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Contents

Overview	1
Key categories of agricultural biologicals	1
Benefits and challenges	3
Market	4
Macro drivers	5
VC activity	7
Exits	8

EMERGING TECH RESEARCH

Biologicals Bring Nature Back to Agriculture

Sustainable alternatives to synthetic agricultural inputs

PitchBook is a Morningstar company providing the most comprehensive, most accurate, and hard-to-find data for professionals doing business in the private markets.

Overview

The agricultural industry is undergoing a transformative shift toward sustainable and environmentally friendly farming practices. One of the key facilitators of this change is the adoption of agricultural biologicals—a category of products derived from natural sources that enhance crop productivity, optimize soil health, and reduce the reliance on traditional chemical inputs. Despite an overall tepid macroeconomic environment and a pullback in VC activity, demand for biologicals has remained robust. We estimate this industry will generate close to \$15 billion in revenue in 2023, with a total VC investment of nearly \$1 billion.

Agricultural biologicals encompass a diverse range of products, including biopesticides, biofertilizers, and biostimulants, among others. Unlike conventional chemical agricultural inputs, biologicals leverage the power of living organisms such as bacteria, fungi, and plant extracts to promote plant growth and protect crops from pests and diseases. This category has experienced rapid growth in new company formation and venture funding. Despite market volatility affecting funding in other industries, strong industry drivers have kept VC funding for biologicals robust. This report provides a comprehensive overview of agricultural biologicals, examining their benefits, challenges, venture activity, and role in shaping the future of sustainable agriculture.

Key categories of agricultural biologicals

Biofertilizers: These products contain beneficial microorganisms (such as bacteria, fungi, or algae) or their byproducts that enhance nutrient availability to plants, promoting healthier root systems and increased nutrient uptake. They work by establishing symbiotic or associative relationships with plants. For example, nitrogen-fixing bacteria in biofertilizers convert atmospheric nitrogen into forms that plants can use, promoting soil fertility. Biofertilizers contribute to improved soil fertility and long-term sustainability. Key VC-backed providers include Pivot Bio, Loam, Kula Bio, and Nutrition Technologies.

Biostimulants: Comprising substances such as seaweed extracts and humic acids,¹ biostimulants stimulate natural processes to enhance plant growth, development, and resilience to stress factors. They act as catalysts for physiological processes, resulting in increased crop yields and quality. Unlike biofertilizers, biostimulants may not contain live microorganisms. Instead, they often consist of compounds such as amino acids, seaweed extracts, humic substances, and other organic materials that activate physiological processes in plants. Key VC-backed providers include Indigo, Sound, Apha.Bio, and NewLeaf Symbiotics.

Inoculants: Inoculants, specifically microbial inoculants, are products that contain beneficial microorganisms, such as bacteria, fungi, or other microbes, and are applied to soil or plant surfaces to establish symbiotic or beneficial relationships that enhance plant growth, nutrient availability, and overall crop productivity. The microorganisms in inoculants interact with plants in ways that enhance nutrient availability, protect against pathogens, or promote overall plant health. Examples include nitrogen-fixing bacteria, mycorrhizal fungi, and plant-growth-promoting bacteria. Key VC-backed providers include Groundwork BioAg, AlgaEnergy, and Ficosterra.

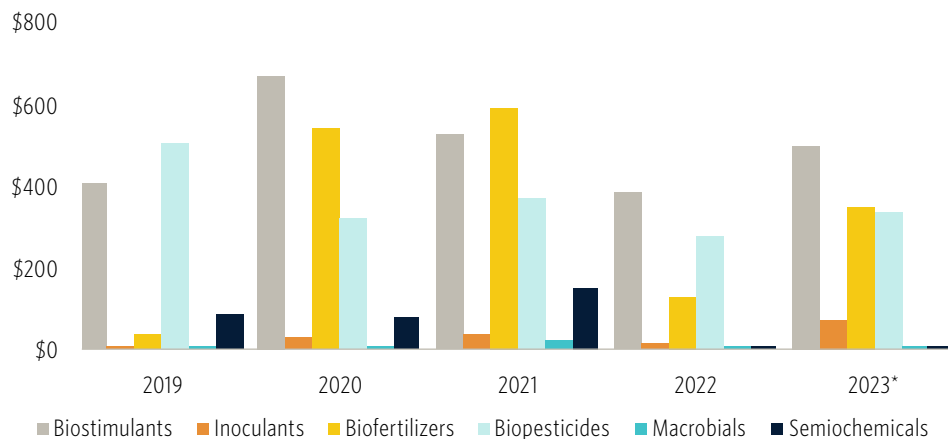
Biopesticides: These are naturally occurring substances, such as microbes or plant extracts, that control pests and diseases. Biopesticides can include microbial pesticides (for example, bacteria and fungi), plant-based pesticides, and biochemical pesticides (pheromones, for example). Unlike chemical pesticides, biopesticides offer targeted solutions with minimal impact on nontarget organisms and the environment. Key VC-backed providers include AgBiome, Vestaron, Enko, and Invaio.

Macrobials: Macrobials generally refer to large organisms used in agriculture for pest control. This category includes macroscopic organisms such as insects, mites, nematodes, and predatory or parasitic organisms. Macrobials are employed as biological control agents to manage pests. For example, predatory insects such as ladybugs or parasitic nematodes may be introduced to control pest populations in a targeted and environmentally friendly manner. Other examples include ladybugs for aphid control, predatory mites for spider mite control, and entomopathogenic nematodes for controlling soil-dwelling pests. Key VC-backed providers include Ubees, Beeflow, and BigSis.

Semiochemicals: Semiochemicals are chemical substances that convey information between organisms. In agriculture, they are often signaling chemicals used for communication between plants, insects, and other organisms. Semiochemicals can act as attractants, repellents, or disruptants in the behavior of pests or beneficial organisms. They play a role in chemical communication within ecosystems. Examples include pheromones released by insects to attract mates, plant volatiles that attract pollinators, and repellents used to deter pests. Key VC-backed providers include Provivi, Pherobio Technologies, and AgroSustain.

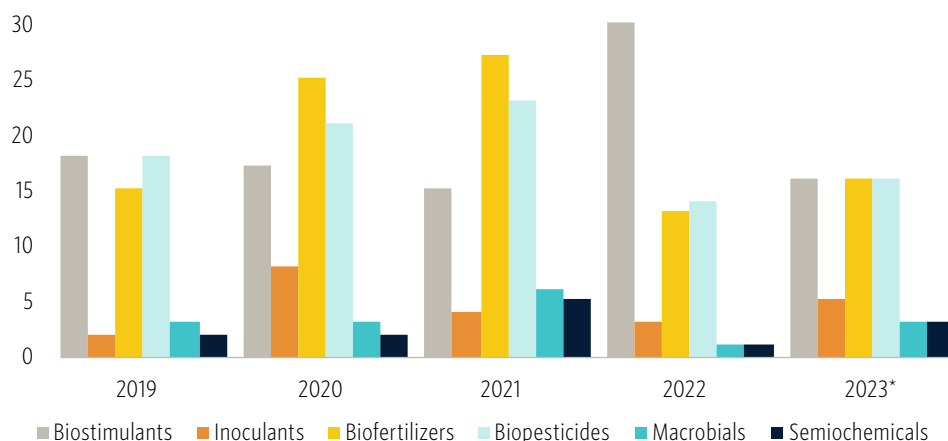
¹: Humic acid is an organic molecule that improves soil structure, water retention, and nutrient uptake by plants. It is derived from coal, lignite, soils, and other organic materials.

Agricultural biologicals VC deal value (\$M) by segment



Source: PitchBook • Geography: Global • *As of December 22, 2023

Agricultural biologicals VC deal count by segment



Source: PitchBook • Geography: Global • *As of December 22, 2023

Benefits and challenges

Agricultural biologicals contribute to environmental sustainability by reducing chemical residues, promoting soil and water conservation, and fostering overall ecosystem health. Biofertilizers enhance soil health by encouraging beneficial microorganisms, improving nutrient cycling, and increasing organic matter content. Adopting biopesticides and biofertilizers reduces reliance on synthetic chemicals, supports integrated pest management, and aligns with sustainable agriculture principles.

Biostimulants play a crucial role in plant growth promotion, optimizing physiological processes as well as enhancing crop yields and quality. Biopesticides also contribute to resistance management by offering a different mode of action compared to conventional chemical pesticides. The introduction of agricultural biologicals supports microbial diversity in the soil, contributing to a healthy and balanced soil microbiome. Moreover, the compatibility of many biologicals with organic farming practices makes them valuable tools for organic farmers.

However, these benefits are accompanied by several challenges. The efficacy of agricultural biologicals can vary, influenced by factors such as environmental conditions, application methods, and compatibility with other inputs. Some biologicals may have limited persistence in the environment, necessitating more frequent applications compared to their synthetic counterparts. The development and commercialization of agricultural biologicals involve research & development costs, posing financial challenges for startups and companies. A 2021 pulse poll of farmers indicated that 21% of respondents knew nothing about biologicals, and another 41% needed to learn more about them before using them on their farms.² Awareness and education among farmers about the benefits and proper use of these biologicals are crucial for their successful adoption.

Storage and shelf-life considerations can present logistical challenges, especially for microbial inoculants with specific requirements. Regulatory approval processes for agricultural biologicals are complex and time-consuming, posing hurdles for market entry. Challenges related to resistance and adaptation of pests and diseases to biopesticides require ongoing research efforts. Achieving market acceptance and widespread adoption of agricultural biologicals may necessitate overcoming skepticism and traditional farming practices. Addressing these challenges involves collaborative efforts among researchers, industry stakeholders, and regulatory bodies, with advancements in technology and better understanding of microbial interactions expected to enhance the benefits of agricultural biologicals over time.

Market

The global agricultural biologicals market is expected to generate \$14.6 billion in 2023, growing to \$27.9 billion by 2028, representing a 13.8% CAGR,³ excluding any structural market disruptions. Environmental concerns, mounting interest in improving soil and overall farm health, technological innovations, and a pursuit of sustainable yield improvement enable this growth. Geopolitical conflicts, such as the ongoing war in Ukraine, can cause supply chain disruptions and result in resource scarcity. This scarcity can affect the accessibility and affordability of conventional agricultural inputs such as synthetic fertilizer. As a result, the adoption of novel alternatives such as biofertilizers may be accelerated.

However, the growing demand for agricultural biologicals is not expected to cannibalize demand for conventional inputs. In fact, demand for conventional inputs is expected to outpace biologicals for the foreseeable future. Due to the challenges of adopting biologicals, experts now largely view them less as a replacement for chemical inputs and more as a new tool in a toolbox of solutions. The consensus among experts at the 2023 Salinas Biological Summit—the largest conference on agricultural biologicals—pointed to the need for an “integrated approach” using various chemical and biological products in tandem to boost or maintain yields while improving farm health.⁴

The crop protection market is dominated by the “big four” agrochemical companies: Bayer, BASF, Corteva, and Chem-China. These companies have gained exposure to

2: “Farmers Want Proof of Concept Before Trying Biologicals,” *Agweb*, Sonja Begemann, January 11, 2021.

3: “Agricultural Biologicals Market,” *Markets and Markets*, July 2023.

4: “Biologicals Won’t Replace Chemical Crop Inputs Anytime Soon: Here’s Why,” *Agfunder News*, Jennifer Marston, June 27, 2023.

biologicals through acquisitions and in-house development. Some of the largest acquisitions include ChemChina's acquisition of Syngenta, Corteva's acquisition of Stoller Group and Symborg Corporate, and BASF's acquisition of Micro Flo Company. These companies also gain exposure through corporate venture activity. Some of the most well-funded biological startups with corporate venture capital (CVC) funding include Pivot Bio, AgBiome, and Provivi.

While the big four continue to dominate, VC-backed startups have raised significant capital and introduced new products to market. Indigo has launched a portfolio of biostimulants for corn, soy, wheat, and cotton products. Pivot Bio has its own portfolio of corn, wheat, and sorghum biofertilizers, and Agbiome recently launched two biofungicide products.

The majority of biological companies—64 out of our list of 764—are based in the US, followed by Canada (37), Spain (36) and India (35). As a region, Europe has produced 169 startups, while Asia has produced 60.

Macro drivers

The adoption of agricultural biologicals is influenced by macroeconomic drivers that reflect broader economic trends and priorities within the agriculture sector. Some key macroeconomic drivers influencing the adoption of agricultural biologicals include:

- Sustainability and environmental concerns:
 - Increasing awareness of environmental sustainability and a desire to reduce the ecological footprint of agriculture are driving increased interest in biologicals. Agricultural producers respond to market signals, recognizing the importance of aligning their practices with consumer preferences for environmentally friendly and responsibly sourced goods.
 - Sustainable practices, including the use of biologicals, align with consumer preferences and regulatory initiatives focused on environmental conservation.
 - Soil carbon projects and carbon credits incentivize agricultural producers to adopt biologicals and other sustainable practices.
- Global population growth:
 - The growing global population, expected to reach 9.7 billion by 2050,⁵ necessitates increased food production, prompting the adoption of technologies that enhance crop yield and quality.
 - Agricultural biologicals contribute to sustainable intensification—an agricultural approach that increases food production while minimizing environmental impact. For example, using biological methods to improve soil health and fertility can improve crop health and yields.

⁵: "Population," United Nations, n.d., accessed December 21, 2023.

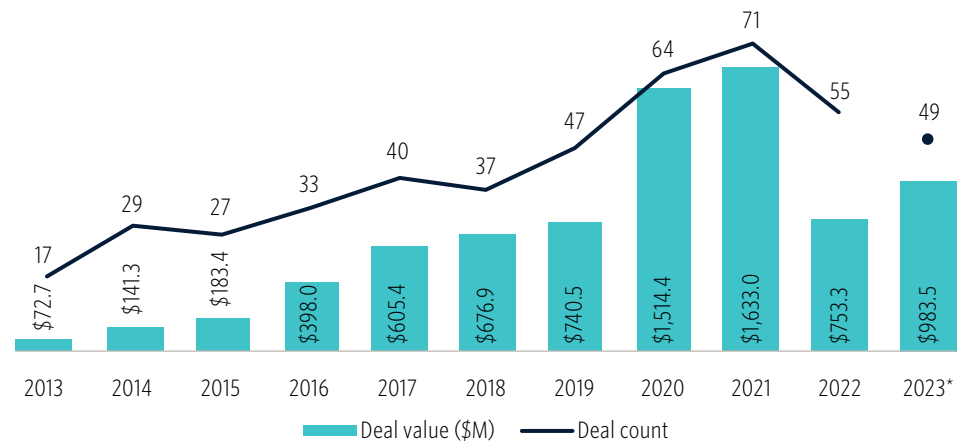
- Government support and regulations:
 - Supportive regulatory frameworks that encourage sustainable agricultural practices, including the use of biologicals, play a crucial role in adoption.
 - Governments promoting reduced reliance on synthetic chemicals and endorsing eco-friendly alternatives create an environment conducive to the adoption of agricultural biologicals. The US Department of Agriculture's Natural Resources Conservation Service offers conservation programs that educate and encourage the adoption of biologicals.
 - Government policies, subsidies, and incentives that promote sustainable agriculture and the adoption of biologicals encourage farmers to incorporate these practices.
- Technological advancements:
 - Advances in biotechnology, microbiology, and precision agriculture contribute to the development of more effective and targeted agricultural biological products.
- Climate change resilience:
 - Concerns about the impact of climate change on agriculture drive the adoption of practices that enhance resilience.
 - Agricultural biologicals, which can contribute to improved soil health and plant stress tolerance, are seen as tools for building climate-resilient farming systems.
- Economic viability:
 - The economic feasibility of adopting agricultural biologicals, considering factors such as input costs, yield improvements, and overall farm profitability, influences adoption decisions.
 - Farmers evaluate the return on investment and cost-effectiveness of incorporating biologicals into their farming practices.
- Geopolitical events and disruptions in supply chains
 - Geopolitical events and conflicts can disrupt traditional supply chains for agricultural inputs, including synthetic fertilizers. This disruption may prompt farmers to explore alternative and locally available inputs, such as biofertilizers.

These macroeconomic drivers collectively influence the decision-making process for farmers and agricultural stakeholders, shaping the adoption landscape for agricultural biologicals within the broader context of global agriculture.

VC activity

The agricultural biologicals sector has gained investor attention due to the increasing demand for sustainable and environmentally friendly agricultural practices. 2023 YTD deal values exceeded the total deal values for 2022, bucking the current trend of VC slowdown. We logged \$983.5 million invested across 49 deals in 2023, with deal values up 30.6% versus the 2022 annual total.

Agricultural biologicals VC deal activity



Source: PitchBook • Geography: Global • *As of December 22, 2023

The biostimulant category attracted the most venture capital, with \$497.7 million invested across 16 deals in 2023. The largest biostimulant deal of 2023 was a \$250.0 million late-stage investment in scale-up Indigo. Although Indigo's first product was a biostimulant, it has since expanded to new products and services, including an integrated carbon credit and carbon farming program and a digital sustainability program. The second-largest deal was a \$77.8 million late-stage round attributed to Elemental Enzymes, a crop nutrient developer that produces various plant nutrient products using naturally occurring enzymes and biochemistries.

Lagging categories include inoculants and semiochemicals. While products in these categories benefit soil and plant health, lack of awareness and education among farmers and the learning curves to handle and store these products have challenged adoption. Scale-up Loam Bio is a key provider of inoculants and has raised \$109.7 million. It provides a microbial soil inoculant product to improve soil health as well as soil carbon projects that compensate farmers for the carbon sequestration benefits of its products.

Valuations increased for three straight years through 2022 as enthusiasm for the space grew. However, market volatility and a challenging exit environment reversed the trend across all venture stages in 2023, with overall median pre-money valuations down 44.5% to \$16.0 million YoY. The most significant decline in valuations is at the venture-growth stage, where a lack of funding opportunities and exit options have compressed valuations by 85.1% to \$44.6 million YoY.

Median deal sizes paint a very different picture, with overall deal sizes up 71.8% to \$10.0 million YoY. Deal sizes increased at every stage, barring pre-seed & seed, which declined 70.6% to \$1.0 million YoY. We attribute the growth in deal sizes to VCs taking a more conservative approach by writing fewer but larger checks, with a focus on portfolio companies or new companies with the greatest chance of success.

Key VC-backed agricultural biologicals companies*

Company	HQ location	Category	Most recent financing	VC (\$M) raised to date	Most recent post-money valuation (\$M)	Most recent deal type
Pivot Bio	Berkeley, US	Biofertilizers	October 13, 2023	\$622.0	\$1,700.0	Late-stage VC
Ynsect	Évry, France	Biofertilizers	December 11, 2023	\$583.4	\$747.5	Series D
AgBiome	Durham, US	Biopesticides	November 14, 2023	\$236.2	N/A	Series D
Vestaron	Durham, US	Biopesticides	March 30, 2023	\$199.3	\$362.0	Series C
Provivi	Santa Monica, US	Semiochemicals	June 12, 2023	\$192.2	\$420.0	Series C2
SemiosBio Technologies	Vancouver, Canada	Semiochemicals	September 4, 2023	\$180.5	\$789.6	Late-stage VC
Sound Agriculture	Emeryville, US	Biostimulants	December 14, 2023	\$170.4	\$375.0	Series D
Enko	Mystic, US	Biopesticides	August 24, 2023	\$151.0	\$330.0	Series C
Invaio	Cambridge, US	Biopesticides	June 20, 2023	\$150.9	\$144.0	Series C
Aphea.Bio	Ghent, Belgium	Biostimulants, biopesticides	July 11, 2023	\$123.9	\$34.8	Series C

Source: PitchBook • Geography: Global • *As of December 22, 2023

Exits

While the agricultural biologicals sector has experienced rapid growth, it is still nascent. VC-backed exit activity remains limited, and upward growth was stunted in 2023 due to broader market challenges. We logged five VC-backed exits in 2022 and four exits in 2023 as of December 21. Analyzing all-time exit activity, companies producing biostimulants and biopesticides were the most likely to exit, with 19 exits logged, or 70.4% of exits. M&A is the most common form of exit, accounting for 37.0% of all exits. We logged seven IPOs and three reverse mergers, making public listing an equally likely exit path. Two of the most notable biological companies include Ginkgo Bioworks and GreenLight Biosciences. Both companies exited via reverse merger.

Agricultural biologicals VC exit activity



Source: PitchBook • Geography: Global • *As of December 22, 2023

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