



Bio-inputs in *Brazil*

Tropical Innovation on a Large
Scale for Productive, Resilient,
and Sustainable Agriculture

How biodiversity, field experience, research,
industry, and regulation have transformed
Brazil into a global reference in the use of
biological solutions for agriculture.

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Introduction

Bio-inputs represent one of the most relevant transformations in contemporary Brazilian agriculture. In a country marked by great biological diversity, different soil profiles, regional climatic variations, and high pressure from pests and diseases, biological solutions have gone from a punctual alternative to a strategic component of agricultural management.

The Brazilian experience shows that bio-inputs consolidate when they respond to these concrete challenges effectively and with quality.

Today, Brazil moves more than \$1.2 billion in annual market, with growth of 22% in the last three years (about 3 times higher than the global average). In 2025 alone, more than 194 million hectares were treated with bio-inputs, a value 28% higher than that recorded in the previous year.

Brazilian biodiversity is also an essential asset in this process. However, biodiversity, by itself, does not generate innovation. For it to be transformed into reliable technology, investment is needed in research, characterization, stability, formulation, quality control, safety, performance evaluation, registration, and technical assistance.

Another fundamental point in this trajectory is regulation. Predictable regulatory frameworks, proportionate to risk and based on science, are fundamental to stimulating innovation, protecting quality, differentiating reliable products, attracting investment, and strengthening the sector's international reputation.

In the global context, the Brazilian experience offers relevant lessons for tropical and subtropical countries. And it shows that the future of bio-inputs will depend on the convergence between biodiversity, science, and trust. Scale is not built solely on market demand; it requires clear regulatory frameworks, industrial development, technical validation, producer support, commitment to quality, and international cooperation.



What are *bio-inputs*

Bio-inputs in a sentence

Bio-inputs are products of biological origin used in agriculture to control pests and diseases, increase nutrient absorption, promote plant development, recover degraded soils, and ensure the maintenance of production systems.

They are classified according to their nature as biochemical compounds or living organisms and divided by agronomic functions, being able to perform multiple functionalities.

NATURE				
BIOCHEMICALS - CHEMICAL NATURE			LIVING ORGANISMS	
Hormones vegetables	Proteins, Enzymes, Amino Acids, Peptides, RNA	Extract of Microorganisms (inactivated)	Macroorganisms	Proteins, Enzymes, Amino Acids, Peptides, RNA
Extracts vegetables	Algae Extractions	Animal Extract (quitina e quitosana)	Algae Extractions	Algae Extractions
	Semiochemicals	OTHERS		

FUNCTION - Effectiveness				
ACTION IN EXTERNAL BODIES	ACTION ON PLANT PHYSIOLOGY OR RHIZOSPHERE		ACTION ON THE GROUND	MULTIPLE FUNCTIONS
Biocontrol	Biostimulants*	Bioinhibidor	Bioconditioner	Combination of any of the functions (e.g. biocontrol and biostimulant)
Bioinsecticide Biofungicida Bionematicide Bioherbicidas Behavioral change (e.g. pheromone)	Biofertilizers: increases the efficiency of nutrient utilization (e.g. N Fixation, P Solubilizer) Promotion of tolerance to abiotic stress Activation of the plant's natural resistance mechanisms Improvement or increase of crop quality factors (Actions independent of the nutritional value of the product)	Inhibitor of the physiological process	Improves soil structure (e.g. increased porosity and water retention). Degradation of organic waste)	OTHER
				Ex. Plant substrate, only nutrition

Bio-inputs can:

- Control pests and diseases
- Fix atmospheric nitrogen
- Make soil nutrients available
- Support the biological balance of the agroecosystem
- Stimulate growth and tolerance to environmental stresses
- Expand the tools of integrated agricultural management

Why Brazil Has Become a *Relevant Case in Bio-inputs*

Brazil possesses natural conditions, agronomic challenges, and institutional capabilities that favor the development and adoption of biological solutions.

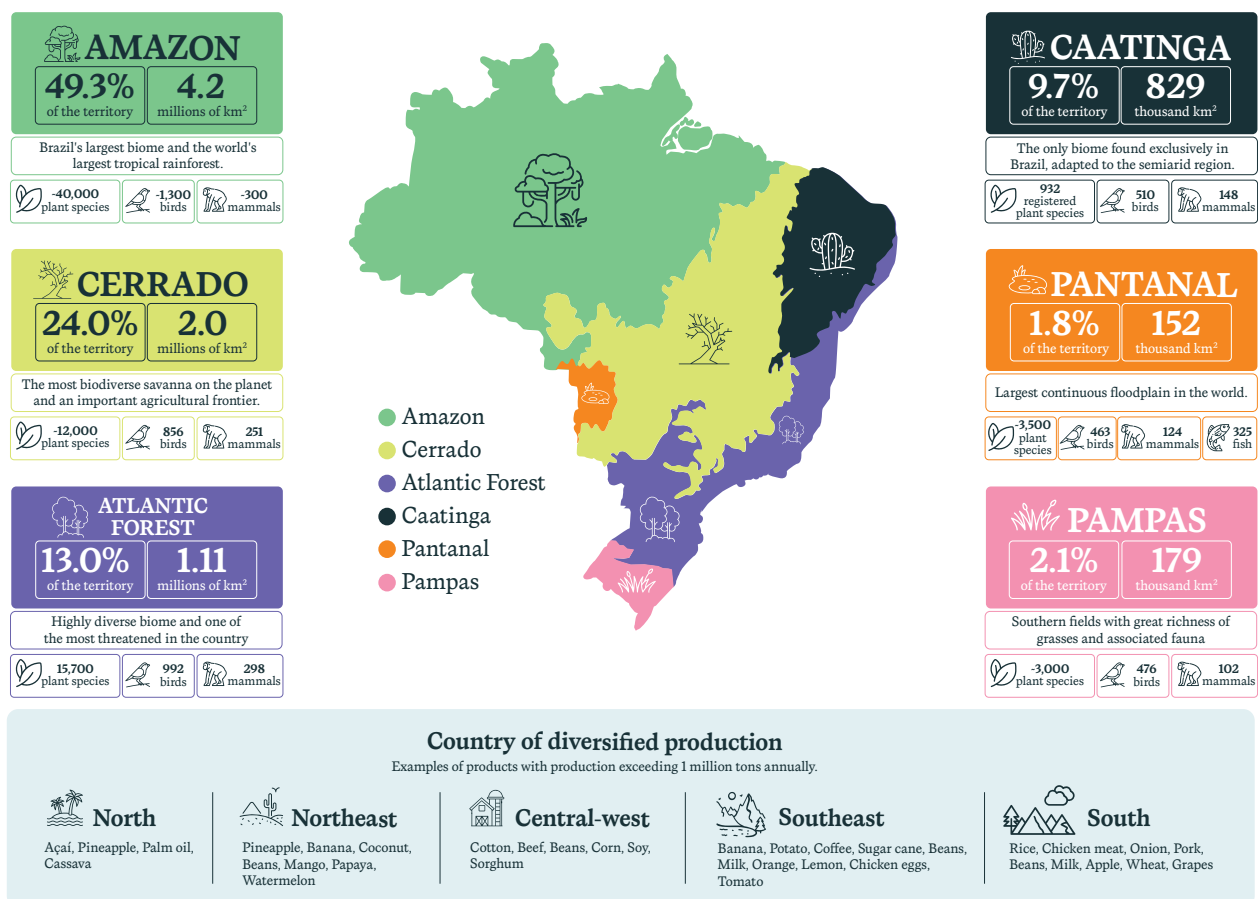
Brazilian agriculture is diverse, knowledge-intensive, and practiced in different biomes, soils, climates, and production systems. Crops such as soybeans, corn, sugarcane, cotton, coffee, citrus, fruits, vegetables, and pastures coexist with constant pressures from pests, diseases, and abiotic stresses.

Furthermore, a large part of Brazilian soils presents natural limitations in fertility, high acidity, and low availability of essential nutrients, requiring continuous technical management to sustain high levels of agricultural productivity.

This environment has generated a permanent demand for technologies capable of supporting productivity, reducing losses, strengthening soil health, and increasing the resilience of production systems. Bio-inputs have begun to respond to this need with agronomic effectiveness.

Brazil as an *Experimental Field*

Brazil is one of the world's largest agricultural producers with over 83 million hectares under cultivation. This agricultural scale provides a testing ground, validation across multiple climatic and agricultural regions, continuous field learning, and the generation of agricultural effectiveness data that underpin international competitiveness and confidence. Few countries simultaneously possess this combination of scale and diversity of production systems.



Reference sources: IBGE; ICMBio/MMA; Embrapa; Flora do Brasil; recent scientific literature. Biodiversity values are approximate and presented for illustrative purposes.

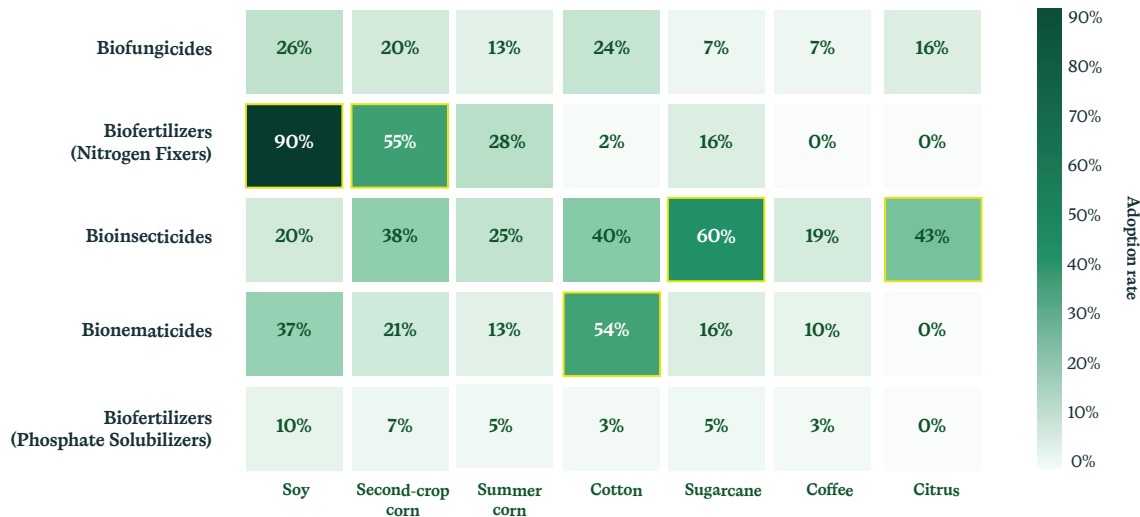


Another decisive factor is the profile of the Brazilian producer. In different regions, farmers have been incorporating digital technologies, integrated management practices, precision agriculture, and new products.

When there are proven results in the field, adoption gains scale.

Adoption rate of *bio-inputs by crop in Brazil* (25/26 crop season)

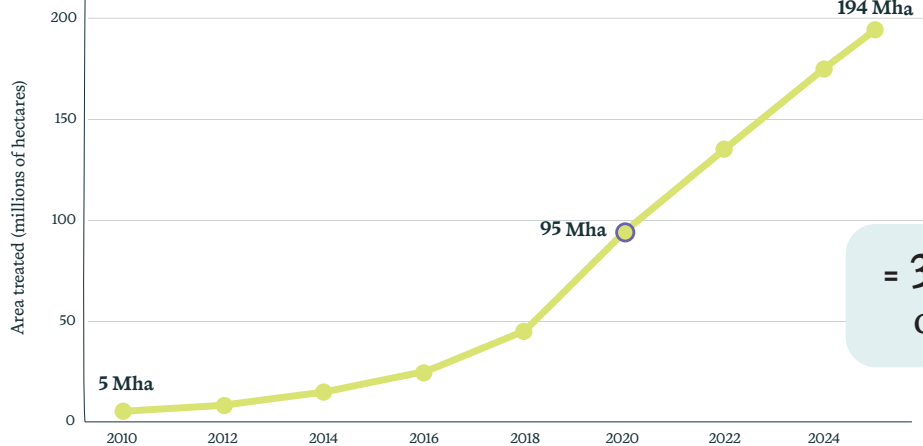
Heat map - adoption percentage by bio-input category



Source: CropLife Brazil/Blink 2026.

Expansion of the Area Treated with Bio-inputs in Brazil

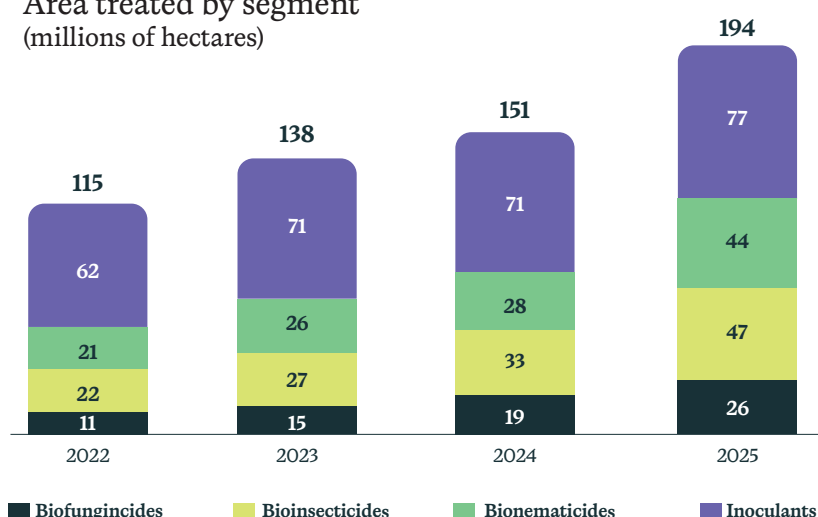
From approximately 5 to 194 million hectares (2010-2025)



= 39 x growth over 15 years

Source: CropLife Brazil, 2026

Area treated by segment
(millions of hectares)



Source: CropLife Brazil, 2026

The Brazilian scale is a strategic asset: it accelerates learning, validation, adaptation, and increases the innovation cycle.

Biological Nitrogen Fixation: Products based on nitrogen-fixing bacteria were applied to approximately 77 million hectares in Brazil in 2025 (CropLife Brazil). In soybeans, this technology avoids the emission between 206 and 250 million tons of CO₂ equivalent emissions per year, depending on the crop season. This amount is comparable to the emissions from Brazil's road transport sector, which totalled 204 million tons of CO₂ equivalent in 2024 (National Inventory of Atmospheric Emissions from Road Motor Vehicles).

Bionematicides are applied to 44 million hectares in Brazil, contributing to reducing productivity losses that can exceed 25% in some crops.

Control of the sugarcane borer (*Diatraea saccharalis*): Parasitoid eggs produced by Brazilian industries are used in more than 5 million hectares of sugarcane, making it one of the world's most successful insect-based biological control programs.

Crops

Main targets with bio-input products



Soybeans

Whitefly • Caterpillars • Stink bugs • Nematodes • White mold • Asian soybean rust • Anthracnose • Root rots • *Fusarium wilt*



Corn

Corn leafhopper • Fall armyworm • Nematodes • Root rots



Sugarcane

Sugarcane borer • Leafhoppers • Nematodes • Fungal diseases



Cotton

Whitefly • Nematodes



Coffee

Coffee berry borer • Coffee leaf miner • Nematodes



Citrus

Coffee berry borer • Coffee leaf miner • Nematodes

Brazilian experience shows that bio-inputs should not be treated as isolated solutions. Their potential is greater when integrated into well-managed production systems, with technical assistance, product quality, and integrated agronomic strategies.

The History of Bio-inputs in Brazil spans a century

1920s	First applications in Brazil: Use of parasitoid wasps, such as <i>*Encarsia berlesei*</i> and <i>*Aphytis mali*</i> , to control mealybugs and aphids.
1970s	Successful initial cases: Embrapa introduces parasitoids to control aphids in wheat in the state of Rio Grande do Sul.
80s 90s	Change in perception: Advancement in the use of <i>*Baculovirus anticarsia*</i> in the control of soybean caterpillars, strengthening biological control as an agricultural tool.
1990s	Consolidation of scientific research: Public and private research centers, Brazilian universities, and Embrapa expand studies with beneficial microorganisms.
2000s	First commercial formulations: More structured products emerge, especially inoculants for soybeans, marking the beginning of the modern bio-input industry in Brazil.
2008	Expansion of inoculants: Accelerated growth in soybean use, with proven economic gains and reduced use of nitrogen fertilizers.
2010	Consolidation of biocontrol programs: Increasing adoption in soybeans, corn, cotton, and beans.
2012	Industrial expansion: Advances in R&D, formulation, and production quality.
2013	Response to the Brazilian phytosanitary emergency: Use of technologies such as <i>Bacillus thuringiensis</i> and HearNPV for the control of the <i>Helicoverpa armigera</i> pest in soybeans, corn, and cotton.
2016	Market acceleration: Estimated annual growth of around 22%, entry of new companies, and portfolio diversification.
20/23	Intensified investments: Companies expand R&D, biopesticides gain ground in major crops, and legislative discussions advance.
2024	Approval of Law No. 15.070/2024: Creation of the Legal Framework for Bio-inputs.
2025	Large-scale consolidation: Estimated use in 194 million hectares, 162 new products registered, and more than 600 researchers involved.
25/26	Regulatory transition and creation of an international hub for bio-inputs: Development of the necessary sub-legal norms for the implementation of the legal framework for bio-inputs and advancement of initiatives to promote the scientific and technological development of bio-inputs in Brazil - Renera Project.



Technology to transform natural potential into real results

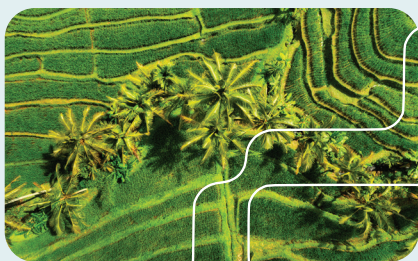
Brazilian biodiversity offers a strategic basis for innovation in bio-inputs. Microorganisms such as fungi, bacteria, viruses and their derivatives, insects, mites, nematodes and plant extracts can support the development of products for different dimensions of agricultural management – from pest and disease control to plant nutrition, from tolerance to environmental stresses to the promotion of soil health.

Brazil is the most biodiverse country in the world. It is ranked first among the 17 megadiverse countries on the planet. It is estimated that Brazil harbors between 15% and 20% of the world's biodiversity, with the largest number of endemic species on a global scale.

However, biodiversity does not automatically translate into technology. For a biological resource to become an effective and reliable bio-input, a rigorous technical process is necessary, involving discovery, selection, characterization, stability, large-scale production, quality control, formulation, performance and safety evaluation, registration, and adequate producer guidance.

This path requires continuous investment in research and development, qualified laboratories, industrial capacity, appropriate regulation, and protection of innovation. It also demands responsibility in access to genetic resources and in the use of biodiversity, in line with the objectives of the **Convention on Biological Diversity (CBD)**.

Brazilian experience shows that biodiversity should be understood not only as an environmental attribute but as a platform for responsible innovation. When connected to science, industry, regulation, and cooperation, it contributes to a more productive, resilient, and sustainable tropical agriculture – capable of transforming natural potential into reliable technological solutions for the producer and relevant to the global challenges of agriculture.

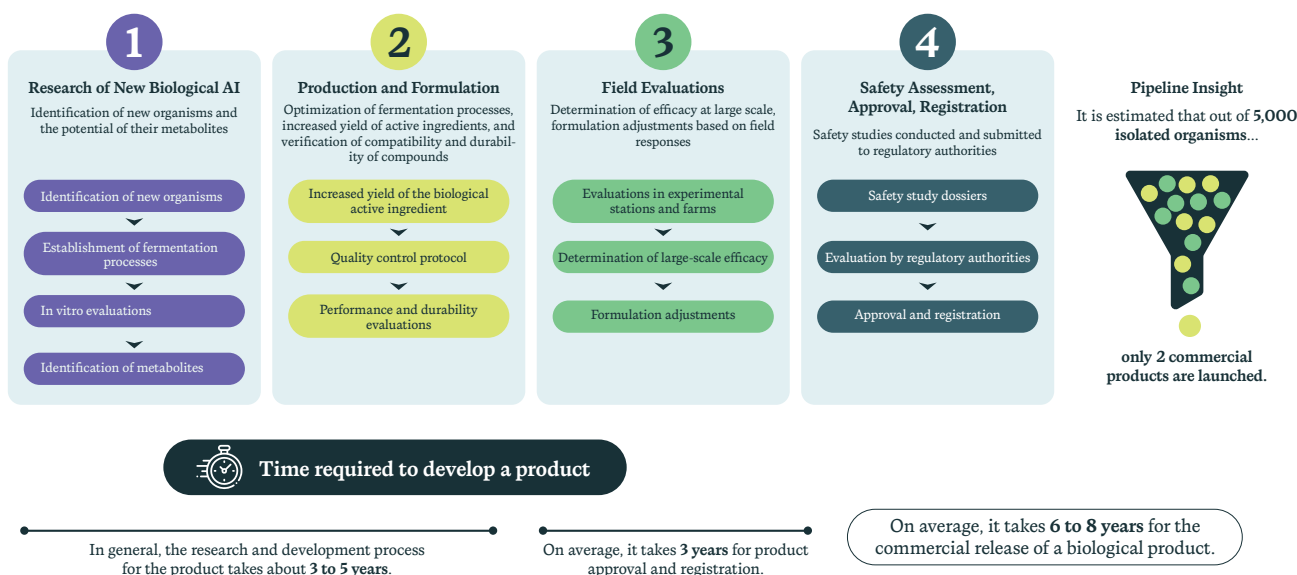


Nature at the Forefront

Biodiversity is the starting point; science, industry, and regulation are the paths to transforming this potential into reliable technology for the producer.

Product development

Stages of the Development Process of Microbiological Products

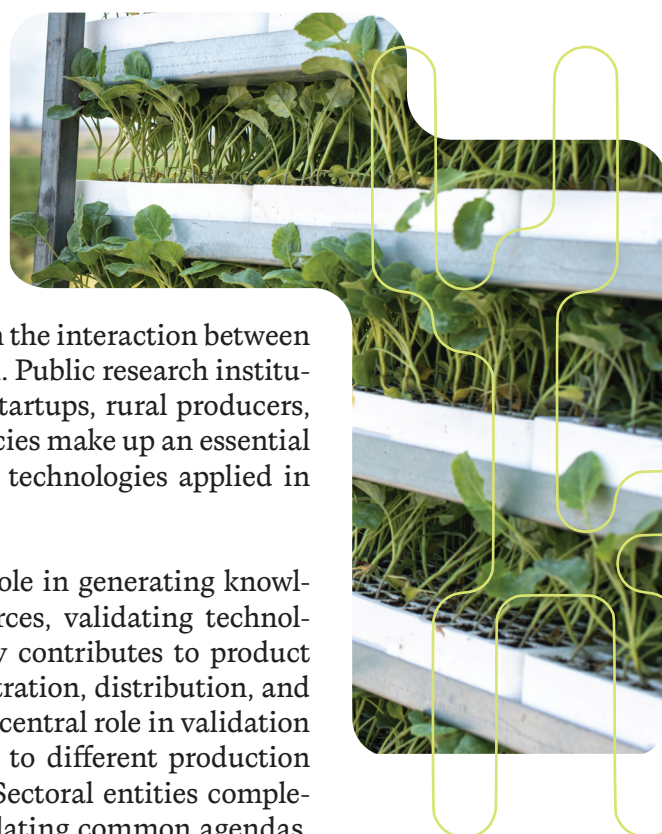


Public-private partnerships and the innovation ecosystem

The Brazilian experience in bio-inputs was built from the interaction between multiple actors in the agricultural innovation system. Public research institutions, universities, technology centers, companies, startups, rural producers, cooperatives, sectoral entities, and government agencies make up an essential network for transforming scientific knowledge into technologies applied in the field.

In this ecosystem, public research plays a relevant role in generating knowledge, conserving and characterizing genetic resources, validating technologies, and developing technical capacities. Industry contributes to product development, production scaling, formulation, registration, distribution, and technical assistance. Rural producers, in turn, play a central role in validation under real-world conditions, adapting technologies to different production systems, and expanding adoption on a large scale. Sectoral entities complement this process by organizing information, articulating common agendas, promoting regulatory dialogue, supporting market intelligence, and contributing to building reputation and trust.

This connection between public science, industrial development, and large-scale adoption is also evident in Brazil's trajectory of Biological Nitrogen Fixation (FBN). Bacterial bio-inputs, developed from decades of research by Embrapa and produced on a large scale by industry, have contributed to consolidating BNF as one of the cornerstones of nitrogen nutrition for soybeans in Brazil. In this crop, the technology completely replaces nitrogen fertilization with minerals, sustaining high levels of productivity with significant economic and environmental benefits.



Embrapa is one of the main pillars of Brazilian agricultural innovation. Created in 1973 and linked to the Ministry of Agriculture and Livestock, the institution was structured to develop the technological base for tropical agriculture, capable of responding to Brazil's productive challenges. Currently, it has 43 research centers and approximately 2,200 researchers, of whom about 90% hold doctoral degrees, forming one of the largest tropical agricultural research structures in the world.

In the field of bio-inputs, this role gains even more relevance due to Embrapa's ability to connect biodiversity to applied science. Embrapa's Genetic Bank brings together collections of plant, animal, and microorganism genetic resources, including approximately 119,000 plant accessions, 28,000 animal accessions, and 7,000 microorganism strains, representing a strategic base for research, selection, and development of new biological solutions.

An example of relevance is the model in which Embrapa engages in open innovation with the productive sector based on a previously defined market demand. Under this model, the partnership is formalized before the project begins with one or more productive agents committed to adopting the innovation assets generated, generally through commercial exploitation, thereby enabling economic returns to Embrapa and fostering a stronger connection between public research and the market.



More recently, this ecosystem has also incorporated initiatives aimed at the internationalization of Brazilian biological solutions. The Renera project (Brazilian Bioinputs Hub), conducted in partnership between CropLife Brasil and ApexBrasil, can support the identification of promising markets, commercial opportunities, technical demands, local partners, and cooperation agendas. By combining market intelligence, international promotion, regulatory dialogue, and institutional articulation, these initiatives contribute to expanding the global reach of bio-inputs developed and used in Brazil.

Cooperation between the public and private sectors strengthens capacities in different dimensions: applied research, technological development, productive quality, data generation, regulatory harmonization, market access, technical training, and trust-building. Brazilian progress in bio-inputs therefore stems from the convergence of science, industry, producers, and public institutions around a common challenge: to produce more, with greater efficiency, resilience, and sustainability.



Regulation, Quality, and **Legal Security**

Bio-inputs depend on clear regulatory frameworks, proportionate to the risk and based on science. Regulation is essential to ensure quality and predictability, both for producers and for companies, investors, researchers, and international partners.

Good regulation should not be understood as a barrier to innovation, but as a reliable infrastructure.

The role of MAPA in the governance of bio-inputs

In Brazil, the evolution of bio-input registration reflects a gradual process of institutional strengthening and regulatory improvement, in which the Ministry of Agriculture, Livestock and Supply (MAPA) played a central role. Over the last few decades, successive regulatory frameworks have contributed to organizing evaluation flows more suited to the nature of biological products, recognizing their technical specificities and their different modes of action.

This trajectory can be observed in both the regulatory framework for fertilizers and pesticides. In the case of fertilizers, inoculants and biological nitrogen fixers have come to have their own definitions and registration rules that differ from those of mineral origin. The combination of registration, inspection, technical recommendations and quality protocols was decisive in consolidating Biological Nitrogen Fixation as a national reference technology. This experience also contributed to the regulatory advancement of biological control products, which gained greater momentum from 2015 onwards.

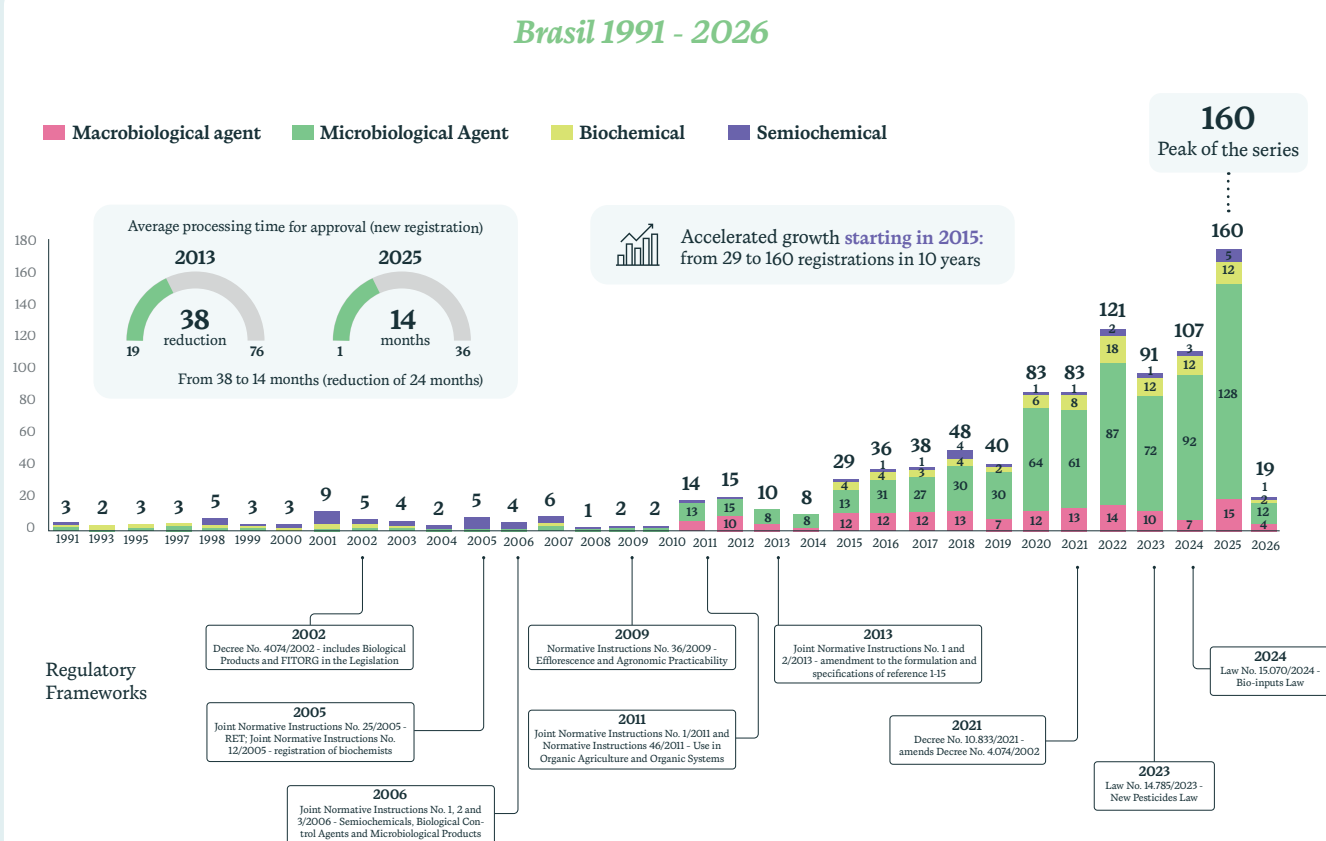
Between 2015 and 2025, the number of registrations for bio-inputs for pest control increased from 29 per year to 160, a growth of 452% in ten years. During the same period, the average time for granting new registrations was reduced from 38 months in 2013 to 14 months in 2025. These results demonstrate that the coordinated action of MAPA (Ministry of Agriculture, Livestock and Supply), in conjunction with Anvisa (National Health Surveillance Agency) and Ibama (Brazilian Institute of Environment and Renewable Natural Resources), in prioritizing analyses and adopting approaches appropriate to biological technology, contributed to expanding farmers' access to new technologies without compromising safety, quality, and efficacy.

The Brazilian experience demonstrates that regulatory efficiency and technical rigor can advance in a complementary way. The improvement of evaluation processes has sought greater alignment with international references, including technical guidelines and protocols defined by the Organisation for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization of the United Nations (FAO). This convergence contributes to strengthening regulatory confidence, reducing technical asymmetries, and supporting the international insertion of biological solutions developed and used in the country.

The approval of Law No. 15.070/2024, which establishes the new legal framework for bio-inputs, represents a new stage for the sector in Brazil. The law consolidates the understanding of a specific regulatory approach, distinct from other agricultural inputs, due to its nature, technological diversity, and multifunctional potential.

The expectation is that the sub-legal regulations under development will consolidate the progress already achieved and improve the governance of bio-inputs, in line with international best practices and with the capacity to stimulate innovation.

Annual Evolution and Regulatory Frameworks - *Biological Control*





Brazil in the Global Context of Bio-inputs.

The global market for bio-inputs is growing, driven by more sustainable agricultural practices, the need for increased productivity, loss reduction, climate adaptation, and demand for solutions that complement traditional production systems.

In this context, Brazilian experience can be particularly relevant for countries facing similar challenges, contributing through technical cooperation, capacity building, field demonstrations, scientific exchange, technology transfer, and market development.

The international transfer of bio-input technology from Brazil requires strategy. Each market has its own rules, priority crops, production systems, distribution channels, and technical requirements. Therefore, exporting bio-inputs is not just about selling products; it means building trust, validating technologies, understanding local contexts, and developing partnerships.

Brazil combines scale, biodiversity, field experience, industry, and regulatory expertise to contribute to the global bio-input agenda.

Conclusion

Brazil projects to consolidate, by 2030, a new phase of maturity for bio-inputs: expanding the treated area, increasing the participation of technology in pest and disease management in all major production chains – grains, fibers, fruits, vegetables and pastures –, and deepening the integration between biological control, biological nutrition and integrated management as a production standard, not as an exception.

This horizon depends on three simultaneous movements that are evolving rapidly in Brazil: consolidating the implementation of the Bio-inputs Law with regulatory predictability and international convergence; expanding industrial capacity and quality control to sustain scale with confidence; and strengthening international technical cooperation, allowing Brazilian learning to support other tropical and subtropical countries in building their own biological innovation ecosystems, as well as enabling Brazil to learn from international regulatory, scientific, and commercial experiences to improve its own innovation environment.

More than a market goal, the 2030 horizon represents a commitment: to transform Brazilian biodiversity into greater productivity gains, climate resilience, and sustainability for the producer, also contributing to Brazil's role in global food security.



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