India. These issues largely arise from poor land management practices, excessive nutrient extraction, and unsustainable use of agricultural inputs. The consequences are systemic: not only are farmers' livelihoods at stake, but the entire agri-input industry faces eroding market growth, declining product efficacy, and the risk of long-term unsustainability.

Soil, once considered an inexhaustible asset, is now in urgent need of revitalization. Excessive use of nitrogenous fertilizers, frequent tillage, and low organic matter input have led to severe nutrient imbalance and a decline in soil organic carbon (SOC). Recent studies show a 23% decline in SOC levels over the past two decades, especially in intensively cultivated areas. In Punjab, for example,

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only 6.9% of soils have high organic carbon, and this percentage is falling.

The NPK ratio in Indian soils is now a skewed 7.7:3.1:1, far from the ideal 4:2:1, reflecting overuse of urea and underuse of phosphorus, potassium, and micronutrients. Nearly 40% of agricultural land shows significant nutrient deficiencies. Erosion, exacerbated by over-tillage and deforestation, removes about 15 tons of topsoil per hectare annually, leading to an economic loss exceeding ☐50,000 crore each year. As soil loses its resilience, even advanced agrochemicals become less effective, making this not just an environmental concern but a direct business risk for the agri-input sector.

Success requires coordinated efforts: public-private partnerships, farmer training, supportive policies, and accessible technologies to scale adoption, especially among smallholders

Nutrient efficiency-how well crops absorb and utilize applied nutrients-remains alarmingly low in India. Only 30% of nitrogen, 20% of phosphorus, and 50% of potassium applied are actually used by crops, with the rest lost to leaching, runoff, or gaseous emissions. This inefficiency results in both economic loss and environmental harm. To address this, the industry is investing in:

To tackle the issue of low nutrient efficiency, the industry is turning to new innovations. Enhanced Efficiency Fertilizers (EEFs) are designed with special coatings or stabilizers that release nutrients in sync with the crop's needs. Nano-fertilizers use ultra-small particles that improve absorption, allowing farmers to reduce nitrogen use by up to 20% without any loss in yield. Bio fertilizers and microbial consortia are being used to reintroduce helpful microbes into the soil, which naturally support soil health and fertility.

The Soil Health Card (SHC) Scheme, launched in 2015, has distributed over 280 million cards, helping farmers adopt balanced fertilizer use. Reports show that SHC users reduced fertilizer costs by 10–25% and improved yields by 5–12%. However, adoption remains uneven, with only about 38% of users regularly following soil-based recommendations. For industry, nutrient efficiency is now a product performance issue, companies that fail to innovate risk irrelevance in a market demanding higher ROI per acre.

Precision agriculture is transforming input management by leveraging data, connectivity, and automation. Technologies such as drones, GPS-guided tractors, IoT sensors, and AI-powered analytics enable site-specific application of nutrients. A 2024 study in Agriculture & Food Systems confirms that precision nutrient management reduces nutrient losses by 25–40% and improves soil microbial biomass, a key indicator of soil regeneration. To tap into this potential, the industry is adopting precision farming approaches. Companies are now bundling input products with tech-enabled solutions to guide farmers more effectively. They are also developing customized micronutrient kits tailored for specific agro-climatic zones to ensure more targeted and efficient nutrient application. Additionally, subscription-based models are emerging, which combine fertilizer products with ongoing advisory services — making precision farming both accessible and sustainable for farmers.

Despite the benefits, adoption among smallholders is limited by high upfront costs and technical barriers. Innovative business models and targeted government incentives are crucial for democratizing access to these technologies.

Soil regeneration through efficient nutrient use and digital farming is the pathway to sustainable agriculture. Healthy soils store more carbon, use less water, and reduce dependency on chemical inputs aligning with emerging ESG and carbon-neutrality mandates. Incentives for corporate adoption of regenerative agriculture are steadily growing. Food and beverage brands are increasingly sourcing produce from farms that follow verified regenerative practices, aligning their supply chains with sustainability goals.

Carbon markets are beginning to recognize soil carbon as a tradable asset, making regenerative farming economically attractive for producers. At the same time, investors are prioritizing companies with climate-smart and traceable supply chains, encouraging broader adoption of soil-friendly practices. Fertilizer companies are also stepping in piloting initiatives like carbon farming, block chain-based traceability, and digital soil passports, all of which depend on accurate and real-time soil and nutrient data.

BIOSTIMULANTS

BOOSTING CROP QUALITY AND YIELDS

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The profitability and prosperity of farmers engaged in agriculture need to be improved substantially to make farming a profitable and attractive business proposition. Moreover, it is imperative to support the livelihood of more than 40% of the Indian population who depend on agricultural income.

On many farms, productivity has stagnated due to the continued use of traditional fertilizers and pesticides, as the law of the minimum plays an important role in limiting farm productivity. These minimums may be caused by deficiencies of primary, secondary, or micronutrients, or by the lack of support for internal physiological reactions within plant systems. Biostimulants play a role in enabling plant physiological processes to be smooth, balanced,

and oriented toward productivity. Thus, they contribute to increasing both crop production and the quality of crop yields.

Recently, with changes in consumer purchasing behaviour, quality has become a key determinant of price realization and farm profitability. Additionally, the demand for high-quality produce is consistently increasing.

While most governments worldwide lack policies for registering biostimulants, India has taken the lead by formulating policies for their registration, which is a commendable initiative. The regulations under the Fertilizer Control Order (FCO), section 20c, specify the following nine categories of biostimulants. It is important to understand how each of these categories contributes to improving farmers' profitability.

Botanical extracts including seaweed extracts:

These extracts contain several molecules composed of mixtures of primary and secondary metabolites and plant hormones. They reduce plant stress levels and increase energy within crops. By supplying these products, some plant biochemical pathways are bypassed, thus conserving energy. Seaweed extracts also contain several vitamins and amino acids that support plant systems.

Biochemicals:

These are molecules synthesized or produced in the metabolism of living organisms. Naturally occurring biochemicals can also be synthesized in laboratories. They are complex compounds that assist major metabolic pathways. Proteins, lipids, and amino acids are provided to plants, helping to reduce crop stress.

Protein hydrolysates and amino acids:

These mixtures of amino acids and peptides are obtained from the chemical or biological breakdown of proteins sourced from plants and animals. The active ingredients include free amino acids and polypeptides. There are 20 amino acids that act as the building blocks of proteins in both plants and animals. They are vital for increasing the nutritional value and quality

Biostimulants typically offer a Marginal Benefit Cost Ratio (MBCR) of 4–5, substantially increasing farmer profitability

of agricultural products.

Vitamins:

Several fat-soluble and water-soluble vitamins are required by plants. Notably, vitamins A, B, C, and E are important for boosting crop immunity against pests and diseases. With these vitamins, plants generate antibodies to combat disease.

Cell-free microbial products and live microorganisms excluding biofertilizers and biopesticides:

These products consist of microbes and microbial cell extracts that are non-pathogenic and do not function as either biocontrol agents or biofertilizers. They include ectophytes (outside the plant) and endophytes (inside plant systems). They release acids at the root level, helping plants absorb nutrients by altering the pH of root exudates. They may also contain different molecules composed of mixtures of primary and secondary metabolites and hormones.

Antioxidants:

These molecules scavenge reactive oxygen species (ROS), and can be classified as enzymatic and non-enzymatic antioxidants. They contain phenols and are main sources of carbon, hydrogen, nitrogen, sulfur, and oxygen, mainly in carboxylic groups. ROS are usually released due to the application of pesticides and other biotic and abiotic stresses on plants. These ROS are harmful to plant cells and must be neutralized, which is where antioxidants are needed.

Antitranspirants:

Antitranspirants reduce water loss caused by transpiration by closing the stomata during drought-like conditions. They also form a thin, waxy layer on the plant, offering protection.

Humic and fulvic acids and their derivatives:

Humic substances are components of natural organic matter present in soil, water, and other sources. They are grouped into humic acid, fulvic acid, and humin. They provide organic carbon in both low and high molecular weights. Crops need them for the production of glucose, sucrose, carbohydrates, and other energy molecules, thereby increasing crop yields.

As can be seen from the benefits outlined above, the use of biostimulants as necessary inputs in crop cultivation is essential. This requires coordinated efforts from both government and private industry to educate farmers and encourage them to take advantage of these products.

While the FCO has already approved certain categories—including humic and fulvic acids, microbial products, seaweed extracts, and amino acids—other categories also need approval. Furthermore, the government provides approvals based on the specific crops on which the biostimulants have been tested. However, the effects of biostimulants are largely universal across plants, with varying degrees of effectiveness. Therefore, they may be approved without crop restrictions or with partial restrictions, such as through a crop grouping system.

BIOCHAR

BLACK GOLD FOR SOIL

In the face of climate change, soil degradation, and mounting agricultural challenges, one natural solution has begun to shine with both ancient wisdom and modern innovation—Biochar. This unique carbon-rich material produced from biomass has the power to rejuvenate soils, lock carbon for millennia, and reshape sustainable farming. In India, Sajeevan Life is leading this transformation, pioneering a Biochar Movement across states like Rajasthan, Maharashtra, Uttar Pradesh, and Gujarat.

Our mission runs deeper than innovation alone. It's about restoring the earth, empowering farmers, and creating a long-lasting impact on agriculture and the environment. Let us look at why biochar is being hailed as a "black gold" for the soil and how Sajeevan Life is driving this revolution.

Benefits of Biochar to Soil

Soil is life itself, and biochar infuses it with vitality. When added to farmland, biochar improves soil porosity and water retention, making it resilient even during dry spells. It acts as a natural sponge that traps nutrients and releases them slowly to the crop roots, reducing the need for excessive chemical fertilizers. Furthermore, its alkaline nature helps balance soil pH, making degraded or acidic lands fertile again. The result: higher yields, reduced crop stress, and healthier soil ecosystems.

Usage of Biomass and Waste

India generates vast amounts of agricultural residue every year, much of which is often burnt in open fields, polluting the air and wasting valuable resources. Biochar production provides a sustainable pathway to convert this biomass into something useful and eco-friendly. Rice husk, sugarcane bagasse, cotton stalks, and other residues can all be transformed into biochar. By this, Sajeevan Life helps farmers turn waste into wealth—reducing stubble burning, controlling pollution, and creating a regenerative loop in agriculture.

Preservation of Soil for Thousands of Years

Unlike fertilizers that wash away after a season, biochar remains stable in the soil for thousands of years without decomposing. Ancient Amazonian civilizations are believed to have used a form of biochar,

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creating fertile "Terra Preta" soils that are still productive today. This longevity makes biochar not just a fertilizer, but a true soil preserver—protecting fertility for future generations.

Environment Safety and Climate Action

Biochar is more than a farming tool—it is a weapon against climate change. By locking carbon into a stable form underground, biochar prevents the release of greenhouse gases into the atmosphere. Every ton of biochar applied to soil is a commitment to climate responsibility. Moreover, the process of biochar production, when done with modern, controlled techniques, is clean and safe. Sajeevan's transition into hi-tech biochar production systems ensures that the activity is environmentally sound, avoiding the pollution risks of traditional burning.

Products Using Biochar

The versatility of biochar is remarkable. Beyond soil amendment, biochar is now being integrated into multiple industries. Farmers use it as a feed additive for livestock, helping in better digestion and reducing methane emissions. It finds use in water treatment by absorbing heavy metals and toxins. Even building materials and eco-friendly consumer products are adopting biochar for sustainability. Sajeevan Life is exploring these dimensions, with the aim of creating a diversified biochar economy.

The Future of Biochar

With sustainable farming moving to the forefront of global priorities, biochar stands as a solution aligned with circular economy principles. Its ability to improve yields while combating climate change positions it perfectly for the agriculture of tomorrow. The biochar market is expected to experience exponential growth worldwide, and Sajeevan Life envisions India as a hub of biochar innovation.

Sajeevan Life's Footprint Across India

Currently, Sajeevan Life is deeply engaged in four states—Rajasthan, Maharashtra, Uttar Pradesh, and Gujarat—where different agricultural and climatic conditions allow for diverse applications. In Rajasthan's sandy soils, biochar improves water-holding capacity; in fertile Maharashtra, it supports high-yield crops; in UP, it helps convert dense crop residues into useful raw material; and in Gujarat, it enhances salinity-prone soils. This geographical spread reflects a deep commitment to serving farmers across different landscapes.

Biochar is a farmer's ally for increasing productivity, reducing input costs, and preserving land for generations. With demonstrations, training programs, and farmer partnerships, Sajeevan is carrying the message across: "By adopting biochar, you are not just growing crops—you are saving your soil.

Entry into Hi-Tech Biochar Production

While traditional methods of making biochar exist, Sajeevan Life is moving toward cutting-edge pyrolysis technologies that maximize carbon retention and ensure zero emissions. These advanced units are scalable, energy-efficient, and capable of processing large volumes of agricultural waste into consistent, high-quality biochar. By bringing science and technology into the rural heartlands, Sajeevan ushers in a new era of professional and eco-friendly biochar production.

Biochar Movement: Sajeevan's Mission

The initiative is not merely about biochar production—it is about a movement. Sajeevan Life envisions a "Biochar Movement" where farmers, policymakers, researchers, and communities come together for soil health and climate action. The organization is building awareness, encouraging collaboration, and creating value chains that make biochar accessible to every farmer in India. This movement holds the promise of restoring degraded soils, reducing emissions, and empowering agriculture with sustainable strength.

Biochar is the bridge between ancient practices and future-ready farming. It holds the capacity to transform waste into resources, barren lands into fertile fields, and carbon emissions into sequestered soil capital. By championing this cause, Sajeevan Life is not just providing an innovative solution—it is shaping a revolution.

With Sajeevan's commitment and India's collective will, Biochar could become the backbone of a truly sustainable agricultural future

Biologicals in Indian Horticulture

Between Promise and Perception

Step into a horticulture farm in Maharashtra, Karnataka, or Himachal, and you'll find a curious mix of tradition and transition. On one hand are chemical sprays and fertilizer bags that have powered India's crop productivity for decades. On the other are bottles of biostimulants biofungicides, or packs of biofertilizers—signs of a shift that is slowly but surely unfolding.

Farmers speak of biologicals with interest, but also with hesitation. For many, the term itself is a catch-all for anything that feels "bio," "organic," or "chemical-free." Few distinguish between categories such as biostimulants, biofertilizers, and biopesticides. And yet, behind this haze lies a significant change in intent: farmers want safer tools that protect their soil, crops, and

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families without compromising yield.

It is this intent that makes the category worth watching.

Safety Above All

Ask a grower why he experiments with biologicals, and the answer is strikingly consistent: safety. Farmers believe biologicals are gentler on plants, safer for their families and workers, and kinder to the soil that sustains them. For many who handle chemical sprays daily, the idea of inputs that don't sting the eyes or irritate the skin feels like an obvious step forward.

The perception is not always scientifically accurate. Some still assume that biologicals contain "milder" forms of chemicals, while others see them as herbal remedies rather than rigorously developed inputs. But the aspiration is unmistakable. Farmers are looking for a balance—products that maintain productivity while reducing risks to health and environment.

Export-oriented crops such as grapes and pomegranates are already strong adopters, where residue management is critical. In everyday farming, however, usage remains patchy, shaped more by individual experience or peer influence than by structured extension.

Biologicals in Indian horticulture are no longer fringe. They sit at the intersection of consumer demand, policy ambition, and farmer aspiration

Winds of Change in the Market

Farmer curiosity alone does not explain the momentum behind biologicals. The growth is being pushed by powerful external forces.

Consumers are demanding residue-free, safer produce, especially in urban centers and export markets.

Dietary shifts are moving Indian households away from cereals toward fruits, vegetables, and high-value crops where quality matters.

Policy support is emerging, most notably through the Fertilizer Control Amendment of 2021, which formally brought biostimulants under regulatory oversight.

Corporate investment is accelerating, with global firms like Verdesian, Atlantis, and Acadian Sea Plant betting big on India. They are building distribution networks, funding farmer education, and positioning biologicals as the "next frontier" in inputs.

This convergence—health-conscious consumers, enabling policy, and corporate ambition—is creating fertile ground for biologicals to move from the margins to the mainstream.

Biostimulants and PGRs: Leading the Pack

Of all categories, biostimulants and Plant Growth Regulators (PGRs) have carved out

the most acceptance. Farmers like them for one simple reason: visible results. Stronger flowering, better fruit quality, and reduced flower or fruit drop are outcomes they can see within a season.

Applications are also intuitive—biostimulants are used early in the crop to build plant vigor, while PGRs are applied during reproductive phases to support fruit set. This predictability has built confidence.

The numbers reflect it. Valued at ☐3,000 crore in 2024, this segment is expected to more than double by 2030, growing at a CAGR of 16%. Yet, growth has not been without roadblocks. Counterfeit products erode farmer trust, fragmented marketing creates confusion, and regulatory ambiguities—where biologicals are often lumped with chemicals—leave farmers unsure of what exactly they are buying.

For many farmers, biostimulants inspire cautious optimism: they want to believe, but they tread carefully.

Biopesticides: Safe but Secondary

Biopesticides are slowly gaining traction, with 20–25% of horticulture farmers reporting usage. Biofungicides—particularly Trichoderma viride—are the most popular, thanks to their availability and effectiveness against fungal diseases.

Yet here lies the paradox. Farmers value biopesticides for their safety, but question their strength. Chemical pesticides remain the default for fast, visible control. Biologicals are used as complements—early in the cycle to build resilience, or near harvest to manage residues in export crops.

"We know chemical sprays work fast, but they also leave us worried about residues. Biologicals feel safer, but we are not always sure if they will protect our crops in time," said a pomegranate grower in Maharashtra"

The market itself is promising: valued at ☐1,500 crore in 2024, it is projected to double by 2030. For that growth to materialize, however, farmers must be convinced not just of safety, but of effectiveness. Trust, once again, is the deciding factor. Until perceptions of effectiveness improve, biopesticides

may remain in this secondary role: trusted for safety, but not for power.

Biofertilizers: The Underdogs

If biostimulants lead and biopesticides follow, biofertilizers are still struggling to find their footing. Most farmers know them only by local names and rarely understand their scientific basis. Mycorrhiza, rhizobium, or phosphate solubilizing bacteria remain largely unfamiliar terms.

Used mainly in cereals and pulses, biofertilizers are seen as soil enhancers rather than core crop drivers. Farmers appreciate their role in boosting nutrient uptake and plant vigor, but don't view them as critical to success.

Valued at ☐2,000 crore, the market is growing steadily at ~15% CAGR. Yet without better branding, farmer education, and integration into crop packages, biofertilizers risk remaining supplements instead of solutions.

Unlocking the Next Leap

For biologicals to achieve their potential in Indian horticulture, three shifts are essential:

Building Trust – Farmers need credible brands, visible field demonstrations, and strict action against counterfeits. Certification systems could provide reassurance in a market where over-claiming is common.

"We don't get proper training. We don't know when to spray, how to mix, or what to avoid. Because of that many farmers are scared to try bio." – Floriculture farmer, Tamil Nadu

Deepening Knowledge – Farmers require clear, science-backed narratives in their own language. Instead of complex explanations, communication should focus on "what it does to my crop" and "when to use it."

Evolving Policy – Current regulations treat biologicals as extensions of chemical frameworks. Dedicated policies, designed for the uniqueness of biologicals, will provide clarity and encourage innovation.

A Sector in Transition

For farmers, the shift to biologicals is not just about inputs. It is about protecting their soil, producing safer food, and meeting the requirements of changing markets. The road ahead is not without challenges—trust, knowledge, and regulation remain gaps. But the direction of travel is unmistakable.

If nurtured with science, policy support, and farmer-centered engagement, biologicals could move from being "experimental extras" to becoming the cornerstone of India's agricultural resil-

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BIOPESTICIDES FOR PLANT PROTECTION

Crop losses due to various biotic and abiotic factors have become a serious issue in the present agricultural scenario. Whether caused by pests or diseases, crop losses are devastatingly increasing from production to storage, with short- and long-term consequences for agricultural productivity. There are approximately 10–35% crop losses due to various plant diseases, directly affecting farmers' livelihoods and global food production. Biotic stresses posed by microorganisms such as bacteria, fungi, nematodes, and viruses are a prominent worldwide threat.

Plants and their pathogens are constantly evolving to out-compete each other and assert dominance. To survive under pathogen-stressed conditions, plants require rigorous defense strategies, while pathogens aim to overcome these defenses. Consequently, activation of complex plant immune strategies—such as the use of chemical or natural elicitors, omics technologies, RNA interference (RNAi), and CRISPR/Cas9 gene editing—shows promise in strengthening plant immunity and protecting crops. These cutting-edge strategies offer better insights into the signaling of plant resistance, but there remains a gap in implementing this knowledge from the lab to the field due to regulatory pressures. This highlights the urgent need to develop more distinct plant protection strategies.

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Plant protection encompasses all measures taken to safeguard crops from threats and ensure high quality and quantity of agricultural produce for food security and farmer livelihoods. Various approaches employed to protect plants—ranging from traditional to modern—include the use of chemical pesticides to kill or inhibit the growth of unwanted organisms. While effective, their indiscriminate use can harm human health and the environment, leading to concerns about residues and the development of resistance. Integrated pest management strategies emphasize prevention, monitoring, and the judicious use of pesticides. The use of physi-

cal barriers and cultural practices, such as crop rotation, adjusting planting and harvesting times, employing resistant varieties, and maintaining field sanitation, are also being exploited.

Sustainable Alternative Technologies

Worldwide awareness of the hazards associated with the high-dose application of chemical pesticides on human health and natural ecosystems has led to a demand for safer, environmentally sound, and sustainable alternative technologies for profitable crop production. More reliable, eco-friendly, and sustainable methods based on biological approaches are gaining importance for the management and control of crop diseases. The biological control method offers the introduction or conservation of beneficial microorganisms, which can significantly reduce reliance on chemical pesticides.

Biological pesticides are biologically active, natural compounds derived from living microorganisms and/or plants, useful for controlling plant pests and pathogens. They offer a wider range of activity with less incidence of resistance development by suppressing pathogen attack and invasion on host plants. This approach relies on the use of biocontrol agents and/or their formulations to suppress target pathogens, providing broad-spectrum antagonism to protect crops and reduce disease incidence. They establish themselves in the soil and plant rhizosphere/phytosphere, continuously producing bioactive compounds in close proximity to the target pathogens. Consequently, they are needed in very limited quantities and often have better efficacy.

Biofungicide-based, novel disease management strategies will be of societal benefit and will help farmers secure global food production

Increased Nutrition, Higher Plant Growth

Microbial interactions with rhizospheric microflora and plant roots promote plant growth and improve plant nutrition, along with the production of plant hormone-like compounds including auxin, gibberellins, cytokinins, etc., that stimulate plant growth. Increased nutrition enhances the plant's overall resistance to pathogens and other stress factors. They are less specific towards non-target species, and their mode of action is usually different from those of conventional pesticides, which suppresses the development of resistance in pathogens.

A number of microorganisms belonging to the genera Bacillus, Pseudomonas, and Trichoderma are useful in bio-priming, seed coating, and seedling root dip treatments to control disease incidence. CSIR-NBRI has characterized a number of microbes with the ability to antagonize different soil-borne pathogens. By targeting two major diseases—fusarium wilt (responsible for 10–100% losses) in chickpea, gladiolus, tomato, and rice, and sheath blight disease of rice (up to 40% losses)—we have developed five biopesticide formulations.

Novel biopesticide formulations such as NBRI-BioPal12 and NBRI-TrichoFx—both with detailed mechanisms of antagonism against fusarium wilt of chickpea—Baciguard-W9 for fusarium wilt and yellows of gladiolus, NBRI-Bioagent-PBE8 for fusarium wilt of tomato, and NBRI-Bam13 for sheath blight disease of rice have been developed. Solid formulations against targeted pathogens were evaluated for their bio-efficacy response at three agroclimatic zones of India. Environmental safety and toxicity evaluations on different animal models from the GLP lab emphasize the non-hazardous nature of the developed biofungicide formulations.

The developed formulations, which are effective in controlling target diseases and safe for non-target organisms, are under technical scrutiny for regulatory approval from the Central Insecticide Board (CIB-RC). After registration at CIB-RC, these biofungicide formulations can be commercialized to different companies for large-scale production. These biofungicide-based, novel disease management strategies will be of societal benefit and help farmers secure global food production. Future research may include integrating multi-layered, microbiome-based approaches targeted to novel pathways of defence.

CLIMATE-RESILIENT CROP PROTECTION
INDIA'S ADAPTIVE STRATEGIES FOR A CHANGING CLIMATE

"Climate change is not a distant threat; it's a present reality"

Today India's agricultural sector stands at a critical juncture. With over 60% of the population dependent on farming and climate change accelerating pest outbreaks, erratic rainfall and soil degradation, the need for **climate-resilient crop protection** has never been more urgent. This feature explores the evolving landscape of crop protection in India, highlighting key strategies, innovations, and policy frameworks that are shaping the future of sustainable agriculture.

Climate change is reshaping agriculture globally altering rainfall patterns, intensifying droughts and increasing pest outbreaks. To safeguard food security and rural livelihoods, farmers and policymakers are turning to climate-resilient and sustainable strategies that adapt to these challenges while preserving the ecosystems. As climate change accelerates, the agricultural sector finds itself at the front lines of a global challenge. From erratic rainfall to rising temperatures and pest outbreaks, farming communities are facing unprecedented threats. India's National Innovation on Climate Resilient Agriculture (NICRA) highlights that pest outbreaks linked to temperature changes have risen by over 30% since 2015 in semi-arid zones. However, hope grows alongside innovation.

Transformation in Our Agricultural Landscape

India's agricultural landscape is undergoing a transformation and crop protection must evolve. Climate change is intensifying pest outbreaks, altering disease cycles, and reducing the efficacy of traditional pesticides. Crops once considered resilient are now vulnerable to new biotic stresses. Indian farmers, especially small holders, are facing unprecedented challenges. The solution

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lies in smart, sustainable, and scalable crop protection strategies tailored to India's diverse agro-climatic zones.

In the past decade, Indian farmers have faced a series of climate-driven challenges that have reshaped the dynamics of crop protection. The pink bollworm, once confined to specific cotton-growing regions, has expanded into non-traditional zones, disrupting established pest management practices. Simultaneously, outbreaks of rice blast and wheat rust have become more erratic, influenced by shifting humidity levels and wind patterns linked to climate variability. Resistance to synthetic pesticides has intensified among major pest species, diminishing the effectiveness of conventional chemical controls. Additionally, the overuse of agrochemicals and reliance on monocropping systems have led to widespread soil fatigue, reducing fertility and resilience. These developments underscore the urgent need for a paradigm shift in India's approach to crop protection that prioritizes sustainability, adaptability, and ecosystem health.

These shifts demand a comprehensive overhaul in how India approaches crop protection. The goal is no longer just to control pests but also to build resilience into the entire agricultural ecosystem.

Holistic Approach To Crop Protection

A holistic approach to crop protection has become essential for ensuring sustainable agricultural productivity in India. From biopesticides to AI-powered advisories, Indian agriculture is evolving through practices like Integrated Pest Management (IPM), climate-smart crop varieties, and digital surveillance systems.

IPM has proven its value over the years, with farmers in Tamil Nadu's delta region reducing pesticide use by 40% while maintaining yields. Genetically improved crops such as Bt cotton, blast-resistant rice, wilt-tolerant chickpea, and pod borer-resistant pigeon pea are offering frontline defense against climate-sensitive pests. The Indian Council

India's policy landscape is also evolving to support climate-resilient agriculture with promotion of IPM, organic farming, and climate-smart technologies

of Agricultural Research (ICAR) has also introduced 109 new crops to counter erratic rainfall, extreme temperatures, and soil degradation. This includes 69 field crops, such as cereals and pulses, and 40 horticultural crops like fruits and medicinal plants.

Agroecological practices such as intercropping, polyculture, and natural pest deterrents are strengthening resilience and biodiversity, with states like Sikkim and Himachal Pradesh leading the way. In many parts, biopesticides, especially neem-based microbial formulations, are gaining popularity as safer alternatives.

Digital platforms such as iSAT, Kisan Suvidha, and Plantix are revolutionizing pest management by delivering hyper-local alerts and advisories, effectively bridging extension service gaps especially in remote regions. Meanwhile, advanced technologies like drones and satellites are transforming early infestation detection, enabling faster and more targeted responses.

On the ground, initiatives under ICAR & UAS Bangalore are empowering communities through distribution of protective equipment, training, and field demonstrations. In Karnataka's H.D Kote taluk, over 100 tribal farmers are successfully employing climate-smart agriculture practices over 225 acres of land. They've adopted biopesticides, protective equipment, and resilient technologies to enhance crop yields and reduce their reliance on chemical pesticides. This initiative, focused on climate-resilient agriculture, is now being extended to other tribal regions, demonstrating the effectiveness of local innovation.

To catalyse this shift, India's policy landscape is also evolving to support climate-resilient agriculture with promotion of IPM, organic farming, and climate-smart technologies. Agri-tech startups and NGOs are collaborating with government bodies to scale innovations, prioritize research, education, and incentives that align with sustainable goals.

While progress is evident, challenges remain as many farmers are unaware of climate-smart options, non-availability of biopesticides and resilient seeds and lack of seamless coordination between research, extension, and digital platforms. Farmers need access to resources, training, and market support to adopt resilient practices. Collaboration across sectors like government, academia, industry, and civil society is essential to drive systemic change.

With India's rich biodiversity, strong research institutions, and growing Agri-tech ecosystem, the opportunities are vast, and the country is well-positioned to lead the global shift toward climate-resilient crop protection.

Ensuring climate-resilient crop protection is no longer optional, it is an urgent imperative for global food security and agricultural sustainability. By embracing integrated strategies, leveraging technology, and empowering communities, India can safeguard its agricultural future. For experts and stakeholders, the call is clear- collaborate, innovate, and invest in resilience.

DATA IS THE NEW OIL, AND IT'S FLOWING FROM INDIA'S FARMS

Every harvest season, crores of Indian farmers wait anxiously - not just for the harvest of their labour, but for the market price their crops will fetch in the markets. In a country where agriculture feeds over a 1.4 billion people and supports nearly half the population's livelihood, the stakes are high.

Challenges in Indian Agriculture

Despite the lifeline provided by the government's Minimum Support Price (MSP) system, deep-rooted challenges continue to plague Indian agriculture - from low productivity and water scarcity to price volatility and farmer distress. What if the key to solving many of these issues lies hidden in the very data the MSP program quietly collects year after year?

The Role and Potential of MSP Data

Twice each year, as part of the MSP program, GOI undertakes the procurement of food grains directly from its farmers. During this process, a comprehensive set of data is systematically collected. This includes detailed information on farmer demographics, such as age, gender, and socio-economic background, as well as precise farm locations and the size of landholdings. The data also covers specifics on crop types, lot details, yield volumes, and standardised quality metrics. Additionally, records of MSP payments and historical as well as current cropping patterns are maintained

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to provide a holistic view of agricultural activity.

In addition to the data gathered through the MSP procurement process, several digital platforms have been established to enhance the scope and accuracy of agricultural data collection in the country. Platforms such as the Digital Crop Survey and AgriStack enable the acquisition of real-time, plot-level data, offering a granular perspective on crop production. Other government sources, including digitised land records, farmer registries, and open datasets like the Agricultural Resource Information System (AgRIS), further enrich this data ecosystem.

The integration and management of these diverse datasets are facilitated by advanced tools and platforms, such as the Agricultural Integrated Management System (AIMS), various e-portals, mobile applications, and Direct Benefit Transfer (DBT) systems. These technologies streamline the processes of data collection, validation, and dissemination, ensuring both accuracy and accessibility for stakeholders.

Vital Information for Farmers

When processed using AI and advanced analytics, these datasets can provide valuable insights that can inform policy and operational decisions. For instance, predictive models can be developed to forecast price trends, while optimisation algorithms can recommend crop choices that are best suited to local soil and climatic conditions. Furthermore, the allocation of critical resources can be improved, ensuring that inputs reach the areas where they are most needed.

Ultimately, the effective utilisation of MSP and related agricultural data

Many of these issues can be tackled by leveraging the vast datasets collected through the MSP system. If used effectively, this data can help make agriculture more sustainable, resilient, and future-ready

serves as a powerful instrument for enhancing food security and promoting sustainable agricultural growth.

India's Groundwater Crisis and the MSP Effect

One unintended consequence of MSP is its contribution to India's growing groundwater crisis. India has just 4% of the world's freshwater but is home to almost 17% of its population. The MSP system often incentivises the cultivation of water-intensive crops like paddy and wheat. While MSP has helped mitigate market risk, it has also encouraged groundwater depletion. A 1% increase in procurement of wheat or paddy leads to a 0.6% decline in groundwater levels (Sharma, 2023). With around 60% of India's net sown area dependent on groundwater, this is not sustainable. The solution lies in data-driven reforms. Policy experts are calling for a shift in the government's MSP system, which currently incentivises water-intensive crops like paddy and wheat.

Proposed MSP Reforms

To address these challenges of depleting water tables, it is essential that agricultural reforms focus on incentivising the cultivation of water-efficient and climate-resilient crops. By leveraging the wealth of information available through MSP data, policymakers can better align crop recommendations with the specific environmental realities of different regions.

For example, in arid zones where water scarcity is a persistent concern, promoting the cultivation of millets can offer a sustainable solution, as these crops require significantly less water and are well-adapted to harsh conditions. Similarly, in states facing acute water stress, encouraging farmers to grow pulses can help conserve water resources while also improving soil health and nutritional outcomes. MSP data provides valuable insights that can guide procurement strategies, enabling the government to balance market demand with ecological considerations.

Data-Driven Monitoring: From Insight to Action

Effective crop diversification requires robust monitoring, which can be achieved by integrating MSP data with AI and satellite imagery. This approach allows for precise tracking of cropping patterns at the district and village levels, measures the impact of incentives in water-stressed regions, and helps identify areas that are lagging behind so that targeted local solutions can be recommended. Policymakers can use these insights to design region-specific policies based on acreage, climate, and crop type, as well as tailor support programs, such as specialised training for smallholders or streamlined procurement for larger farms. State incentives can also be fine-tuned to boost participation, while MSP sale records and farmer profiles can help assess creditworthiness.

Challenges to Implementation

To fully realise the potential of MSP data, India must overcome several key implementation challenges. First, fragmented datasets across various ministries require common standards and integration protocols to ensure interoperability. Second, robust consent mechanisms must be established to protect privacy and build trust, in line with India's data protection laws. Third, the digital divide remains a concern; leveraging FPOs, Common Service Centres and mobile platforms will be essential to make data-driven insights accessible to all stakeholders.

(The views expressed are personal opinions and do not reflect the official position of NeML)

REIMAGINING FARMING: TIME TO THINK ALTERNATE BUSINESS MODELS AND THE CASE FOR LAND REFORMS

Across India's rural landscape, the struggles of farmers resonate more intensely than ever. The fertile soil that once nourished families is now burdened by fragmentation and the mounting challenges faced by small and marginal farmers. The question looms large: how can farming remain viable when landholdings are shrinking?

With 84% of landholdings already under small and marginal farmers—and this figure set to rise due to continued land mutation—farming is becoming increasingly unsustainable. To compound the issue, fewer individuals are inclined to take up farming as a livelihood. In this scenario, it is imperative to explore long-term, sustainable models for small and marginal farms to thrive.

It's time for bold ideas and actionable solutions, grounded in evolving business models and reformed land laws.

FPOs Taking Charge of Farming

Farmer Producer Organizations (FPOs) currently focus on aggregating inputs and outputs to secure better bargains—lower input costs and higher produce prices. However, the time has come to encourage FPOs to actively engage in farming itself.

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In this model, farmers pool their lands, resources, and efforts under the umbrella of an FPO. These organizations introduce advanced technology, modern farming practices, and economies of scale. The unique strength of this approach lies in its ability to preserve farmers' ownership of their land while sharing operational responsibilities and profits.

For this vision to materialize, certain land laws require amendments. Specifically, laws need to facilitate time-bound land leasing, enable flexible agreements, and permit land swaps between FPOs to ensure contiguous and operationally efficient landholdings.

The Build-Operate-Transfer (BOT) Model

Another transformative approach is the Build-Operate-Transfer (BOT) model, where third-party entities—be it FPOs or large agribusiness corporations—invest in developing farmland infrastructure, enhancing productivity, and sharing profits over a fixed period.

Once the agreed term concludes, the land reverts to the farmer or FPO, often in a more productive state. However, this model demands distinct legal recognition of temporary business arrangements. Land laws must differentiate such agreements from permanent tenancy, protecting farmers' ownership while allowing external investments to improve land productivity.

The Build-Own-Operate (BOO) Model

The Build-Own-Operate (BOO) model provides another pathway, where entities invest in infrastructure like warehouses/ greenhouses, irrigation systems, or storage facilities on leased land. These assets remain under the entity's ownership, while farmers lease their land for specific durations. The cultivation will be done on large piece of agricultural land, this model will try to integrate cultivation processing and storage, in the end there could be an arrangement of buy back of the assets owned by the corporate by the FPO/Farmer.

To make this model viable, land laws must guarantee that farmers' rights are safeguarded while ensuring they receive equitable benefits from such long-term investments. Legal frameworks should also guard against exploitative practices by mandating fair revenue-sharing mechanisms and transparent contracts.

Land laws must no longer act as barriers but as enablers of change. By protecting ownership, fostering collaboration, and embracing modern farming practices, India can uphold its agricultural heritage while building a sustainable future

Strengthening Contract Farming

Contract farming, while recognized and regulated in some states, continues to suffer from loopholes. While on one hand farmers are frequently left vulnerable to delayed payments, forced price renegotiations, and other unfair practices on the other hand when prices rise farmers not supplying the produce to the corporates have occurred too. Strengthening the Contract Farming Act is critical.

Laws should include enforceable dispute resolution mechanisms, clear penalties for breaches, and transparency in agreements to ensure farmers receive their rightful dues and equitable benefits.

Modernizing Land Records

Land reforms cannot stop at leasing and contracts; the system of land records itself demands modernization. A robust digital platform for managing landownership, agreements, and disputes can bring transparency and significantly reduce conflicts.

Small and marginal farmers must also be incentivized to register their lands for collective farming models without fearing the loss of ownership rights. Modern land records would not only aid in building trust but also facilitate the smooth implementation of advanced farming models.

Addressing Farmers' Emotional Connection to Land while also encouraging corporate farming through lease.

For farmers, land is more than a livelihood—it is their identity and legacy. Any reform in land laws must honour this emotional connection. Policies must explicitly guarantee that models like FPO pooling, BOT, or BOO will not alienate farmers from their land. In addition to these we can look at corporate farming with land being leased for each season.

Evolving Land Use Laws

Agribusinesses increasingly require integrated operations such as processing, storage, and packaging. To support these, zoning regulations need to evolve, allowing such activities on agricultural land without compromising its primary purpose—farming.

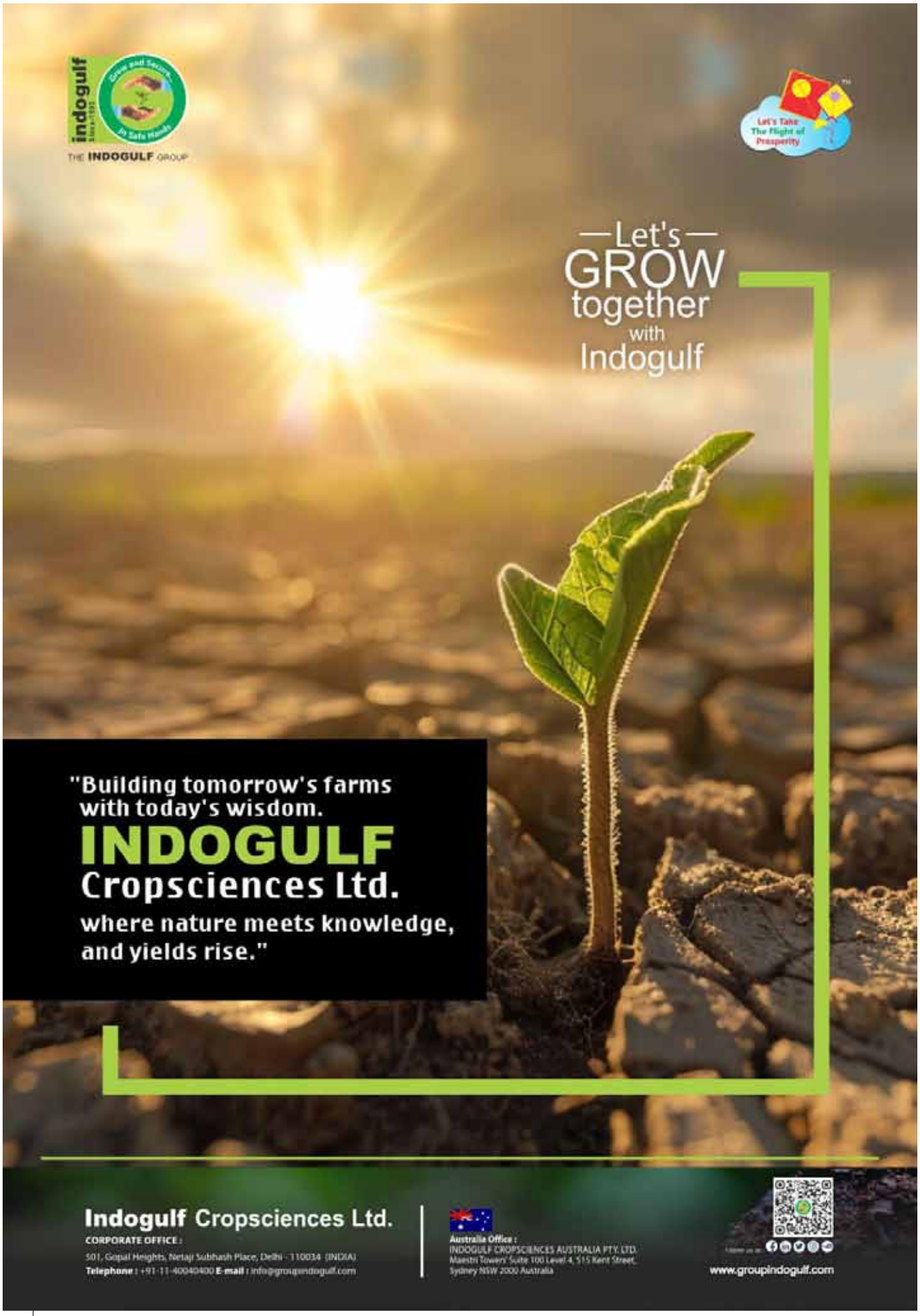
Encouraging Shared Ownership

Fragmented landholdings remain one of the most significant challenges in Indian agriculture. Policies that promote shared ownership and cooperative farming can address this issue. Farmers must be enabled and encouraged to voluntarily pool their lands for joint operations, creating larger, more viable agricultural enterprises.

The Path Forward

Reimagining Indian farming is a challenging but achievable goal. With the right blend of innovative business models and forward-thinking land reforms, the agricultural sector can be transformed into a source of pride and prosperity for farmers.

(The intent of this article is to ignite thoughts in various directions for policy makers and practitioners to evolve and is not prescriptive.)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