

INNOVATION IN CROP PROTECTION SECTOR

The India Opportunity

September 2026





KEYNOTE MESSAGE

India stands at an important inflection point in agriculture. As we strive to build a more productive, resilient and sustainable agricultural sector, innovation in crop protection will be central to securing food, farmer incomes and the long-term competitiveness of Indian agriculture.

The opportunity before India is significant. Advances in science, digital technologies, artificial intelligence, biological solutions and precision agriculture are reshaping the way crop protection products are discovered, developed and deployed. For India to fully harness this transformation, we need not only continued investment in research and technology, but also a regulatory ecosystem that enables innovation, encourages responsible investment and ensures timely access to modern solutions for farmers.

At CropLife India, our engagement during the year has remained focused on enabling this environment. The Pesticide Management Bill 2025 has been at the centre of our advocacy. We have consistently engaged with policymakers, regulators and stakeholders to support a modern, science-based regulatory framework—one that protects farmers and consumers, strengthens enforcement, encourages innovation and is aligned with evolving global practices.

Equally important is Regulatory Data Protection (RDP). A predictable and globally aligned approach to protecting regulatory data can play a critical role in attracting investment, supporting research and development, and enabling the introduction of newer crop protection technologies in India. If India is to emerge as a leading destination for agricultural innovation and manufacturing, regulatory certainty will be an important competitive advantage.

Our advocacy has also addressed specific molecules and regulatory challenges at both the national and State levels. Through constructive engagement, we have consistently advocated for science- and risk-based decision-making, while highlighting the importance of consistent registration, licensing and implementation processes. The objective is straightforward: farmers should have continued access to registered, scientifically evaluated and effective crop protection solutions, while regulatory decisions remain firmly grounded in evidence.

We have also worked towards improving the efficiency, transparency and predictability of the regulatory system. The operationalization of the New Molecule definition and priority pathway, along with our engagement on CROP portal challenges, labelling, testing standards, crop grouping and other regulatory processes, reflects our commitment to making India's regulatory framework more responsive to the needs of a rapidly evolving agricultural sector.

The India opportunity, however, extends beyond regulation. India has the scientific talent, entrepreneurial energy, manufacturing capabilities and agricultural diversity to become a global hub for innovation in crop protection. What is required is a stronger convergence between science, industry, policymakers, farmers and technology providers.

The next generation of crop protection will be defined not simply by new molecules, but by how intelligently we combine chemistry, biologicals, data, AI, precision application and farmer knowledge. Innovation must ultimately translate into solutions that are accessible, affordable, safe, effective and relevant to Indian agriculture.

As we look ahead, CropLife India remains committed to being a constructive partner in this journey. We believe that a progressive policy and regulatory environment, coupled with sustained investment in innovation, can unlock tremendous value for farmers and position India at the forefront of the global agricultural transformation.

The opportunity is before us. Our collective responsibility is to turn India's potential into innovation that delivers—for the farmer, for agriculture and for the future.

Ankur Aggarwal
Chairman
CropLife India

MESSAGE



Turning Innovation into Impact

Innovation in agriculture is ultimately measured not by the technology we create, but by the difference it makes in the field.

I am pleased to present “Innovation in Crop Protection Sector: The India Opportunity,” a comprehensive Knowledge Report developed by YES BANK with the support of the CropLife India members, highlighting the transformative journey of India’s agricultural landscape, driven by modern technological advancements and sustainable crop protection solutions.

For India’s farmers, crop protection is about much more than managing pests and diseases. It is about protecting yield, improving crop quality, reducing losses, meeting increasingly demanding market standards and making every acre more productive. As Indian agriculture evolves, the crop protection sector too is undergoing a fundamental transformation.

The innovation landscape today is far broader than conventional crop protection chemistry. New molecules are being complemented by biological solutions, precision application technologies, digital tools, artificial intelligence, data-driven decision-making and integrated approaches to crop health. Together, these technologies are creating new possibilities for more targeted, efficient and responsible crop protection.

This Knowledge Report captures that changing landscape and, importantly, the opportunity that India presents and the real opportunity lies in creating an ecosystem where science meets farmer experience, innovation meets affordability, and technology meets scale.

This is also why knowledge-sharing is so important. Reports such as this help bring together perspectives, evidence and emerging trends at a time when the agricultural sector is changing rapidly. They provide an opportunity to look beyond individual products or technologies and consider the larger ecosystem required to make innovation work for Indian agriculture.

I express my sincere gratitude to the CropLife India Board, Experts, Industry leaders, and the knowledge team at YES BANK whose support and the dedicated efforts have made this insightful publication possible. I am confident that this report will serve as a valuable reference point for policymakers, industry stakeholders, and academia driving sustainable agricultural growth.

Durgesh Chandra

Secretary General

CropLife India

FOREWORD



India stands at a pivotal moment in its agricultural journey. With the vision of Viksit Bharat, the country is focused on enhancing farm productivity, improving farmers' income, strengthening food and nutritional security and promoting sustainable agricultural practices. Effective crop protection is critical for achieving these objectives.

Every year, pests, diseases and weeds lead to substantial crop losses, undermining farm incomes and reducing efficiency across the agricultural value chain. As the challenges of pest attacks become more complex due to evolving pest dynamics, shifting cropping patterns and climate change driven crop stress, conventional approaches of crop protection alone are no longer sufficient. India needs an innovation ecosystem that accelerates discovery, development and adoption of next-generation crop protection technologies.

India's crop protection innovation landscape encompasses a wide range of solutions including biologicals, precision application technologies, digital decision-support tools, integrated pest management and advanced formulations that enable farmers to protect crops more efficiently while minimising environmental impact. Together, these innovations are reshaping the future of Indian agriculture.

India has the potential to emerge as a global hub for innovation in the crop protection domain. This is backed by a strong manufacturing base, scientific capabilities, skilled talent and an expanding research ecosystem. Unlocking this potential, however, will require sustained investments in research and development, stronger industry-academia collaboration, supportive regulatory frameworks and policies that encourage innovation while ensuring safety and quality.

YES BANK is privileged to knowledge partner with CropLife India to develop this report titled - "Innovation in Crop Protection Sector: The India Opportunity". This report explores the current innovation landscape of the crop protection industry, identifies critical challenges that the industry is currently facing and puts forth select initiatives that could boost innovation in the crop protection sector. We hope that this report provides the insights required to strengthen the ecosystem and unlock the full potential of innovation in crop protection.

Sincerely,

Manish Jain

Executive Director

YES BANK Ltd.

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Executive Summary



The vision of Viksit Bharat@2047 marks one of the most ambitious national development agendas in India's history—transforming the country into a developed, prosperous and globally competitive economy by the centenary of its independence. While this vision spans every sector of the economy, India's journey towards becoming a developed nation will ultimately be determined by the progress of India's agricultural economy.

Over the past six decades, India has witnessed one of the most remarkable agricultural transformations globally. From being dependent on food imports during the 1960s, the country has emerged as one of the world's largest producers of rice, wheat, fruits, vegetables, milk, spices and pulses. This transformation has been enabled by sustained investments in irrigation, improved crop varieties, mechanization, fertilizers, crop protection technologies, extension services and supportive government policies.

The next phase of agricultural growth will demand more. India today feeds nearly 1.48 billion¹ of human population while possessing only around 4% of the world's agricultural land resources² and approximately 4% of global water resources³. By 2050, population is expected to reach 1.7 billion, while natural resources are expected to be under unprecedented pressure. Climate change is making monsoons increasingly erratic, with more frequent regional droughts, floods and extreme weather events. Water security is expected to worsen as groundwater levels continue to decline and competition for water intensifies across agriculture, industry and cities.

With the country's net sown area remaining largely stable at around 142 million hectares, future gains can no longer rely on expanding cultivated land. At the same time, rapid urbanisation and infrastructure development are expected to place additional pressure on India's agricultural land base, with an estimated 10% of cropland projected to be converted for urban uses by 2050.⁴

Thus, growth must increasingly come from producing more from every hectare. Productivity gains, however, cannot be achieved through improved seeds, fertilizers or better agronomic practices alone. Their benefits are realised only when crops are effectively protected from insects, diseases and weeds. In India, about USD 30 billion (INR 2 lakh crores) worth of crop yield loss has been estimated due to pests.⁵ Thus, with arable land under pressure and pest-induced losses continuing to erode agricultural output, safeguarding every hectare of production will

¹ United Nations, Department of Economic and Social Affairs, Population Division (2024). World Population Prospects: The 2024 Revision, custom data acquired via website. Global population 8.3 billion.

² Land used for cultivation of crops and animal husbandry. The total of areas under "Cropland" and "Permanent meadows and pastures- FAOSTAT

³ <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2055582®=48&lang=2>

⁴ https://icrier.org/pdf/Working_Paper_361.

⁵ Herbicides Vis-à-vis other pesticides: Trend analysis and economic impact, ICAR (A. Jamaludheen, Singh P.K, Choudhary V.K., Gharde Yogita and Mishra J.S 2023, Technical Bulletin No. 23, ICAR- Directorate of Weed Research, Jabalpur. 32p.) estimate yield loss due to weeds to be USD 11 Bn annually (Gharde et al 2018). The studies further estimate that yield loss due to weeds is 37%, due to insects is 29%, due to diseases is 22% and due to other pests is 12%. Based on these findings the estimated crop loss due to pests has been calculated. The loss when converted to INR at 2018 rates (1 USD=INR 70) amounts to ~ INR 2 lakh crores.

be as important as increasing productivity. As climate change alters pest dynamics and intensifies production risks, safeguarding crop health has become a prerequisite for sustaining productivity growth. Innovation in crop protection is therefore a strategic necessity.

Beyond crop loss, bringing innovation in the crop protection segment is imperative to bridge the productivity gap existing in India vis-a-vis global leaders, address issues related to rising pest resistance, changing pest dynamics due to climate change, increasing wage rate & labor shortage, building export competitiveness and moving towards environmental sustainability. Newer crop protection technologies enable farmers to manage evolving pest pressures more effectively, protect their returns on investments and support more produce from every hectare.

The innovation landscape

The global agrochemicals' industry is witnessing a significant shift in how innovation is approached, shifting from a pure product-centric model to an integrated "crop-health solutions" approach. While synthetic chemistries continue to play an important role, innovation is increasingly focused on developing solutions that are more targeted, sustainable and technology-enabled.

According to the World Intellectual Property Organization's (WIPO) "Patent Landscape Report on Agrifood", pest and disease management has emerged as the area where most international patents have been filed in the Agritech domain over the past two decades (globally). This is followed by crop adaptation and genetics, livestock management, and IoT-related areas such as connectivity/sensors/smart farming, precision agriculture and mapping/imagery. The report also identifies non-pesticide pest and disease management as an emerging and important area of innovation globally. This broadly includes use of living organisms, compositions, devices and gene modification for pest control.

Beyond crop protection products, innovation is increasingly extending to the broader agricultural technology ecosystem worldwide. Advances in remote sensing, satellite imagery, IoT-enabled monitoring, precision agriculture, artificial intelligence and predictive analytics are enabling real-time pest surveillance, site-specific crop protection and data-driven farm management.

India's crop protection innovation ecosystem is also undergoing a gradual transition. Historically, innovation has been driven by process chemistry, generic manufacturing and formulation development, enabling the country to emerge as one of the world's leading producers and exporters of crop protection products. However, as global innovation shifts towards novel chemistries, biologicals, precision agriculture and digital crop health solutions, India's innovation priorities are also beginning to evolve. This evolution can be viewed through four key foundational pillars that together shape India's crop protection innovation journey.

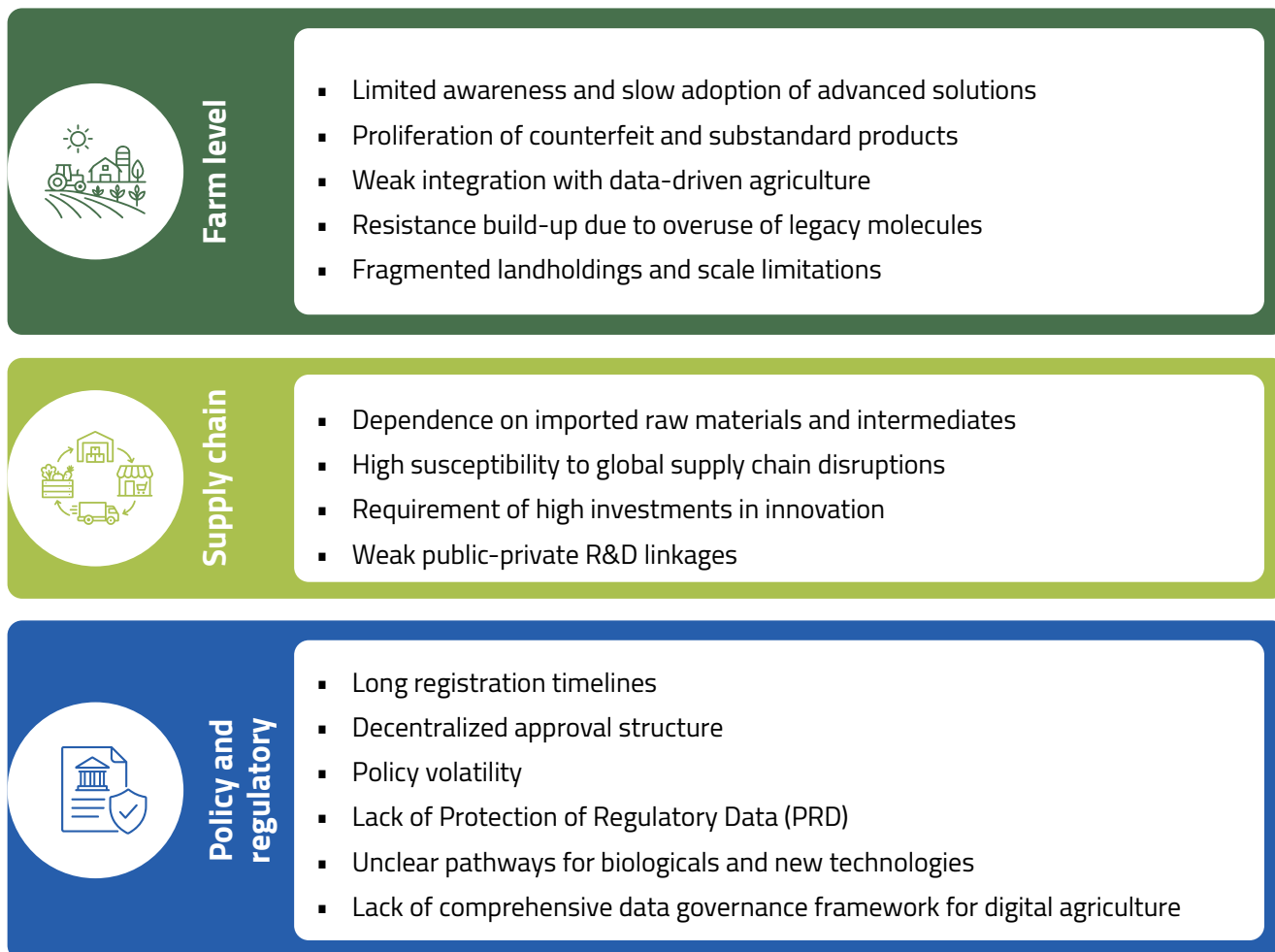
- Strong manufacturing capabilities provide a foundation for innovation
- Indian innovation remains stronger in formulations than discovery
- Digitally guided agriculture is becoming an innovation multiplier
- Regulatory and policy frameworks are improving, however, several procedural and structural gaps continue to limit the ease of introduction and adoption of innovative solutions.

Taken collectively, these foundational pillars highlight a sector that is moving beyond traditional chemistry into a more diversified innovation landscape which can be broadly classified into ten thematics including-

- **Discovery of Novel Active Ingredients and New Chemistry-** that offer superior efficacy, lower application rates, improved environmental profiles and differentiated intellectual property.
- **Advanced Formulation Technologies** - that enhance product performance by improving rain fastness, spray retention, penetration into plant tissues, stability, ease of handling and compatibility with modern application equipment.
- **Bio-based Crop Protection-** is emerging as one of the fastest-growing innovation segments within the crop protection industry. These products aim to improve soil and plant health, reduce pesticide residues, delay resistance development and support sustainable agricultural practices.
- **Climate-smart Crop Protection-** integrated solutions that help crops withstand drought, heat stress, erratic rainfall and changing pest dynamics associated with climate change.
- **Precision Application Technologies-** drone-compatible formulations, precision spraying technologies, sensor-based application systems, predictive scouting platforms and weather-enabled spray advisories to ensure that products are applied at the right place, time and dosage.
- **Sustainability Beyond Products-** Sustainability considerations for crop protection industry are going beyond green products and biologicals portfolio. Companies are developing safer manufacturing processes that reduce environmental impact, lower carbon emissions, reduce packaging waste and promote circular resource use.
- **Digital Technology Enabled Agriculture-** At the farm level, digital platforms integrate satellite imagery, weather information, sensor data, crop modelling and agronomic intelligence to provide real-time recommendations on pest management and crop protection interventions.
- **Advanced R&D Infrastructure and Research Platforms-** Advanced R&D centres equipped with automated systems, pilot plants, GLP-certified laboratories etc. are becoming critical competitive differentiators.
- **Open Innovation and Collaborative Research-** Strategic partnerships, venture investments, acquisitions and joint research programmes are becoming essential mechanisms for accelerating innovation and commercialization, creating a more connected agricultural innovation ecosystem.
- **Integrated Pest Management Continuum-** Crop protection innovation is increasingly shifting from standalone solutions to an integrated pest management (IPM) continuum, where multiple technologies work together across the crop lifecycle. These are complemented by digital surveillance tools that enable early detection and forecasting, and precision application technologies that ensure interventions are targeted, efficient, and sustainable. Together, these innovations create an integrated, data-driven crop protection ecosystem.

While the private sector has been at the forefront of driving innovation, Government initiatives have played a critical enabling role in strengthening India's agricultural innovation ecosystem. Policy interventions have focused on improving farm productivity, promoting R&D and innovation, expanding digital agriculture, developing enabling infrastructure, and advancing sustainable farming practices. For the crop protection sector, key initiatives include the National Pest Surveillance System, the Kisan Drone Initiative, support for drone adoption through the Agriculture Infrastructure Fund (AIF), and the Chemical Promotion and Development Scheme. In addition, the proposed Draft Pesticides Management Bill, 2025 seeks to establish a modern, science-based regulatory framework. It introduces provisions relating to digital administration, traceability, testing-laboratory accreditation, deterrence against spurious pesticides and rationalisation of offences and penalties. Although the Bill is yet to be enacted, it reflects the Government's intent to modernize the regulatory landscape and support long-term innovation in the sector.

While India has the foundational strengths to emerge as a global hub for crop protection innovation, unlocking this potential requires addressing structural bottlenecks that continue to constrain innovation. The report examines key structural barriers that are limiting innovation in India's crop protection sector. It assesses challenges across the farm level, supply chain and regulatory framework.



Bridging these gaps is essential to accelerating innovation, strengthening industry competitiveness, and ensuring farmers have timely access to advanced crop protection solutions. Achieving this vision will require an enabling ecosystem that supports research, accelerates commercialization, drives farmer adoption and fosters collaboration across the value chain.

The Government has a critical role to play in creating this ecosystem by enabling a stable and predictable policy environment, strengthening research support, safeguarding intellectual property and introducing targeted incentives that encourage innovation and investment.

The private sector has an equally important role in advancing R&D, expanding manufacturing capabilities, leveraging digital technologies, strengthening farmer outreach, and promoting responsible product stewardship.

Together, through strong public-private collaboration, these efforts can build a resilient and innovation-driven crop protection ecosystem that accelerates technology adoption, enhances farm productivity, strengthens food security and reinforces India's global competitiveness. This report outlines the key imperatives to realize this vision.

Imperatives for the Industry

- **Strengthen Stewardship and Farmer Outreach** – on product selection, dosage, application methods, resistance management and safe handling practices
- **Strengthen Manufacturing Competitiveness and Accelerate Indigenous Innovation-** Continue to build domestic manufacturing capabilities across technical-grade products, intermediates, formulations and biologicals to reduce supply chain vulnerabilities, improve self-reliance and contribute to exports from India.
- **Evolve Towards Integrated Crop Health Solutions-** Move beyond a product-centric approach and offer integrated crop health solutions that combine chemical and biological products with agronomic advisory and digital decision-support tools.
- **Harness Digital Technologies to Improve Farm-Level Outcomes-** Expand the use of artificial intelligence, remote sensing, drones, weather analytics, predictive pest surveillance and field diagnostics to enable timely interventions, optimize input use and provide customized advisories. Digital platforms have immense potential to strengthen farmer engagement and improve decision-making throughout the crop cycle.
- **Foster Collaborative Innovation Ecosystems-** Establish structured partnerships with public research organizations, startups, agritech companies and academic institutions to facilitate knowledge exchange, technology validation and faster commercialization of new solutions.
- **Improve Export Competitiveness-** Align product development, manufacturing and stewardship practices with international quality, residue and traceability requirements.

Imperatives for the Government

- **Enhance Farmer Extension Services-** Strengthen public extension systems to disseminate scientific, crop-specific guidance on product selection, judicious usage, application methods, resistance management and safe handling practices.
- **Strengthen Quality Control and Curb Counterfeit Products** by strengthening market surveillance and enforcement mechanisms; digitizing and standardizing sampling, testing and rationalizing institutional responsibilities by separating licensing and enforcement functions.
- **Strengthen Testing Infrastructure** through equipment upgradation as well as human resource capacity building for advanced analytical capabilities
- **Strengthen Surveillance and Resistance Monitoring** by regularly conducting national crop-loss and pest-impact assessment, establishing a national surveillance system for monitoring pest incidence, creating a national resistance baseline for key crop-pest combinations and creating a centralized national platform for periodic reporting and dissemination of resistance trends.
- **Promote Domestic R&D, Manufacturing and Innovation** through targeted policy incentives (like PLI) for advanced manufacturing across technical-grade products, formulations and biologicals.
- **Foster Public–Private Collaboration** to address emerging crop protection challenges

▪ **Create an enabling policy and regulatory environment through**

- ✧ Streamlining and digitising regulatory approval processes to enable transparent, predictable and time-bound registration of crop protection products while maintaining rigorous safety, quality and efficacy standards.
- ✧ Developing a fully integrated digital regulatory platform covering application submission, scientific review, stakeholder communication, approval tracking and post-registration compliance to enhance transparency and ease of doing business.
- ✧ Introducing a centralized license valid across all states for the manufacture, import and sale of crop protection products.
- ✧ Introducing a robust Protection of Regulatory Data (PRD) framework- A five year exclusivity period for newly registered products and new uses (from the first registration date) will help provide innovators with a predictable return on investments in safety, efficacy and residue data generation.
- ✧ Developing a National Minor Use Programme through collaboration between government, research institutions and industry to generate the scientific data required for registration and label expansion in minor and specialty crops.
- ✧ Developing a progressive regulatory framework for biologicals and emerging technologies
- ✧ Creating a centralized, digital platform with information on MRLs as well as pre-shipment testing requirements of the commodities will help exporters, farmers, regulators as well as food safety professionals.
- ✧ Developing a comprehensive agricultural data governance framework that aligns with the Digital Personal Data Protection Act, 2023
- ✧ Strengthen export-only licensing pathway
- ✧ Strengthening Industry–Government Collaboration to strengthen evidence-based policymaking.

The future of crop protection in India lies in fostering innovation across the full spectrum of crop health technologies. An integrated crop health approach—combining advanced crop protection chemistries, biologicals, preventive agronomic practices, precision application technologies, digital decision-support systems and data-driven advisory services—will be critical to improving productivity, resilience and environmental sustainability.

Realising this vision requires a policy ecosystem that actively encourages innovation across the value chain. This includes strengthening public-private collaboration, creating predictable and science-based regulatory pathways, supporting research, expanding extension services, and accelerating the adoption of new technologies by farmers. This approach will enable India to transition from being primarily a global manufacturing hub to becoming a leading developer, innovator and adopter of next-generation agricultural technologies.

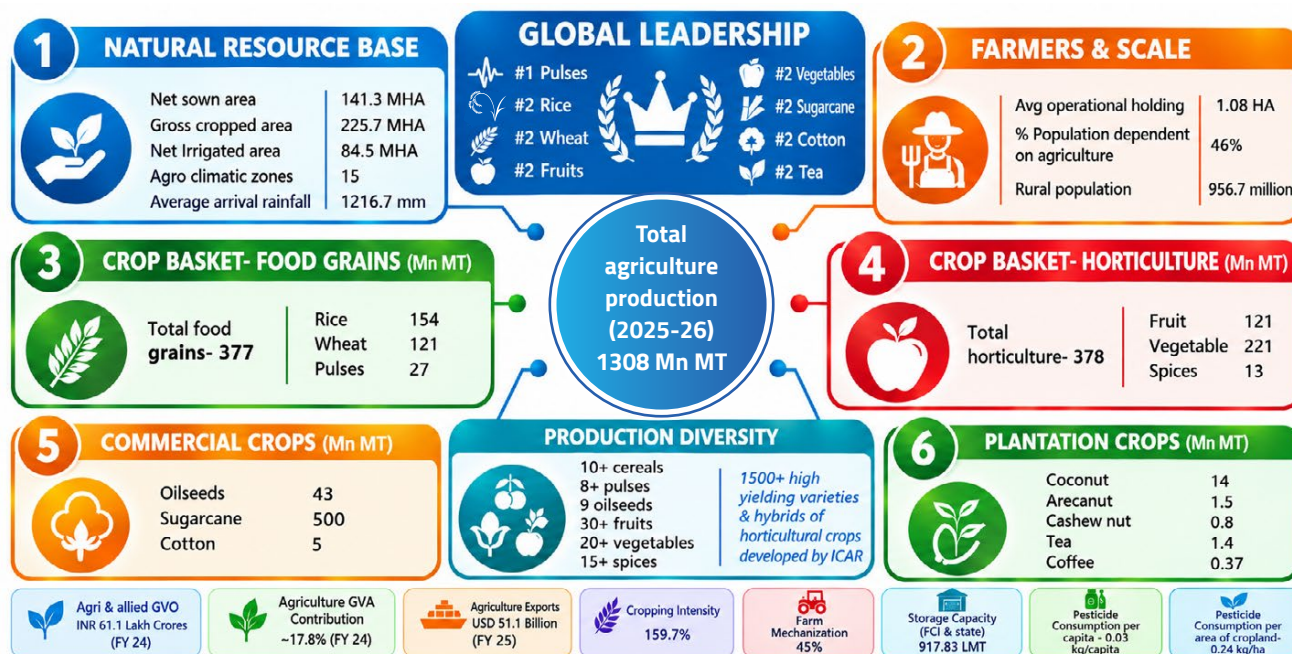
Introduction

1

1.1 India's agricultural transformation: A context for crop protection

Over the past six decades, India has witnessed one of the most remarkable agricultural transformations globally. From being dependent on food imports during the 1960s, the country has emerged as one of the world's largest producers of rice, wheat, fruits, vegetables, milk, spices and pulses (refer exhibit 1). This transformation has been enabled by sustained investments in irrigation, improved crop varieties, mechanization, fertilizers, crop protection technologies, extension services and supportive government policies.

Exhibit 1: The scale of India's farm production



Total agriculture production includes total of horticulture, agriculture (including sugarcane, cotton, jute & mesta) and tea & coffee for FY 26. Horticulture data is of 2nd advance estimates (<https://agriwelfare.gov.in/en/StatHortEst>) while agriculture data is of 3rd advance estimates (UPAg Portal). For cotton, considered 1 Bale = 170 kg and for Jute & Mesta, considered 1 Bale= 180 kg, for converting numbers into weight.

Agriculture GVO includes allied sectors also and is for FY 2023-24

Sources: UPAg Portal, PIB, MoSPI, Jal Shakti, FAOSTAT 2024; Land use Statistics (2024), Tea Board of India, Coffee Board

India today feeds nearly 1.48 billion⁶ of human population while possessing only around 4% of the world's agricultural land resources⁷ and approximately 4% of global water resources⁸. Population is expected to reach 1.7 billion by 2050⁹, while natural resources remain unchanged or rather diminish. Historically, agricultural production increased through expansion of cultivated land and adoption of high-yielding varieties. Today, the scope of expanding cultivable land is severely constrained. India's net sown area has remained around 142 million hectares¹⁰ for several years. Urbanization, industrial development and other competing land-use priorities leave no room for expanding cultivable land.

Further, pre-harvest and post-harvest crop losses pose a serious challenge to food security. Pre-harvest losses are primarily caused by crop pests. FAO estimates suggest that annually up to 40%¹¹ of global crop production is lost to pests. Plant diseases alone cost the global economy more than USD 220 billion each year, which is almost equivalent to the GDP of countries like Qatar and Ukraine.¹²

In India, about USD 30 billion (INR 2 lakh crores) worth of crop yield loss has been estimated due to pests. This loss to crops is estimated to be maximum by weeds (37%), followed by insects (29%), diseases (22%) and others (12%).¹³ Thus, with arable land under pressure and pest-induced losses continuing to erode agricultural output, safeguarding every hectare of production will be as important as increasing productivity. Ensuring food security in the coming decades will therefore depend not only on producing more, but also on protecting existing yields from losses throughout the crop cycle.

1.2 Role of crop protection in India's agri-economy

The crop protection industry is a critical pillar of India's agricultural ecosystem, enabling farmers to protect crops from insects, diseases, weeds and other biotic stresses. By reducing crop losses and preserving yield and quality, the industry supports agricultural productivity, food security and safeguards the returns on other agricultural investment, including quality seeds, balanced nutrition, irrigation, mechanization and precision farming.

The importance of crop protection industry also extends well beyond the farm gate. It supports raw material availability for the food processing industry, strengthens agricultural exports through improved quality and phytosanitary compliance, generates high-value manufacturing and R&D employment, and reinforces India's position as a global agrochemical manufacturing hub.

⁶ United Nations, Department of Economic and Social Affairs, Population Division (2024). World Population Prospects: The 2024 Revision, custom data acquired via website. Global population is estimated at 8.3 billion.

⁷ Land used for cultivation of crops and animal husbandry. The total of areas under "Cropland" and "Permanent meadows and pastures- FAOSTAT

⁸ <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2055582®=48&lang=2>

⁹ <https://databank.worldbank.org/source/population-estimates-and-projections>

¹⁰ LUS data. In 2025 the net sown area was recorded at 141.3 Mn Ha

¹¹ FAO

¹² Nominal GDP- <https://www.worldometers.info/gdp/gdp-by-country/>

¹³ While no comprehensive study is available, past research papers like Herbicides Vis-à-vis other pesticides: Trend analysis and economic impact, ICAR (A. Jamaludheen, Singh P.K, Choudhary V.K., Gharde Yogita and Mishra J.S 2023, Technical Bulletin No. 23, ICAR- Directorate of Weed Research, Jabalpur. 32p.) estimate yield loss due to weeds to be USD 11 Bn annually (Gharde et al 2018). The studies further estimate that yield loss due to weeds is 37%, due to insects is 29%, due to diseases is 22% and due to other pests is 12%. Based on these findings the estimated crop loss due to pests has been calculated. The loss when converted to INR at 2018 rates (1 USD=INR 70) amounts to ~ INR 2 lakh crores.

The industry has also been fostering innovation and working towards upskilling of farmers which has empowered them to take up entrepreneurship roles. Training farmers on aspects such as good agriculture practices, judicious use of resources and climate smart agriculture has aided in increasing productivity and enhanced income levels.

The contribution of crop protection industry to India's economy is captured in exhibit 2.



Suraksha Hamesha meaning "Safety All the Time," is BASF's flagship stewardship initiative to foster a culture of safe and responsible farming across India.

The initiative serves as a dedicated stewardship platform to educate farmers and agricultural sprayers on the responsible use of crop protection products, focusing on the nine steps of responsible use of crop protection products and the importance of personal protective measures.

Since its launch in 2016, Suraksha Hamesha has directly engaged approximately 998,300 farmers and 133,000 agricultural spraying operators nationwide. The program has further expanded its outreach to include women farmers, students, and agricultural officials, building awareness around the safe handling, storage, mixing, and application of crop protection products.

Exhibit 2: Contribution of crop protection industry to India's economy

Strategic Role		Contribution
Safeguarding food security and agricultural productivity		Protects crops from insects, weeds and diseases, preventing yield losses and improving productivity, quality and resource-use efficiency.
Enhancing farmer income		Reduces production risks, stabilizes yields, improves crop quality and enables farmers to achieve higher and more predictable incomes
Generating employment and strengthening rural enterprises		Creates employment across manufacturing, R&D, distribution, retail, logistics, extension services, drone operations and agri-service businesses while fostering rural entrepreneurship.
Developing human capital and rural capabilities		Builds farmers' technical knowledge through training, demonstrations and digital advisory services while upskilling rural youth and empowering women through entrepreneurship, leadership and skill-development initiatives.
Driving innovation and sustainable agriculture		Invests in advanced chemistries, biologicals, integrated pest management (IPM), precision application, drones and digital agriculture to improve productivity while reducing environmental impact.
Boosting exports and global competitiveness		Improves crop quality and supports compliance with international phytosanitary and residue standards. Positions India as a leading agrochemical manufacturing and export hub.

Sources: Industry Discussions

By protecting crops against insects, diseases and weeds at different stages of cultivation, crop protection solutions help preserve yield and quality, improve resource-use efficiency, stabilize farm incomes, and strengthen the resilience of agricultural production systems. As production risks intensify due to climate change and evolving pest pressures, effective crop protection has become an indispensable pillar of sustainable agricultural production.

The Need for Innovation in Crop Protection

2



By 2050, global food production will need to increase by 50%¹⁴ to meet the needs of growing population. It is estimated that 80% of the projected additional food demand by 2050 will need to come from plant products.¹⁵

In India's context, estimates suggest that to meet the objectives of Viksit Bharat by 2047, the country will have to produce approximately 440 million MT of food grains, requiring an additional 63 million MT production. Production of key commodities such as maize, oilseeds, sugarcane, meat, fish and eggs may have to double, while the production of fruits, vegetables and milk may have to increase nearly three-fold to meet future demand.¹⁶ Achieving these targets, while conserving natural resources, amid growing complexity of climate variability, will require a sharp improvement in agricultural productivity.

Productivity gains, however, cannot be achieved through improved seeds, fertilizers or better agronomic practices alone. Their benefits are realised only when crops are effectively protected from insects, diseases and weeds, which continue to cause substantial yield and quality losses every year. As climate change alters pest dynamics and intensifies production risks, safeguarding crop health has become a prerequisite for sustaining productivity growth. Innovation in crop protection is therefore a strategic necessity.

Newer crop protection technologies enable farmers to manage evolving pest pressures more effectively, protect the returns on investments in modern farming practices and produce more from every hectare. In a country where nearly half the workforce depends on agriculture and food security remains a national priority, delayed access to such innovations carries significant economic, social and environmental consequences.

This chapter identifies seven key factors that make innovation in crop protection essential for securing India's agricultural future and achieving its long-term development aspirations.

2.1 Continued crop loss due to pests

Crop losses caused by insects, diseases and weeds remain one of the largest constraints to agricultural production worldwide. India also continues to lose a significant share of agricultural production to insects, diseases and weeds. Estimates suggest that about INR 2 lakh crores worth of crop yield is lost annually due to pests in India¹⁷. Of the estimated economic losses attributable to pests, weeds account for approximately 37%, insects 29%, diseases 22%, and other causes 12% (refer exhibit 3).

¹⁴ FAO

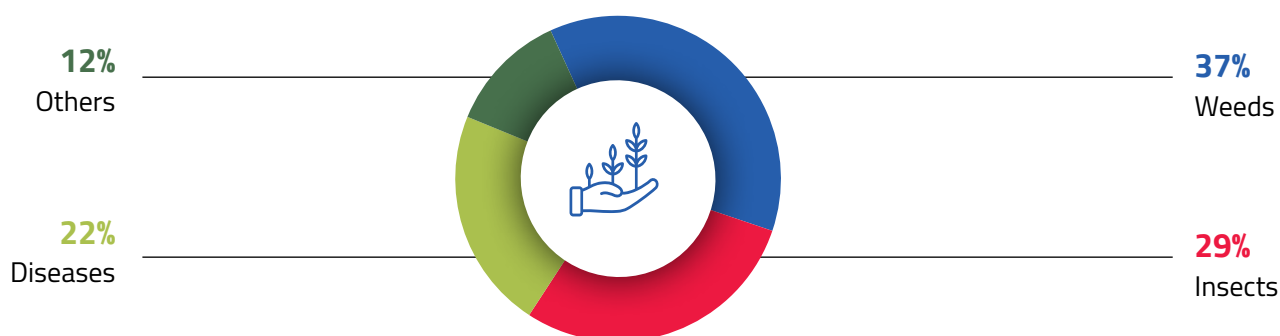
¹⁵ <https://openknowledge.fao.org/server/api/core/bitstreams/f700bc9e-bdda-4818-9d29-a295d0aad0f6/content>

¹⁶ <https://naas.org.in/News/NN26012026.pdf>

¹⁷ While no comprehensive study is available, past research papers like Herbicides Vis-à-vis other pesticides: Trend analysis and economic impact, ICAR (A. Jamaludheen, Singh P.K, Choudhary V.K., Gharde Yogita and Mishra J.S 2023, Technical Bulletin No. 23, ICAR- Directorate of Weed Research, Jabalpur. 32p.) estimate yield loss due to weeds to be USD 11 Bn annually (Gharde et al 2018). The studies further estimate that yield loss due to weeds is 37%, due to insects is 29%, due to diseases is 22% and due to other pests is 12%. Based on these findings the estimated crop loss due to pests has been calculated.

The loss when converted to INR at 2018 rates (1 USD=INR 70) amounts to ~ INR 2 lakh crores.

Exhibit 3: Crop yield loss due to pests in India



Source: ICAR (A.Jamaludheen, Singh P.K, Choudhary V.K., Gharde Yogita and Mishra J.S 2023. Herbicides Vis-à-vis other pesticides: Trend analysis and economic impact. Technical Bulletin No. 23, ICAR- Directorate of Weed Research, Jabalpur. 32p.)

For an agricultural economy of India's size, reducing avoidable crop losses offers one of the highest-return opportunities to strengthen food security and farmer incomes. With annual foodgrain and horticulture production exceeding 750 million MT¹⁸, even modest improvements in crop protection can yield substantial benefits.

Unlike expanding cultivated area or increasing input intensity, preventing avoidable crop losses enables India to produce more from existing farmland, making crop protection one of the most cost-effective pathways for enhancing farmer incomes and food security.

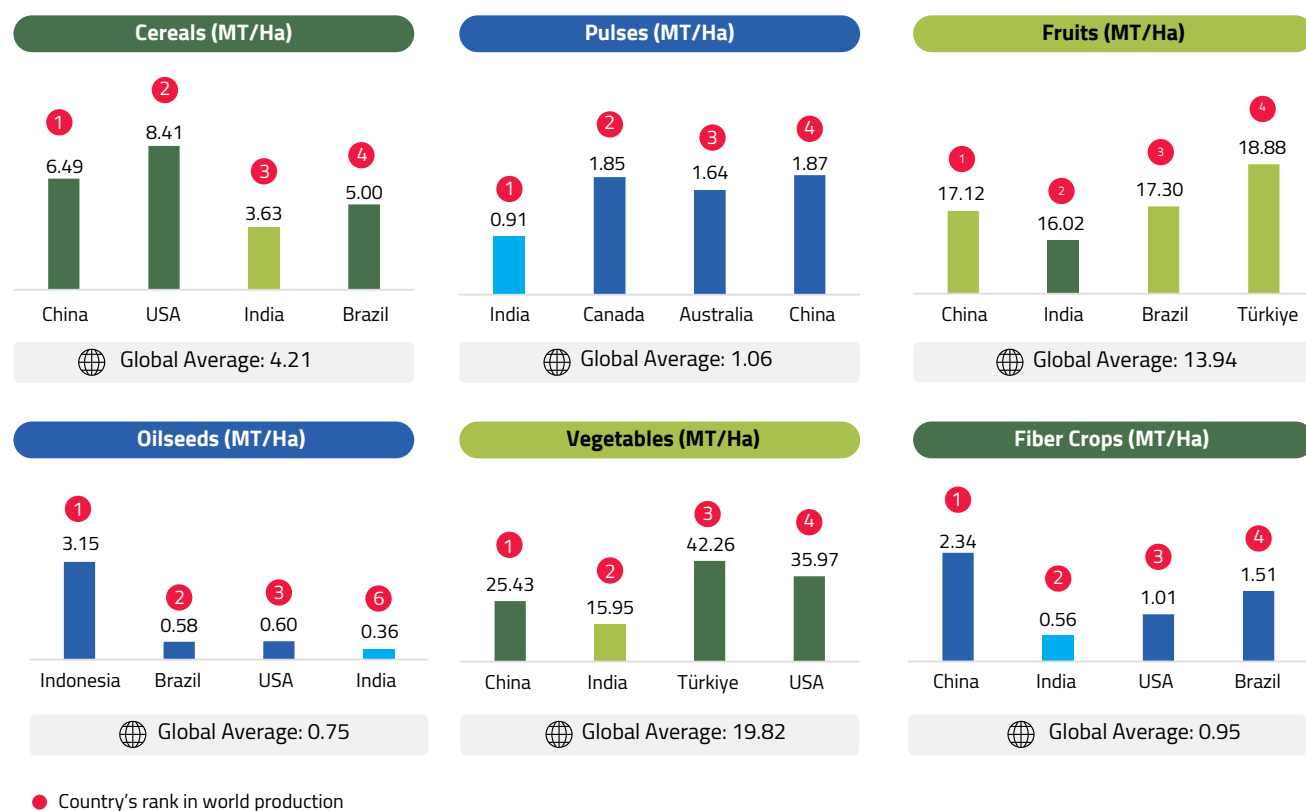
2.2 Productivity gap

The next phase of India's agricultural growth will come from producing more from every hectare. While India has made notable progress in enhancing agricultural productivity, the gap vis-à-vis global benchmarks remain significant. In case of cereals, India's average productivity stands at 3.6 MT/Ha, lower than the global average of 4.2 MT/Ha. Similarly, India's yields are below the global average across pulses, oilseeds, fiber crops and vegetables (by 14%, 52%, 41% and 19% respectively).¹⁹ Exhibit 4 compares India's productivity with global average and leading producers across key food categories.

¹⁸ UPAg Portal

¹⁹ FAOSTAT 2024

Exhibit 4: Comparison of India's agricultural productivity vs. global benchmarks (2024)



Source: FAOSTAT 2024, YES BANK Analysis

Effective crop protection is critical to closing this gap. Modern crop protection solutions safeguard yield potential throughout the crop cycle, improve input-use efficiency and ensure that investments in quality seeds, fertilizers, irrigation and mechanization translate into higher farm productivity. However, limited access to innovative crop protection technologies continues to constrain India's productivity gains.

While leading agricultural economies rapidly adopt newer molecules and precision crop protection technologies to combat evolving pest and disease pressures, Indian farmers continue to rely largely on a product mix that has not kept pace with the rapid introduction of novel chemistries and innovative crop protection technologies seen globally. At present India has approximately >350 registered molecules, out of the 1200 pesticide molecules used globally.²⁰

2.3 Rising pest resistance

The development of pesticide resistance has emerged as a worldwide challenge affecting numerous economically important pest species in agricultural ecosystems. Resistance monitoring programmes have documented hundreds of insect species exhibiting resistance to one or more insecticide groups, with many populations showing multiple resistance involving different modes of action. Prominent examples include the diamondback moth (*Plutella xylostella*), cotton bollworm (*Helicoverpa armigera*), fall armyworm (*Spodoptera frugiperda*), whitefly (*Bemisia tabaci*) and several aphid species.

India has also reported insecticide resistance in several economically important pests such as cotton bollworm, pink bollworm, whitefly, brown planthopper and fall armyworm. Similarly, herbicide resistance has been confirmed in multiple weed species across wheat, rice and soybean production systems.

²⁰44th Annual Report 2023-24, CropLife India

The increasing incidence of resistance reduces pest control efficiency, lowers crop productivity and often necessitates more frequent insecticide applications or higher application rates²¹.

Thus, sustained innovation in crop protection becomes essential to stay ahead of evolving pests, weeds and plant pathogens. New molecules with differentiated modes of action enable effective resistance management, preserve the efficacy of existing products and help farmers maintain consistent crop protection under changing agro-climatic conditions. Without a continuous pipeline of innovation, resistance develops rapidly, reducing the effectiveness of available solutions and increasing the cost of pest management.

2.4 Climate change impacting pest dynamics

Climate variability is adding a new dimension to agricultural risk. Rising temperatures, changing rainfall patterns, elevated CO₂ levels and milder winters are expanding the geographical range, survival rates and reproductive cycles of insects, weeds and plant pathogens. Many insect species are completing more life cycles within a single season, while new invasive pests are spreading into previously unaffected regions. According to research studies, insects may go through one to five more life cycles per season with a 2 degree temperature increase²². At the same time, extreme weather events weaken crop resilience, making plants more vulnerable to pest attacks. Exhibit 5 captures the various climate drivers impacting pest behavior.

Exhibit 5: How climate drivers change pest behavior

TEMPERATURE- Acceleration of life cycles and range shifts 	PRECIPITATION AND SOIL MOISTURE - Creating boom conditions 
Insects are ectotherms, so their metabolism and development depend on temperature. Warmer conditions speed development from egg to adult, increasing the number of generations and raising outbreak risks, though extreme heat can reduce survival. Higher minimum temperatures also help pests overwinter in areas that were once too cold, leading to poleward and upward range expansion Example: Fall armyworm- Warmer conditions increase its generations and extend its activity, while continuous cropping provides year-round hosts. Rice stem borers, sugarcane borers, and stemborers of millets- Warmer nights and higher mean temperatures can shorten larval periods, leading to more frequent generations and intensified damage in paddy, maize and sorghum.	Changing rainfall patterns, with heavier rains and longer dry spells, alter pest habitats and food sources. Sudden rains that green up vegetation can trigger large outbreaks of migratory pests like desert locusts (Liu et al., 2024). In contrast, drought-stressed crops become more vulnerable to certain insects or may favor pests adapted to dry conditions.

²¹ Vanlalhmuliana, H. (2026) "Insecticide Resistance Mechanisms and Strategies for Resistance Management in Agroecosystems: A Review", Journal of Experimental Agriculture International, 48(7), pp. 102–115. doi: 10.9734/jeai/2026/v48i74317.

²² Sharma, S., Rana, A., Kaur, P., Verma, J.S. and Dhulley, V.K. (2026) 'Impact of climate change and pest management', International Journal of Agriculture and Plant Science, 8(3), pp. 26–32.

CO₂ ENRICHMENT -

Subtle effects via crop physiology



Elevated atmospheric CO₂ often increases plant growth but changes tissue quality (e.g., lower nitrogen concentration).

Many chewing pests respond by eating more or altering feeding patterns; some phloem feeders (aphids, whiteflies) respond differently because sap composition changes.

These indirect effects can alter pest performance and crop damage in non-intuitive ways.

Extreme weather events and wind patterns aiding dispersal



Stronger storms and shifts in wind regimes can carry adult insects' long distances. Migratory pests such as desert locusts and certain moths can thus invade new areas.

Extreme events (storms, unseasonal rains, heatwaves) can also synchronize pest outbreaks across regions, complicating localized control.

Example:

Desert locusts- increasing erratic heavy rains and shifting wind patterns lead to unusual locust breeding and large swarm movements.

Source: Yadav, Kamal & Yadav, Tejpal & Landge, Amol & Yadav, Ajay. (2025). How Climate Change is Altering Insect Pest Behavior in Indian Farms.

Addressing these evolving threats requires continuous innovation in crop protection. Reliance on a narrow set of older modes of action can become increasingly problematic where resistance has developed or pest complexes have changed. New modes of action, alongside stewardship tools, are therefore important for maintaining an effective crop-protection toolbox.

2.5 Building export competitiveness

India has set an ambitious target of reaching USD 100 billion of agricultural and processed food exports by 2030²³. Achieving this will require not only increased volumes, but higher quality and export compliant products.

Meanwhile, international markets are becoming increasingly stringent with respect to pesticide residues, traceability, environmental compliance and sustainability standards. Export consignments failing to meet importing-country regulations face rejection, increased inspections and reputational risks.

When existing crop protection products lose effectiveness, farmers often increase application frequency or spray closer to harvest. This raises the cost of cultivation as well as probability of pesticide residues exceeding permissible limits, leading to rejection of export consignments and loss of premium export markets.

Continuous innovation in crop protection plays a critical role in improving export readiness. Newer molecules offer improved efficacy, favourable residue profiles, shorter pre-harvest intervals and better environmental performance, helping farmers comply with international Maximum Residue Limits (MRLs) and phytosanitary standards.

2.6 Environmental sustainability

Modern agriculture is increasingly expected to balance productivity with environmental stewardship. Stakeholders across the agricultural value chain are seeking solutions that reduce environmental impact while maintaining effective crop protection. This includes protecting beneficial insects, reducing pesticide loads and improving application efficiency.

²³<https://www.pib.gov.in/PressReleasePage.aspx?PRID=2091975®=48&lang=2>

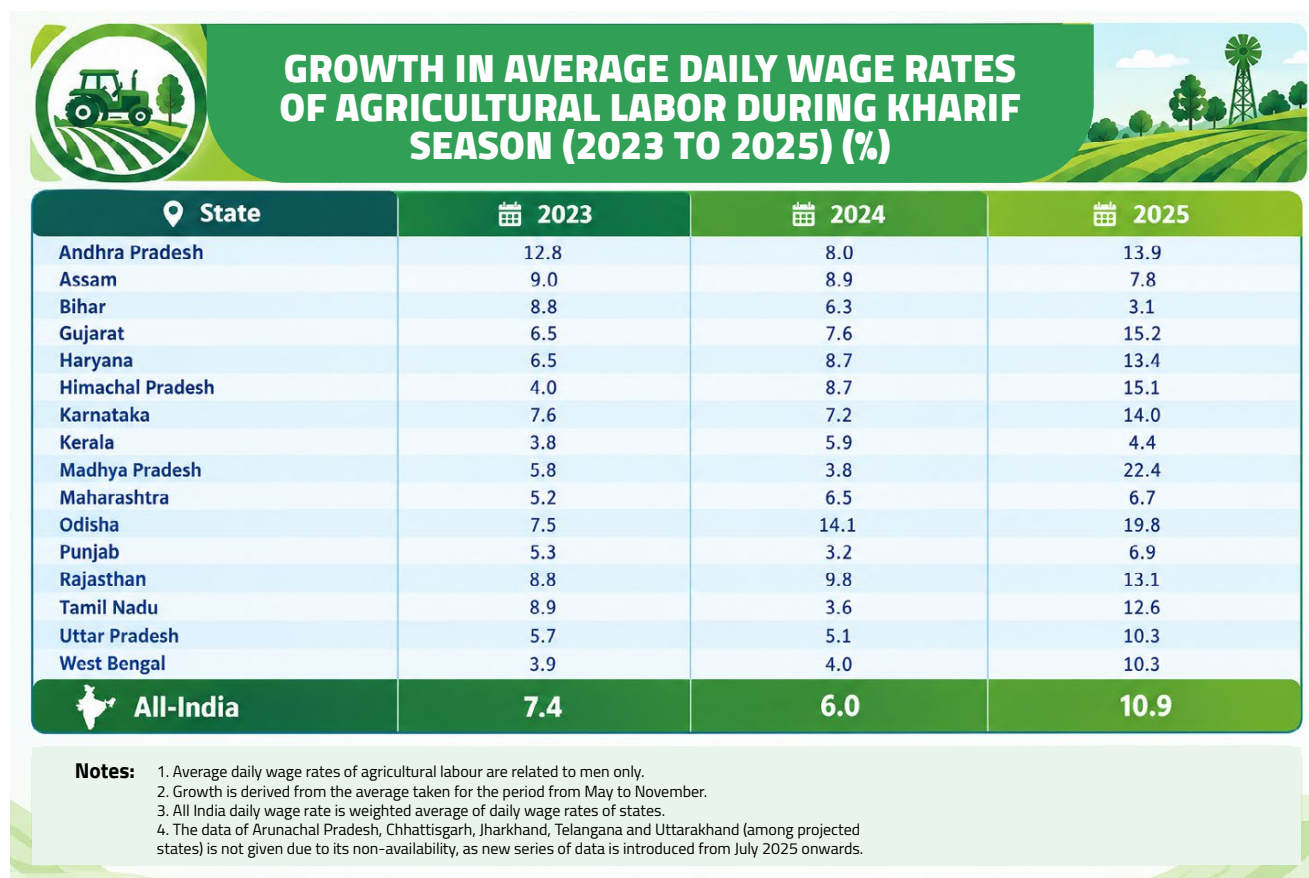
Innovation enables the development of safer formulations, biological crop protection products, precision spraying technologies, seed treatments and integrated pest management approaches that deliver effective pest control with reduced environmental footprint. These technologies improve resource-use efficiency while conserving biodiversity, soil health and ecosystem services.

2.7 Labor shortages and increasing wage rates

Indian agriculture is facing growing labor shortages driven by rural-to-urban migration, an ageing agricultural workforce and the increasing shift of labor to non-farm sectors. At the same time, agricultural wages have risen steadily (refer exhibit 6), significantly increasing the cost of cultivation and placing additional pressure on farm profitability. Labor shortages are particularly acute during critical crop stages when timely pest management is essential to prevent irreversible crop losses.

Innovative crop protection technologies can significantly reduce dependence on manual labor through longer-lasting formulations, precision spraying equipment, drone-based pesticide application, mechanized spraying systems and digital pest surveillance. Such technologies improve operational efficiency, reduce application costs and ensure timely interventions even under labor-constrained conditions. As labor availability continues to tighten, innovation in application technologies will become as important as innovation in crop protection products themselves.

Exhibit 6: Growth in average daily wage rates of agricultural labor



Source: Labour Bureau, Ministry of Labour and Employment and CACP Calculations

The Current Innovation Landscape

3

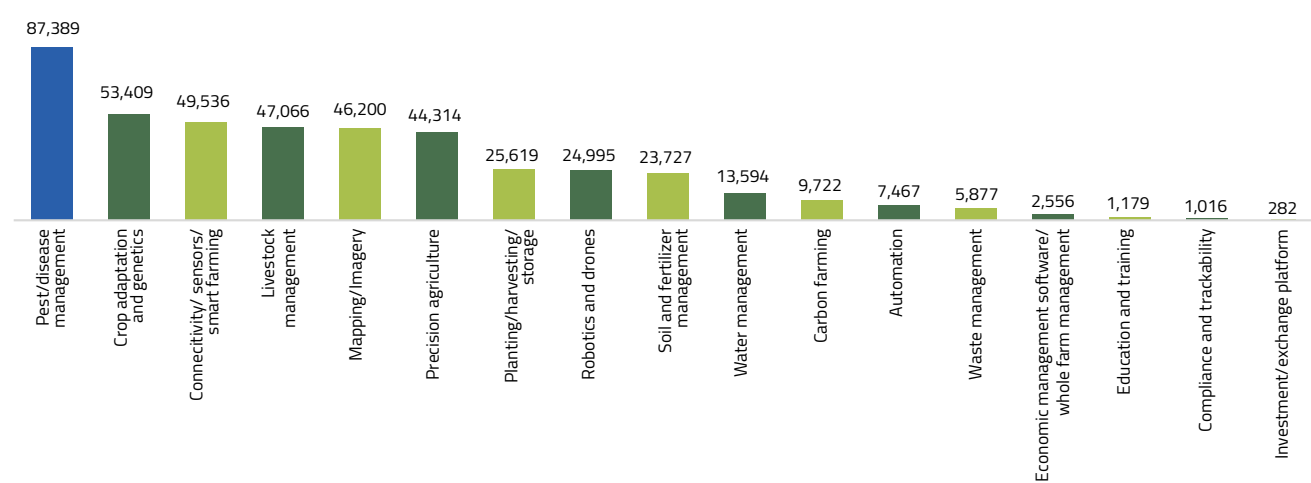


3.1 Global innovation landscape

The global agrochemicals' industry is witnessing a significant shift in how innovation is approached, shifting from a pure product-centric model to an integrated "crop-health solutions" approach. While synthetic chemistries continue to play an important role, innovations are increasingly focused on developing solutions that are more targeted, sustainable and technology-enabled. This shift is being driven by changing pest pressures, shifting regulatory framework, resistance management, environmental considerations and the adoption of digital technology for improving efficiency of agricultural production.

Evidence of this shift is reflected in global innovation trends. According to the World Intellectual Property Organization's (WIPO) "Patent Landscape Report on Agrifood", pest and disease management has emerged as the area where most international patents have been filed in the Agritech domain over the past two decades, followed by crop adaptation and genetics, livestock management, and IoT-related areas such as connectivity/sensors/smart farming, precision agriculture and mapping/imagery (refer exhibit 7). In the pest and disease management field, innovation is primarily spearheaded by companies such as BASF and Bayer from Germany, Syngenta from Switzerland²⁴, Corteva from the United States and Sumitomo from Japan.²⁵

Exhibit 7: Pest & disease management has emerged as a key segment of innovation globally



The number depicts international patent families which as per the report is defined as- International patent families are a reliable and neutral proxy for inventive activity because they represent inventions that applicants deem important enough to seek international protection. This serves to highlight innovations with universal application, control for the difference in the propensity to file multiple patent applications for a single invention between patent offices and excludes singletons of very low value while including high-value domestic inventions.

Source: WIPO, Patent Landscape Report on Agrifood

²⁴Syngenta is part of Syngenta Group, which is owned by Sinochem Holdings

²⁵World Intellectual Property Organization's (WIPO) "Patent Landscape Report on Agrifood"

The report also identifies **non-pesticide pest and disease management** as an emerging and important area of innovation globally. This area encompasses a range of innovations including use of:

- Living organisms: various species of animals and microorganisms used as natural enemies, predators or infectious agents of agricultural pest species.
- Compositions: chemical or natural substances that act as repellents to deter pests, attractants to lure them into traps, or even bio-natural pesticides derived from essential oils, plant extracts or microorganisms.
- Devices: traps, sprayers and dispensers used in conjunction with other biocontrol methods.
- Genetic modification: production of transgenic plants resistant to specific pests.

Globally, non-pesticide pest and disease management innovations are being led by players such as Bayer, BASF, Sumitomo Chemical, Syngenta²⁶ and Corteva²⁷ among others.

Beyond products, innovation in crop protection is increasingly extending to the broader agricultural technology ecosystem. Advances in remote sensing, satellite imagery, IoT-enabled monitoring, precision agriculture, artificial intelligence and predictive analytics are enabling real-time pest surveillance, site-specific crop protection and data-driven farm management. Together, these technologies are improving decision-making, optimizing input use, enhancing productivity and supporting more sustainable agricultural production systems. Some of the key innovation themes beyond crop protection product innovation include:

- Connectivity/sensors/smart farming: Built upon the foundation of interconnected devices and IoT sensors that synergize to usher in a transformational change in how farms are managed and operated.
- Mapping/imagery services: Use of aerial or satellite imagery to gather data and create detailed maps of agricultural fields. These maps can provide valuable information about the health, size and composition of crops, as well as identify areas of stress or disease. By analyzing this data, farmers can make more informed decisions about irrigation, fertilization and pest control, ultimately leading to improved crop yields and more sustainable farming practices.
- Precision agriculture: Including auto steer, wireless telematics, variable rate technology, indoor agriculture, remote sensing and data collection as well as predictive yield analytics and monitoring.
- Robotics and drones: Application of cutting-edge technologies such as drones, sensors and artificial intelligence (AI) to enhance crop yields, optimize water usage and improve soil health.²⁸

²⁶Syngenta is part of Syngenta Group, which is owned by Sinochem Holdings

²⁷World Intellectual Property Organization's (WIPO) "Patent Landscape Report on Agrifood"

²⁸World Intellectual Property Organization's (WIPO) "Patent Landscape Report on Agrifood"

3.2 India's innovation landscape

India's crop protection innovation ecosystem is undergoing a gradual transition. Historically, innovation has been driven by process chemistry, generic manufacturing and formulation development, enabling the country to emerge as one of the world's leading producers and exporters of crop protection products. However, as global innovation shifts towards novel chemistries, biologicals, precision agriculture and digitally guided crop health solutions, India's innovation priorities are also beginning to evolve.

This evolution can be viewed through four key foundational pillars that together shape India's crop protection innovation journey



Strong manufacturing capabilities provide a foundation for innovation

India's leadership in generic manufacturing and formulation chemistry provide a strong base for future innovation. The country combines cost-competitive manufacturing, a skilled scientific workforce, diverse agro-climatic conditions and an expanding agri-tech ecosystem, creating favourable conditions for developing and validating new crop protection technologies.



Indian innovation remains stronger in formulations than discovery

Indian companies possess world-class formulation chemistry and process engineering capabilities. However, compared with global innovators, relatively fewer companies invest in discovery chemistry, novel active ingredient development and long-term molecular research, indicating significant scope for strengthening indigenous R&D capabilities.



Digitally guided agriculture is becoming an innovation multiplier

Unlike earlier decades where innovation revolved around new products, today's innovation increasingly combines chemistry with digital technologies. Companies are integrating AI-based pest forecasting, satellite and drone-based crop monitoring, mobile advisory platforms, precision pesticide application, variable-rate spraying and farm data analytics to improve efficacy and promoting judicious pesticide consumption.



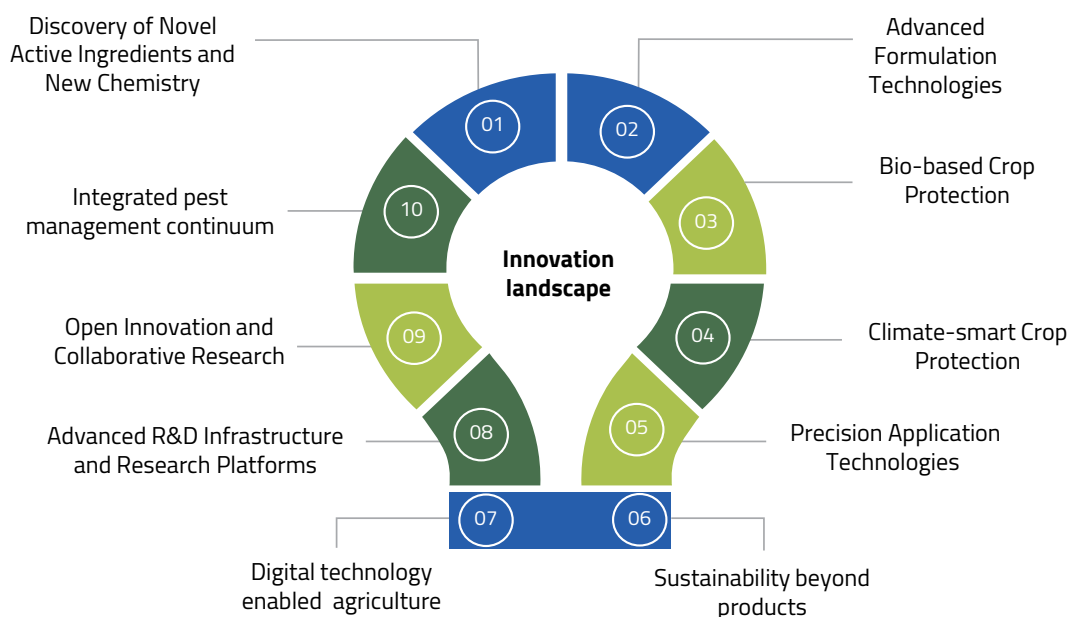
Regulatory and policy frameworks are improving, however, several procedural and structural gaps continue to limit ease of introduction and adoption for innovative solutions

India has witnessed policy and regulatory reforms that have improved the overall ecosystem for crop protection products. However, India's innovation ecosystem continues to face challenges related to discovery research, regulatory timelines, technology transfer and commercialization. Addressing these gaps will be essential for accelerating the development and adoption of next-generation crop protection solutions.

Taken collectively, these foundational pillars highlight a sector that is moving beyond traditional chemistry into a more diversified innovation landscape—spanning biological products, advanced formulations, precision technologies, digital platforms and beyond.

This section captures the innovation landscape of India's crop protection industry, across ten select thematic (refer exhibit 8).

Exhibit 8: Innovation landscape in India



Source: Industry Discussions, YES BANK Analysis

3.2.1 Discovery of novel active ingredients and new chemistry

The crop protection industry in India continues to invest in the discovery of new active ingredients and novel modes of action to address emerging pest resistance, evolving regulatory requirements, and changing climatic conditions. While generic products remain important, agrochemical companies are increasingly focusing on proprietary chemistry that offers superior efficacy, lower application rates, improved environmental profiles, and differentiated intellectual property.

Several companies are strengthening their innovation pipelines with next-generation insecticides, fungicides and herbicides targeted at resistant pests and weeds, reflecting a clear shift towards breakthrough innovation.

CASE STUDY

Pioxaniliprole is a novel, pyridylpyrazole-based insecticide developed by PI Industries. It is recognized as India's first indigenously discovered and developed new chemical entity/molecule for crop protection.



For decades, patented agrochemical innovations introduced in India have originated from global multinational research programmes, while Indian companies built strong capabilities in manufacturing, formulation and process chemistry. Pioxaniliprole marks a shift in that trajectory, positioning India not only as a manufacturing base, but also as an originator of crop protection innovation.

Source: PI Industries Integrated Annual report 2025-26

CASE STUDY

Crystal is emerging as one of the domestic leaders in Innovation in India, who research and develop formulation products which are centric to India's need, based on its agro-climatic conditions and soil, pests & crop reality profile. The company has one of the highest innovation turnover rates among domestic and global agrochemical companies operating in India and additionally exhibits a strong capability in intellectual property creation. The company has filed 28 patents as of CY2025, reflecting its sustained focus on R&D, out of which 18 patent applications have been examined and granted in India.



Source: <https://www.crystalcropprotection.com/DRHP.pdf>

3.2.2 Advanced formulation technologies

Innovation in crop protection solutions is also about formulation science. Companies are developing advanced formulation technologies that enhance product performance by improving rain fastness, spray retention, penetration into plant tissues, stability, ease of handling, and compatibility with modern application equipment.

Controlled-release technologies, polymer-based delivery systems, high-load suspensions, and solvent-free formulations are gaining prominence as companies seek to improve efficacy while reducing environmental impact.

Such innovations also improve user safety, reduce packaging requirements, and enable lower application rates, thereby increasing resource-use efficiency throughout the crop protection value chain.

CASE STUDY

ADAMA's Ayalon® Formulation Technology is a proprietary technology developed for enhanced biological efficacy of water-based formulations. This technology improves spreading, rain fastness and penetration, ensuring superior performance while reducing reliance on organic solvents for a more sustainable solution.



Also, the company's Sessgama® Technology utilizes a unique polymeric surfactant platform and enables high-load liquid suspensions with high shelf stability. The technology also reduces packaging waste and prevents nozzle clogging to streamline field application.

Source: ADAMA ESG report 2025

3.2.3 Bio-based crop protection

Biological crop protection has emerged as one of the fastest-growing innovation segments within the crop protection industry. Companies are expanding investments in microbial pesticides, biofungicides, bionematicides, pheromones, plant extracts, microbial metabolites and other nature-based solutions that complement conventional chemistry.

These products aim to improve soil and plant health, reduce pesticide residues, delay resistance development, and support sustainable agricultural practices. Rather than replacing chemical crop protection, biologicals are increasingly being positioned as part of integrated crop management programmes that combine biological and chemical interventions for improved productivity and environmental sustainability.

3.2.4 Climate smart crop protection

Climate variability is fundamentally reshaping crop protection innovation. Companies are increasingly designing products and integrated solutions that help crops withstand drought, heat stress, erratic rainfall and changing pest dynamics associated with climate change. Innovation efforts now encompass climate-resilient chemistries, improved water-use efficiency, stress tolerance, regenerative agricultural practices and climate-informed digital advisory systems. This reflects a transition from protecting crops against pests alone towards strengthening the overall resilience of farming systems.

CASE STUDY

Syngenta launched its SOLATENOL® and ADEPIDYN® technologies that are specialized chemical technologies tested to help crops maintain photosynthesis, lower water transpiration rates, and improve yields under dry conditions.



Source: Syngenta Annual report 2025-26

3.2.5 Precision application technologies

Innovation in crop protection industry is increasingly focused on improving the precision with which crop protection products are applied. Companies are developing drone-compatible formulations, precision spraying technologies, sensor-based application systems, predictive scouting platforms and weather-enabled spray advisories to ensure that products are applied at the right place, time and dosage. Precision application technologies not only improve efficacy but also minimize wastage, reduce environmental impact and enhance farmer profitability through more efficient resource utilization.

CASE STUDY

Corteva Agriscience has introduced Bexavie® insecticide in India, the country's first bait formulation product developed for the management of Fall Armyworm (FAW) in corn.



This unique bait insecticide is designed for targeted application in corn fields and combines high efficacy with precision-targeted application. Moreover, its long-lasting control and favorable safety profile make it a strong choice for sustainable agriculture.

Source: Corteva

CASE STUDY

BASF's Agricultural Research Station at Pune (recognized by Department of Scientific and Industrial Research, Ministry of Science and Technology), carries out drone based application testing for BASF's commercial insecticides and fungicides against important pests to understand the efficacy and benefits of drone-based application as compared to the traditional application methods.



Source: BASF Annual report 2025-26

3.2.6 Sustainability beyond products

Sustainability considerations for crop protection industry are going beyond green products and biologicals portfolio. Companies are developing safer manufacturing processes that reduce environmental impact, lower carbon emissions, reduce packaging waste and promote circular resource use. These initiatives align with evolving sustainability expectations from regulators, customers and global food value chains.

CASE STUDY

Dhanuka deploys Zero Liquid Discharge (ZLD) systems, solar power installations, rainwater harvesting, and waste management protocols compliant with environmental regulations. From 1,200 KW solar projects under development in Dahej to rainwater harvesting and plastic waste compliance in Sanand, each facility actively reduces its ecological footprint. Air pollution control systems like scrubbers, bag filters, and dust collectors are in place across sites, reinforcing green manufacturing ethos.



Source: www.dhanuka.com

Further, the crop protection industry is increasingly adopting stewardship innovations across the product lifecycle, including sustainable packaging, container collection and recycling program and anti- reuse and anti- counterfeit features.

3.2.7 Digital technology enabled agriculture

Digital technologies are becoming central to crop protection innovation across research, manufacturing and farm advisory services. Companies are leveraging digital tools to optimize supply chains, enable predictive pest surveillance and enhance commercial decision-making. At the farm level, digital platforms integrate satellite imagery, weather information, sensor data, crop modelling and agronomic intelligence to provide real-time recommendations on pest management and crop protection interventions. These technologies enable precision decision-making, improve input-use efficiency and strengthen farmers' resilience against increasingly variable climatic conditions.

CASE STUDY

Bayer has recently launched Alivio - meaning "relief" in Spanish - a pioneering digital solution that reimagines risk mitigation while equipping growers with actionable plot insights, delivered as an integrated, value-adding service via Alivio's mobile application. Unlike traditional insurance products, Alivio - launched in collaboration with the insurance ecosystem and public sector undertaking United India Insurance - uses high-resolution satellite data and advanced crop modelling to offer growth stage-aligned, plot-based, and geo-contextualized protection.



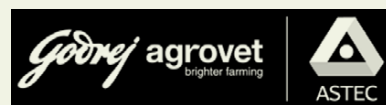
Source: www.bayer.in

3.2.8 Advanced R&D infrastructure and research platforms

Leading crop protection companies are strengthening their innovation capabilities through significant investments in modern research infrastructure. Advanced R&D centres equipped with automated systems, pilot plants, GLP-certified laboratories etc. are becoming critical competitive differentiators.

CASE STUDY

Astec LifeSciences, a subsidiary of Godrej Agrovet (GAVL), has launched its new advanced research and development (R&D) center in Maharashtra. The facility will focus on leading-edge innovation and developing sustainable and safe solutions for people and the environment.



The R&D Center is equipped with a synthesis lab for product synthesis and a formulation lab to develop new formulations in the crop protection space. Supported by advanced analytical instruments to drive R&D, the center also houses sophisticated process safety infrastructure to undertake safe and sustainable chemical reactions.

Source: <https://www.godrejastec.com/media/in-the-news/astec-lifesciences-launches-rd-centre-in-maharashtra>

3.2.9 Open innovation and collaborative research

Recognizing the increasing complexity of agricultural innovation, companies are expanding collaborations with universities, research institutions, biotechnology firms, start-ups and technology providers. Open innovation models enable faster access to emerging technologies such as biologicals, artificial intelligence, precision agriculture and new chemistries while reducing development risks. Strategic partnerships, venture investments, acquisitions and joint research programmes are becoming essential mechanisms for accelerating innovation and commercialization, creating a more connected agricultural innovation ecosystem.

CASE STUDY

Idea2Impact™ is an open innovation platform launched by Rallis India in January 2026 to connect farmers, researchers, startups, and universities, helping scale sustainable agricultural solutions from early concepts to commercialization. Through this platform, Rallis opens its expertise, R&D infrastructure, testing capabilities, and market access to scale meaningful innovations responsibly.



Source: <https://idea2impact.rallis.com/>

3.2.10 Integrated pest management continuum

Crop protection innovation is increasingly shifting from standalone solutions to an integrated pest management (IPM) continuum, where multiple technologies work together across the crop lifecycle. Advances in pest-resistant genetics and improved agronomic practices help prevent pest outbreaks, while chemical and biological crop protection solutions provide effective control when needed. These are increasingly complemented by digital surveillance tools that enable early detection and forecasting, and precision application technologies that ensure interventions are targeted, efficient, and sustainable. Together, these innovations create an integrated, data-driven crop protection ecosystem that enhances productivity, improves resource efficiency, and builds resilience against evolving pest challenges.

India is transitioning from being primarily a global manufacturing hub for generic crop protection products to becoming an emerging innovation ecosystem. While it lags behind the United States, Europe and China in original molecule discovery and patent generation, it is making rapid progress in biologicals, advanced formulations and digital agriculture. With stronger investment in discovery R&D, public-private research partnerships and faster commercialization pathways, India has the potential to evolve from a major producer of crop protection products into a globally significant source of innovations in crop protection.

Government Efforts Towards Promoting Crop Protection Solutions

4

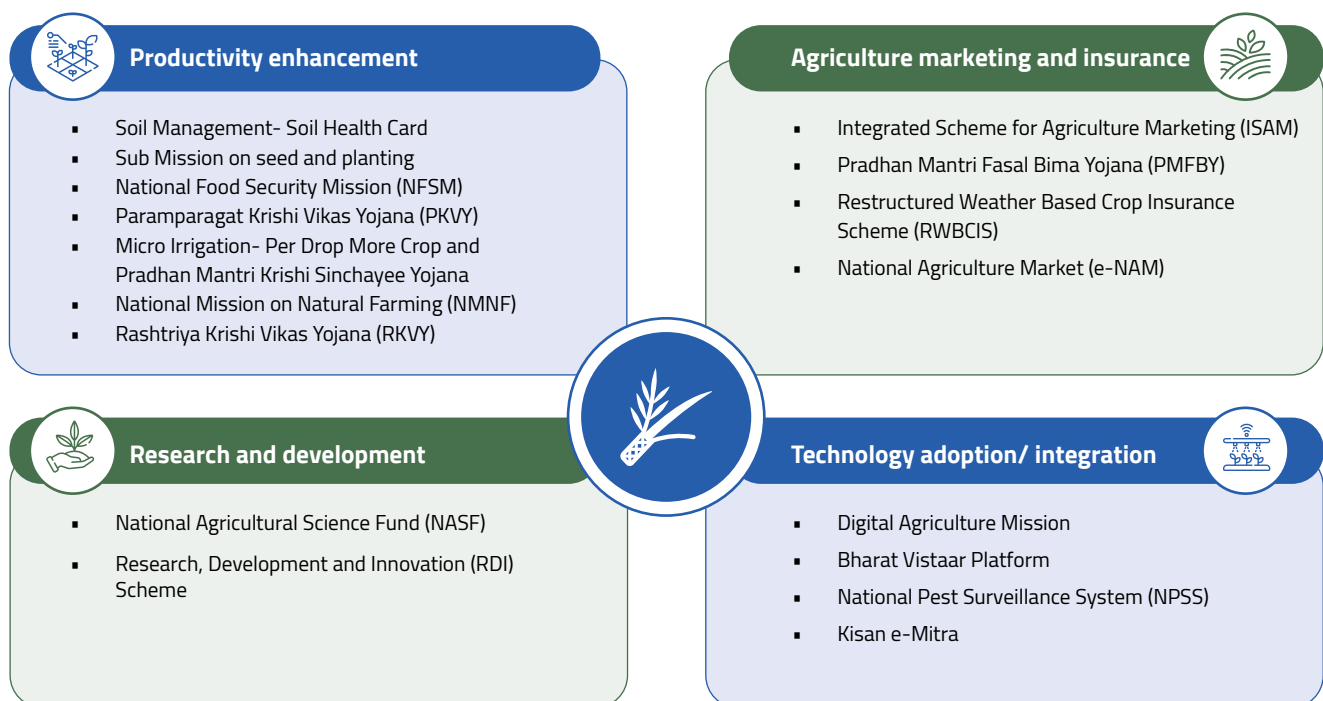


India's ambition to build a resilient, productive and globally competitive agricultural sector has increasingly been supported by government initiatives. Recognizing that sustainable productivity growth depends not only on improved farming practices but also on continuous scientific advancement, the Government of India has undertaken a range of initiatives to enhance productivity and strengthen the broader agricultural innovation ecosystem.

4.1 Key initiatives by Government of India for strengthening Indian agriculture

Agriculture remains a priority sector for the Government of India. Several initiatives have been taken to boost the growth of this sector. Efforts have been made to enhance productivity, increase investments in R&D, develop requisite infrastructure and avenues for marketing and promote technology adoption. Select initiatives by Government of India for augmenting agricultural growth are captured in exhibit 9.

Exhibit 9: Initiatives by Government of India in agriculture sector



4.2 Select initiatives by Government of India for agrochemicals industry

4.2.1 National Pest Surveillance System (NPSS)

The National Pest Surveillance System (NPSS) was launched on 15 August, 2024 by the Hon'ble Union Minister of Agriculture and Farmers Welfare to enhance the surveillance and management of pest diseases across India. Accessible via a dedicated portal and user-friendly mobile application, the system utilizes latest digital technologies such as Artificial Intelligence and Machine Learning (AI and ML) to provide instant solutions regarding pest attacks, crop diseases, crop damage etc., by issuing real time crop protection advisory to the farmers.

Currently, utilized by over 10,000 extension workers, NPSS supports 73 crops including cotton, paddy, wheat, maize, pigeon pea, moong, soyabean, sugarcane, brinjal, tomato, apple, banana, grapes, pomegranate etc. and cover more than 436 pests²⁹. This tool is available in four languages namely English, Hindi, Marathi and Punjabi.

4.2.2 Kisan drones

Kisan Drone is an initiative by the Indian government to utilize drones in the agricultural sector, particularly to benefit farmers. It is an innovative agricultural drone designed for precision farming in India, aiming to increase crop yields and reduce production costs for farmers.

Kisan Drones are specialized Unmanned Aerial Vehicles (UAVs) equipped with sensors and cameras to capture data, which is analyzed to provide actionable insights for informed decision-making. They have proven to be among the most promising technologies and have emerged as essential tools for farmers across various applications.

The benefits of Kisan drone in agriculture include the following:

- | | |
|--|------------------------|
| ▪ Crop monitoring | ▪ Soil analysis |
| ▪ Precision irrigation | ▪ Planting and seeding |
| ▪ Fertilizer and pesticide application | ▪ Livestock monitoring |
| ▪ Yield prediction | ▪ Field mapping |

The use of drones is promoted under Sub-Mission on Agriculture Mechanization (SMAM) by providing assistance up to 50% for agriculture graduates as well as small and marginal farmers in the North Eastern States to procure kisan drones. For other farmers, financial assistance is provided at 40% of the cost. Financial assistance of 40% of the cost is also provided for establishing Custom Hiring Centres of Kisan Drones. A total of 2,122 drones has been distributed or approved under SMAM scheme.³⁰

Further, the 'Namo Drone Didi' Central Sector Scheme aims to equip selected Women Self Help Groups (SHGs) with drones to offer rental services to farmers for agricultural applications, including spraying of fertilizers and pesticides. According to the Department of Fertilizers, 1,094 drones³¹ have been distributed to Drone Didis of SHGs. All these SHG members have been provided training at the Remote Pilot Organizations (RPTOS) authorized by Directorate General of Civil Aviation (DGCA).

²⁹ PIB

³⁰ <https://www.pib.gov.in/PressReleasePage.aspx?PRID=2297646®=48&lang=1>

³¹ PIB

4.2.3 Agriculture Infrastructure Fund (AIF) for drones

The Department of Agriculture and Farmers Welfare (DA&FW) has formulated the Central Sector Scheme to mobilize a medium to long term debt financing facility. This facility supports investment in viable projects relating to post-harvest management infrastructure and community farming assets through incentives and financial support. The purchase of drone under “Infrastructure for Smart and Precision Agriculture” is one of the eligible components of this scheme.

Credit guarantee coverage will be available for eligible borrowers through this financing facility under Credit Guarantee Fund Trust for Micro and Small Enterprises (CGTMSE) scheme for loans up to INR 2 crores, with the Government covering the guaranteed fee. In case of Farmer Producer Organizations (FPOs), the credit guarantee may be availed from the facility created under FPO promotion scheme of DA&FW.

All loans under this financing facility receive an interest subvention of 3% per annum up to a limit of INR 2 crores, available for a maximum period of 7 years. In case of loans beyond INR 2 crores, then interest subvention will be limited up to INR 2 crores. The extent and percentage of funding to private entrepreneurs out of the total financing facility may be fixed by the National Monitoring Committee. The scheme remains operational from 2020-21 to 2032-33.³²

4.2.4 Chemical Promotion Development Scheme (CPDS)

The Chemical Promotion and Development Scheme (CPDS) is a sub-scheme under the New Scheme of Petrochemicals (NSP), a Central Sector Scheme implemented by the Department of Chemicals and Petrochemicals (DCPC). It has been implemented since 1997 in the Chemical Division of DCPC under Plan Head of Account.

The Department implements this scheme to attract investment and facilitate growth and development of chemicals and petrochemicals industry. It aims to disseminate knowledge by conducting seminars, conferences, exhibitions and related events in different sub sectors of the industry such as agrochemicals, dyes and pigments, chlor-alkali, plastics and petrochemicals. These events promote Indian industry and trade, attract foreign investment, encourage R&D for indigenization of technologies, improve skills and support sustainability initiatives for comprehensive development of the sector.

The scheme has the following four components:

- | | |
|--|--|
| ▪ Component I – Creation of knowledge products | ▪ Component III – Excellence awards |
| ▪ Component II – Knowledge dissemination | ▪ Component IV – Organise any other activity |

³² <https://agriinfra.dac.gov.in/Home/SchemeOverview>

4.2.5 Draft Pesticides Management Bill, 2025

The Government released the Draft Pesticides Management Bill, 2025 for stakeholder consultation in January 2026. The proposed legislation seeks to replace the Insecticides Act, 1968 and the Insecticides Rules, 1971 and introduces provisions relating to digital administration, traceability, testing-laboratory accreditation, deterrence against spurious pesticides, and rationalisation of offences and penalties. The final legislation remains under development, providing an important opportunity to create a science-based, predictable and innovation-supportive regulatory framework.

The salient features of the bill include:

- The Bill incorporates provisions such as transparency and traceability to ensure better services to farmers, thereby promoting ease of living.
- It includes reform-oriented measures, including the use of technology and digital methods for streamlining processes, along with stricter control over spurious pesticides through higher penalties.
- Provisions have also been made for compounding of offences, with enhanced penalties to act as a deterrent, to be defined by State-level authorities.
- Further, amendments have been introduced to strengthen administrative control and management of pesticides, striking a balance between ease of life and ease of doing business.
- This bill also provides for mandatory accreditation of testing laboratories, ensuring that only quality pesticides are available to farmers.³³

The industry has also suggested adding Protection of Regulatory Data framework to this draft pesticides management bill. Such a framework could encourage investment in newer chemistry, improve farmer's access to safer products and strengthen India's export position. This proposal envisages a limited, time-bound period during which regulatory data submitted for a new molecule or a new use would remain protected. As proposed by the industry, a five year protection period from first registration would provide the first applicant with a defined period to recover the cost of generating local safety, efficacy and residue data, while ensuring that the data become available for use by other applicants after the protection period expires.

³³<https://www.pib.gov.in/PressReleasePage.aspx?PRID=2212144®=3&lang=1>

The Innovation Deficit: Structural Challenges

5

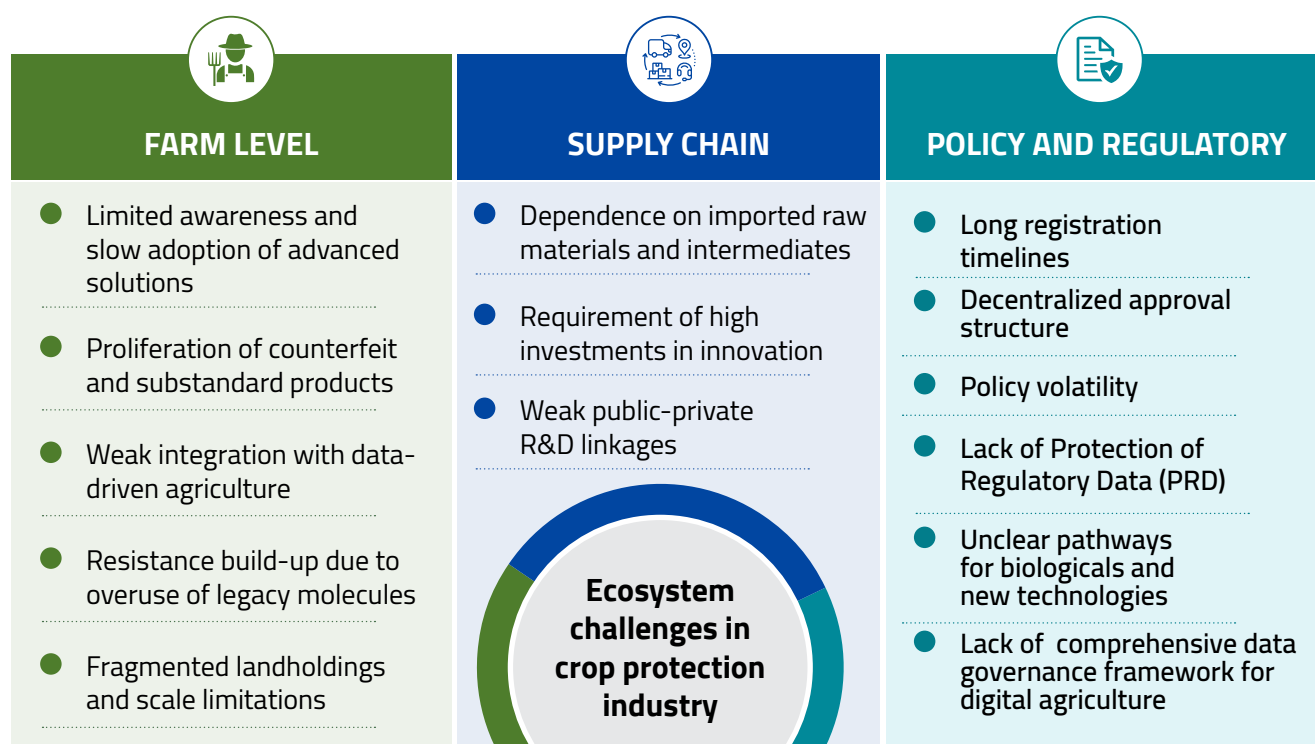


India has the foundational strengths to emerge as a global hub for crop protection innovation. A large agricultural base, a well-established agrochemical industry, a strong scientific ecosystem and a growing manufacturing footprint provide a solid platform to develop and commercialise next-generation crop protection technologies.

However, unlocking this potential requires addressing structural bottlenecks that continue to constrain innovation. Among others, challenges related to awareness at the farm level, dependence on global supply chains for critical inputs and lengthy regulatory approval processes increase the cost, complexity and time required to bring new products to market. Bridging gaps in these areas will be critical to accelerating innovation, improving industry competitiveness and ensuring Indian farmers have timely access to advanced crop protection solutions.

This chapter examines the key structural barriers that are limiting innovation in India's crop protection sector. It assesses challenges across the farm level, supply chain and regulatory framework (refer exhibit 10).

Exhibit 10: Ecosystem challenges in crop protection industry



Source: Industry Discussions, YES BANK Analysis

5.1 Farm level

5.1.1 Limited awareness and slow adoption of advanced solutions

- Gaps in last mile dissemination of information due to constrained extension capacity leads to limited awareness of next-generation crop protection technologies, particularly among small and marginal farmers. Moreover, inadequate awareness on correct dosage and use of inappropriate application methods reduce the effectiveness of crop protection interventions, diminishing the value of innovation.
- Risk aversion and preference for familiar products often discourage farmers from adopting innovative crop protection solutions. This results in continued dependence on ageing chemistries, despite their declining effectiveness.
- The current approach to adoption of crop protection solutions does not consider the full value delivered. Decisions should be driven by the overall economics of adoption, including crop yield protection, reduction in application frequency, labor savings and improved predictability of outcomes.
- Emerging solutions including nano-pesticides or complex biological inputs require greater technical knowledge and adherence to specific handling and applications protocols.
- Limited access to timely and accurate field diagnostics often results in late or misidentification of pests and diseases, leading to delayed or incorrect interventions.
- Ensuring the safe handling and application of crop protection products is essential to protect farmers, farm workers and rural communities. While safety requirements exist, greater emphasis on awareness, training, use of personal protective equipment (PPE) and safe handling practices are required to further strengthen occupational safety outcomes.

5.1.2 Proliferation of counterfeit and substandard products

- The widespread availability of counterfeit and sub-standard pesticides compromise crop protection outcomes, erode farmer confidence and distorts market competition. Such products create reputational risks for entire category of solutions, and are particularly detrimental to emerging biological and advanced formulations.
- Counterfeit and substandard products divert market share from legitimate manufacturers and reduce their ability to recover investments in research, development and product registration thereby weakening incentives for continued innovation.

5.1.3 Weak integration with data-driven agriculture

- Limited adoption of pest surveillance systems, weather-based advisories, precision application technologies and Integrated Pest Management (IPM) practices reduces the effectiveness of crop protection decisions and delays the transition to knowledge-led farming.

5.1.4 Resistance build-up due to overuse of legacy molecules

- Extensive use of legacy molecules may lead to development of pesticide resistance, reducing their effectiveness over time.
- As resistance builds, farmers increase the dosage or frequency of the legacy molecules rather than switching to a new innovative formulation.

5.1.5 Fragmented landholdings and scale limitations

- Fragmented holdings and diverse cropping patterns make adoption of specialized, precision-oriented or advanced crop-protection technologies less practical and economically unviable for smallholders.

5.2 Supply chain

5.2.1 Dependence on imported raw materials and intermediates

- The crop protection industry remains significantly dependent on import for key intermediates, technical-grade materials and specialty chemicals (especially adjuvants).
- The industry remains highly susceptible to global supply chain disruptions - Global events, including geopolitical conflicts, logistics bottlenecks and fluctuations in energy and commodity prices, increase input costs and create uncertainty in the availability of critical raw materials, impacting R&D, production planning and product availability.

5.2.2 Requirement of high investments in innovation

- Creating new molecules involves significant cost and time for R&D, regulatory approvals, field trials, environmental and toxicology testing, and quality control. This complex process requires substantial financial resources, expertise and a long-term commitment to bring innovative crop protection solutions to the market. A new product or molecule requires over INR 2,000 crores of investment in R&D and over 10-12 years to reach commercialization.³⁴

5.2.3 Weak public-private R&D linkages

- Gaps in collaboration between public institutions and private sector companies limit the translation of scientific research into commercially viable crop-protection solutions.
- Weak mechanisms for technology transfer, joint research and industry-led validation further slow the development and scale-up of innovative solutions.

5.3 Policy and regulatory

5.3.1 Long registration timelines

- The registration process of new active ingredients and formulations is stringent and complex. For registration of a molecule, while the prescribed duration is about 18 months, it takes much longer to get the registration done. This may be due to involvement of multiple departments, limitation on resources, infrastructure, skills etc.

³⁴ CropLife India

5.3.2 Decentralized approval structure

- The decentralized approval architecture, characterized by overlapping central and state-level processes, results in prolonged timelines and additional cost.
- The central license is not valid for the state and companies must apply for sale in each state for operations separately, through different portals which increases the time and cost of market entry.
- Differences in interpretation and enforcement of national regulations across states further increase compliance complexity.

5.3.3 Policy volatility

- Policy volatility at the state level poses a major challenge, as states exercise significant control over licensing, inspections, product approvals, and distribution mechanisms. Ad-hoc regulatory actions such as sudden license suspensions and product sales restrictions create an uneven and unpredictable operating environment. Under such an environment, bringing innovative products becomes risky and non-lucrative.
- Differences in interpretation and enforcement of national regulations across states further increase compliance complexity and delay product rollout.

5.3.4 Lack of Protection of Regulatory Data (PRD)

- India currently lacks a formal and clearly established period of regulatory data exclusivity for crop protection products. As a result, innovators investing significantly in safety, efficacy, residue and environmental data may have limited certainty regarding the period for which such data receives regulatory protection.

5.3.5 Unclear pathways for biologicals and new technologies

- India's regulatory framework has largely evolved around conventional chemical pesticides, which can create challenges for biologicals, microbial products, botanicals and other emerging technologies. Their distinct modes of action and risk profiles may not always align with existing testing protocols and data requirements. This leads to disproportionate compliance burdens, longer approval timelines and uncertainty in regulatory classification, potentially slowing down the adoption of innovative crop-protection solutions.

5.3.6 Lack of comprehensive data governance framework for digital agriculture

- Digital agriculture is becoming central to modern agriculture. However, there is a growing need for a comprehensive governance framework to ensure the responsible use of digital tools. Addressing issues related to farmer consent, data ownership, cybersecurity, accountability for digital advisories and commercial use of farm data will be essential to build trust and encourage adoption of digital tools for agriculture.

Imperatives for Building an Innovative Crop Protection Ecosystem



India has a unique opportunity to emerge as a global leader in agricultural innovation. With one of the world's largest farming sectors, a strong scientific base, expanding digital capabilities, and growing policy focus on agricultural transformation, the country is well positioned to develop and deploy next-generation crop protection solutions that enhance productivity while advancing sustainability.

Realizing this opportunity, however, requires more than just technological innovation, it demands an enabling ecosystem that nurtures research, accelerates commercialization, strengthens farmer adoption, and encourages collaboration across stakeholders.

The Government has a critical role in creating an enabling policy and regulatory environment through predictable regulations, stronger research support, intellectual property protection, and incentives for innovation.

The private sector must complement these efforts by investing in R&D, manufacturing, extension services, digital technologies and responsible product stewardship. Together, through strong public-private collaboration, these efforts can build a resilient and innovation-driven crop protection ecosystem that accelerates technology adoption, enhances farmer outcomes, strengthens food security and reinforces India's global competitiveness. This chapter outlines the key imperatives needed to create such an ecosystem.

Exhibit 11: Imperatives for building an innovative crop protection ecosystem

FOR INDUSTRY



- Strengthen Stewardship and Farmer Outreach
- Strengthen Manufacturing Competitiveness and Accelerate Indigenous Innovation
- Evolve Towards Integrated Crop Health Solutions
- Harness Digital Technologies to Improve Farm-Level Outcomes
- Foster Collaborative Innovation Ecosystems
- Improve Export Competitiveness

FOR GOVERNMENT



- Enhance Farmer Extension Services
- Strengthen Quality Control and Curb Counterfeit Products
- Strengthen Testing Infrastructure
- Strengthen Surveillance and Resistance Monitoring
- Promote Domestic R&D, Manufacturing and Innovation
- Create an Enabling Policy and Regulatory Environment

Source: Industry Discussions, YES BANK Analysis

6.1 Imperatives for industry

6.1.1 Strengthen stewardship and farmer outreach

- Expand farmer education programmes on appropriate product selection, dosage, application methods, resistance management and occupational safety.
- Build technical capabilities of dealers and extension personnel to ensure that farmers receive accurate recommendations, leading to improved efficacy and reduced misuse.
- Ensure that all product claims are accurate, scientifically validated and supported by robust field evidence. Clear, transparent and consistent product communication strengthens farmer confidence, enables informed decision-making and reinforces the credibility of the industry.

6.1.2 Strengthen manufacturing competitiveness and accelerate indigenous innovation

- Continue to build domestic manufacturing capabilities across technical-grade products, intermediates, formulations and biologicals to reduce supply chain vulnerabilities, improve self-reliance and contribute to exports from India.
- Strengthen investments in research and innovation to develop crop protection solutions tailored to India's diverse agro-climatic conditions and emerging pest challenges.
- Build a stronger domestic innovation ecosystem to reduce reliance on imported technologies and enhance India's position as a global hub for crop protection innovation.

6.1.3 Evolve towards integrated crop health solutions

- Move beyond a product-centric approach and offer integrated crop health solutions that combine chemical and biological products with agronomic advisory and digital decision-support tools. Such an approach can improve pest management outcomes while supporting sustainable agricultural practices and long-term farm productivity.

6.1.4 Harness digital technologies to improve farm-level outcomes

- The adoption of digital technologies presents a significant opportunity to improve the efficiency and precision of crop protection. The industry needs to expand the use of artificial intelligence, remote sensing, drones, weather analytics, predictive pest surveillance and field diagnostics to enable timely interventions, optimize input use and provide customized advisories. Digital platforms have immense potential to strengthen farmer engagement and improve decision-making throughout the crop cycle.

6.1.5 Foster collaborative innovation ecosystems

- Establish structured partnerships with public research organizations, startups, agritech companies and academic institutions to facilitate knowledge exchange, technology validation and faster commercialization of new solutions. Collaborative innovation can reduce development timelines and improve the relevance of emerging technologies.

6.1.6 Improve export competitiveness

- Align product development, manufacturing and stewardship practices with international quality, residue and traceability requirements.
- Help farmers achieve MRL compliance through stewardship programmes.
- Work closely with exporters and value chains to improve traceability and residue compliance.

6.2 Imperatives for the Government

6.2.1 Enhance farmer extension services

- Strengthen extension systems to disseminate scientific, crop-specific guidance on product selection, judicious usage, application methods, resistance management and safe handling practices. Greater involvement of KVKs, engagement with FPOs/FPCs supported by public-private partnerships, can accelerate field-level demonstrations, capacity building, and adoption of science-based crop protection solutions.
- Institutionalize regular trainings and certification programmes on the safe handling, storage, mixing, application and disposal of crop protection products. Also, promote the use of affordable, climate-appropriate personal protective equipment (PPE) through awareness campaigns.
- Leverage digital platforms, mobile advisory services and partnerships with state agencies and private stakeholders to expand the reach and effectiveness of farmer advisories.
- A well-informed and efficient extension system is central to driving adoption of innovative crop protection solutions. Thus, prioritising capacity building of extension officers to ensure they are equipped with up-to-date knowledge on advanced solutions and at the same time are able to issue local, weather-based and crop-specific advisories is important.

6.2.2 Strengthen quality control and curb counterfeit products

- Strengthen market surveillance and enforcement mechanisms to prevent the manufacture, distribution and sale of counterfeit, sub-standard and spurious crop protection products.
- Modernize and standardize sampling, testing and evidence management protocols across states through harmonized Standard Operating Procedures (SOPs) and digital traceability systems to ensure consistency, transparency and scientific integrity in quality enforcement.
- Rationalize institutional responsibilities by separating licensing and enforcement functions, enabling more focused regulatory oversight, robust compliance monitoring and timely action against counterfeit and illegal products.
- Establish stringent deterrence measures and expedite legal action against non-compliant entities to safeguard farmer interests and maintain market integrity.

6.2.3 Strengthen testing infrastructure

- Standardize sampling protocols and strengthen chain-of-custody procedures.
- Expand and modernise quality testing infrastructure by strengthening laboratory capacity, adopting advanced analytical capabilities and building technical expertise to enable timely and reliable quality assessments.
- Standardize testing protocols and strengthen laboratory accreditation (NABL) to ensure consistency, reliability and transparency across states.

6.2.4 Strengthen surveillance and resistance monitoring

- Conduct a national crop-loss and pest-impact assessment every three to five years.
- Establish a national surveillance system for monitoring pest incidence, resistance development and emerging threats across agro-climatic regions.
- Create a national resistance baseline for key crop-pest combinations, to enable systematic tracking of resistance evolution and support evidence-based regulatory and management decisions.
- Develop crop-pest mode-of-action maps that guide product selection, sequencing and rotation based on local resistance risks and agro-climatic conditions.
- Promote integrated resistance management through science-based rotation and mixture guidelines aligned with IRAC, FRAC and HRAC principles.
- Create a centralized national platform for periodic reporting and dissemination of resistance trends, enabling timely advisories and informed decision-making by farmers, extension agencies, researchers, and policymakers.
- Strengthen data collection (with standardized protocols), sharing and collaboration among research institutions, state agencies and industry to support evidence-based pest management strategies.

6.2.5 Promote domestic R&D, manufacturing and innovation

- Introduce targeted policy incentives (like PLI) to encourage investments in research, innovation and advanced manufacturing across technical-grade products, formulations and biologicals.
- Facilitate access to research infrastructure, high end laboratories, funding and innovation ecosystems to strengthen indigenous technology development and commercialization.
- Develop public-private challenge grants for India-specific pest problems.

6.2.6 Create an enabling policy and regulatory environment

6.2.6.1 Streamline the regulatory approval framework

- Streamline and digitise regulatory approval processes to enable transparent, predictable and time-bound registration of crop protection products while maintaining rigorous safety, quality and efficacy standards.

- Strengthen institutional coordination between CIBRC, FSSAI and other relevant regulatory agencies to enable parallel processing of registrations, MRL fixation and associated approvals, reducing the overall time-to-market for new crop protection technologies.
- Accelerate regulatory processes, including timely notification of approved molecules and inclusion in the Insecticides Schedule, to ensure that approvals translate into faster commercial availability of innovative products.
- Provide real-time tracking and transparent communication throughout the approval process.
- Publish annual registration-performance metrics, including median review time and pending applications.
- Strengthen the institutional capacity of CIBRC through investments in scientific talent, digital infrastructure, advanced evaluation capabilities and continuous capacity building, supported by reinvestment of regulatory fee collections to improve the speed and quality of regulatory decision-making.
- Simplify administrative procedures for routine post-registration changes, including manufacturing locations, supplier additions, company details and other minor endorsements, through risk-based self-certification and digital notification mechanisms, enabling regulators to focus resources on scientific evaluations and high-risk applications.
- Integrate crop grouping principles into pesticide registration framework to reduce duplication of residual trials and improve farmers' access to innovative crop protection solutions.
- Adopt a parallel review mechanism for pesticide registration and MRL applications to streamline regulatory approvals and reduce time- to- market.

6.2.6.2 Create a harmonized and digitally integrated regulatory ecosystem

- Develop a fully integrated digital regulatory platform covering application submission, scientific review, stakeholder communication, approval tracking and post-registration compliance to enhance transparency and ease of doing business. Integrate Computerized Registration of Pesticides (CROP), Integrated Pesticide Management System (IPMS) and state portals into a single digital regulatory ecosystem. This will also warrant harmonization of regulatory data requirements across central and state agencies to create a unified ecosystem that reduces duplication.

6.2.6.3 Introduction of one Nation one License

- Introduce a centralized license valid across all states for the manufacture, import and sale of crop protection products. This will eliminate the need for multiple state-wise registrations for the same product/formulation and improve Ease of Doing Business.

6.2.6.4 Foster innovation through an enabling regulatory and intellectual property framework

- Introduce a robust Protection of Regulatory Data framework and align regulatory approvals of follow-on products with intellectual property protection. A five year exclusivity period for newly registered products and new uses (from the first registration date) will help provide innovators with a predictable return on investments in safety, efficacy and residue data generation, which costs around INR 40-50³⁵ crores. The subsequent applicants can access the data within a year for much lesser investments. This gap weakens the case for innovators wanting to bring in new chemistries into India.

³⁵ Paper on pesticide patent and data protection, CropLife India.

6.2.6.5 Develop a progressive regulatory framework for biologicals and emerging technologies

- Establish dedicated, science-based regulatory pathways for biologicals.
- Strengthen specialized scientific expertise and institutional capacity within regulatory agencies to support efficient evaluation of novel products.
- Digitize regulatory processes through integrated dossier submission, review and deficiency management systems to improve transparency and efficiency.
- Accelerate market access through transparent, risk-based and time-bound regulatory evaluation processes.

6.2.6.6 Create a national minor-use program

- Develop a National Minor Use Programme through collaboration between government, research institutions and industry to generate the scientific data required for registration and label expansion in minor and specialty crops. This will expand farmers' access to safe and effective crop protection technologies, reduce reliance on unregistered uses particularly in the horticulture sector.

6.2.6.7 Create a digital portal for publishing MRLs (for domestic and export markets)

- As India's exports grow, it is essential to have a clear visibility and understanding of the domestic as well as importing nations' MRLs. Thus, creating a centralized, digital platform with information on MRLs as well as pre-shipment testing requirements of the commodities will help exporters, farmers, regulators as well as food safety professionals. This portal can play a critical role in facilitating trade compliance, reducing rejections, and supporting regulatory transparency. This will also ease-out the entry barrier for new players targeting exports

6.2.6.8 Develop a regulatory framework for data governance

- Develop a comprehensive agricultural data governance framework that aligns with the Digital Personal Data Protection Act, 2023, and establishes clear provisions on farmer consent, data rights, responsible data sharing, cybersecurity, accountability for digital advisories, ethical commercial use of farm data and inclusive access to digital services.

6.2.6.9 Strengthen export-only licensing pathway

- Strengthen export-only licensing pathway by tightening the current, highly flexible approach and requiring pre-grant confirmation that the declared manufacturing sites (AI and formulations) have valid approvals/clearances from the competent authorities responsible for manufacturing permissions, safety, and facility compliance. This confirmation (via inter-departmental verification and/or documented evidence, with inspection where required) should cover minimum quality, EHS, and traceability/infrastructure standards. This will ensure licences are issued only to capable, compliant manufacturers, safeguarding export integrity and India's credibility in importing markets.

6.2.6.10 Strengthen Industry–Government collaboration

- Institutionalize regular consultation between government, industry and research institutions to strengthen evidence-based policymaking.
- Undertake joint outreach initiatives to enhance awareness of the science, safety and responsible use of crop protection technologies among farmers and other stakeholders.
- Develop coordinated, science-based national positions on international pesticide conventions, standards and regulatory developments to safeguard India's agricultural and trade interests.

List of Abbreviations

AI	Artificial Intelligence
AIF	Agriculture Infrastructure Fund
CACP	Commission for Agricultural Costs and Prices
CGTMSE	Credit Guarantee Fund Trust for Micro and Small Enterprises
CIBRC	Central Insecticides Board and Registration Committee
CPDS	Chemical Promotion Development Scheme
CROP	Computerized Registration of Pesticides
DA&FW	Department of Agriculture and Farmers Welfare
DCPC	Department of Chemicals and Petrochemicals
DGCA	Directorate General of Civil Aviation
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FPO	Farmer Producer Organizations
FSSAI	Food Safety and Standards Authority of India
FY	Financial Year
GAVL	Godrej Agrovat
GLP	Good Laboratory Practice
GVA	Gross Value Added
GVO	Gross Value of Output
Ha	Hectare
ICAR	Indian Council of Agricultural Research
INR	Indian Rupee
IoT	Internet of Things
IPM	Integrated Pest Management
IPMS	Integrated Pesticide Management System
ISAM	Integrated Scheme for Agriculture Marketing
KW	Kilo Watt
LMT	Lakh Metric Tonne
MHA	Million Hectare
ML	Machine Learning
mm	Millimeter
Mn	Million

MoSPI	Ministry of Statistics and Programme Implementation
MRL	Maximum Residue Limit
MT	Metric Tonne
NABL	National Accreditation Board for Testing and Calibration Laboratories
NAM	National Agriculture Market
NASF	National Agricultural Science Fund
NFSM	National Food Security Mission
NMNF	National Mission on Natural Farming
NPSS	National Pest Surveillance System
NSP	New Scheme of Petrochemicals
PIB	Press Information Bureau
PKVY	Paramparagat Krishi Vikas Yojana
PLI	Production-Linked Incentive
PMFBY	Pradhan Mantri Fasal Bima Yojana
PPE	Personal Protective Equipment
R&D	Research and Development
RDI	Research, Development and Innovation
PRD	Protection of Regulatory Data
RKVY	Rashtriya Krishi Vikas Yojana
RPTOS	Remote Pilot Organizations
RWBCIS	Restructured Weather Based Crop Insurance Scheme
SHG	Self Help Group
SMAM	Sub-Mission on Agriculture Mechanization
SOP	Standard Operating Procedure
UAV	Unmanned Aerial Vehicles
UPAg	Unified Portal for Agricultural Statistics
USD	U.S. Dollar
WIPO	World Intellectual Property Organization
ZLD	Zero Liquid Discharge



CropLife India is a leading industry association of both Indian and Global R & D driven crop science organizations. CropLife India jointly represents around 70% of the Indian crop protection market and are responsible for 95% of the molecules introduced in the country. CropLife India member companies have an annual global R & D spend of over INR 50,000 crores.

CropLife India member companies were established in India as far back as the 1950s. CropLife India continues to work hand-in-hand with the Government to build the agriculture sector– from introduction of several newer and safer molecules, direct investment of building factories, jobs creation, bringing in agriculture innovation and working endlessly over the years with multistakeholders to enhance agriculture productivity. All member companies are firmly committed to engage with the farming community to enable Safe, Secure and Sustainable Food Supply.

CropLife India members enable farmers adopt new technologies in agriculture, while providing in depth farmer trainings on good farming practices, including responsible use of crop protection products, container management and spraying techniques promotion of safe, responsible & judicious use of crop protection products under Integrated Pest Management approach.

CropLife India extensively engages with the farming community including dealers and traders for growing safe, secured and nutritious food committed to responsible crop care and crop production for sustainable development of Indian Agriculture.

CropLife India is a not for profit organization, (registered under Section 8 Companies Act 2013) wholly funded by membership. CropLife India is a part of the CropLife International Network; and works closely with CropLife Asia & CropLife International, spread across 91 countries while engaging with diverse stakeholders to drive programs on Progressive Regulations, IPR/Data Protection, Policy & Advocacy, Communications & Outreach, Anti-Counterfeiting and Product Stewardship.



YES BANK At a Glance - A New Generation Private Sector Bank

At YES BANK, we are driven by a deep purpose and relentless commitment to our customers. Headquartered in Mumbai, YES BANK is the 6th largest private sector Bank in India offering full-fledged banking solutions with its comprehensive bouquet of product and services, digital solutions catering to Retail, MSME, Wholesale and Rural segments. The Bank has a pan India presence with 1,255 branches, 235 BCBOs and 1,331 ATMs (including CRMs and BNAs) in over 300 districts in India.

The Bank operates its Brokerage business through YES SECURITIES, a wholly-owned subsidiary of the Bank. The Bank has a pan-India presence including an International Banking Unit (IBU) at GIFT City in the Ahmedabad district, Gujarat and a Representative Office in Abu Dhabi. Through a growing pan-India presence, we empower our customers to achieve their full potential and serve India's future businesses.

The Bank's vision rests on three strategic pillars:

Universal Banking with Granular Focus: Maintain our role as a universal bank while concentrating on refining and expanding each business segment.

Digital Leadership and Relationship Banking: Leverage our established digital market leadership to serve the new-age economy and future value pools, ensuring we also support and capture transactional business.

Employee-centric Culture and Efficient Processes: Prioritise an employee-focussed culture, streamline processes, and develop a scalable technology infrastructure.

YES BANK has consistently fostered a strong sustainability ethos within its culture, enabling it to respond effectively to evolving ESG expectations, regulations, and opportunities. The Bank continuously monitors ESG and climate developments, collaborating with stakeholders to integrate key sustainability themes and practices into its operations.



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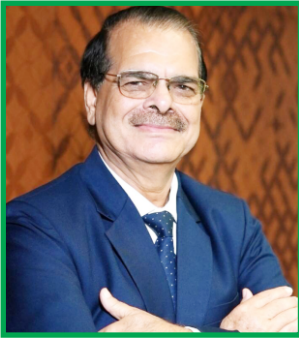


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Mr. Sarjiwan Manhas

Chief Sustainability Officer and Head Greenag
Crystal Crop Protection Limited



Mr. Rajvir Rath

Head - Agricultural Affairs & Policy
India, Bangladesh and Sri Lanka
Bayer Crop Science



Ms. Neetu Kapasi

South Asia Leader - Government &
Industry Affairs
Corteva Agriscience India



Mr. Rahul Pandey

Business Head - Crop Care
Rallis India Limited



Ms. Sangeeta Dawar

Head of Business Sustainability
& Corporate Affairs
Syngenta (India)



Mr. Arjun Chowdhuri

Lead - Industry Affairs,
India, Bangladesh and Sri Lanka
Bayer CropScience



Mr. Yuvraj Chopra

Country Advocacy
Lead-Agricultural Solutions
BASF India Ltd



Mr. Amit Shekhar

Government & Industry
Affairs-Lead, South Asia
Corteva Agriscience



Mr. Joydeep Chakraborty

Head - Communications
CropLife India

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AUTHORS	YES BANK Food and Agribusiness Strategic Advisory & Research Team (FASAR), YES BANK	CropLife India
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CONTACTS	YES BANK Ltd. Registered and Head Office YES BANK House, Off Western Express Highway, Santacruz (East), Mumbai-400055 Email : fasar@yesbank.in Website : www.yesbank.in	CropLife India Address: Bhikaji Cama Bhawan, 702, 7th Floor, Bhikaji Cama Place, New Delhi, Delhi 110066 Tel : 011 2618 6296

