Biological Seed Treatments on Soybeans

SCIENCE FOR SUCCESS

Science for Success evaluated biostimulant seed treatments in over 100 different growing environments across 22 states. **Across 100 growing environments in 22 states, there was no product that consistently improved soybean yield compared to the non-treated control.**

What is a biostimulant?

In 2018, United States legislators introduced the first legal definition for the term *plant biosimulan*t, defining it as "a substance or microorganism [*biological*] that, when applied to seeds, plants, or the rhizosphere, stimulates natural processes to enhance or benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, or crop quality and yield."[1] Biostimulant seed treatment products may include one or multiple types of microbes (living microscopic organisms). Some commonly used microbes include *Azospirillum*, *Bacillus, Pseudomonas, Bradyrhizobium,* and *Trichoderma*, which have proposed benefits of enhancing early growth, vigor, and root mass, improved plant nutrient uptake and nitrogen fixation, and increased yield.

Table 1. Commercially available biostimulant seed treatment products evaluated in 2022 and 2023.

Product Number	Year Tested	Active Ingredient	Marketed Benefits According to Company
1	Both	***Azospirillum brasilense, Bacillus licheniformis, Bacillus amyloliquefaciens, Bacillus subtillis, Pseudomonas fluorescens, Rhizobium***	Enhance early growth, vigor, and root mass
2	2022	***Trichoderma virens***	No information provided
2	2023	***Kosakonia cowaii***	Suppress seedling diseases
3	Both	***Bradyrhizobium japonicum***	Enhance nitrogen fixation and improve grain yield
4	2022	***Bacillus subtillis, Bacillus amyloliquefaciens, Bradyrhizobium japonicum***	Protection against fungal root diseases, enhance nitrogen fixation, and improve grain yield
4	2023	***Bacillus subtillis, Bradyrhizobium japonicum***	Improve plant nutrient uptake, plant growth and resilience, and grain yield
5	2023	***Bacillus amyloliquefaciens***	Protection against plant parasitic nematodes
6	2023	***Methylobacterium hispanicum***	Enhance root area, root depth, and root tips, increase nutrient uptake and plant efficiency, and increase yield
7	Both	***Bradyrhizobium elkanii, Delftia acidovorans, Bacillus velezensis***	Increase crop establishment, improve root vigor and plant growth, solubilize phosphorus from organic and inorganic reservoirs, and increase grain yield
8	Both	***Bacillus velezensis***	Increase crop establishment, improve root vigor and plant growth, solubilize phosphorus from organic and inorganic reservoirs, and increase grain yield
9	Both	***Glomus intraradices, Glomus mosseae, Glomus aggregatum, Glomus etunicatum***	Improve plant vigor, enhance water and nutrient absorption, enhance phosphorus uptake

[1] *Agricultural Improvement Act, Sec. 10111 (2018). https://www.congress.gov/115/bills/hr2/BILLS-115hr2enr.pdf*

Why study biostimulant seed treatments?

Although there are benefits associated with biostimulant seed treatments, most of the published efficacy research was conducted in a laboratory or greenhouse environment, and previous field studies were regional in scope.

In 2022 and 2023, the Science for Success team worked together to evaluate several commercially available biostimulant seed treatments in field settings in over 100 environments across 22 states (Figure 1). The full treatment list is shown in Table 1.

Research Goal: Evaluate the effectiveness of commercially available products over a large set of growing environments and field settings

Biostimulant seed treatments were applied to soybean seed previously treated with a commercially available fungicide and insecticide seed treatment. Great care was taken to ensure all biostimulant seed treatments were compatible with fungicide and insecticide treatments and product handling and application guidelines were followed according to each company's instructions. Biostimulant seed treatment products were compared to a non-treated control (soybean seed treated with fungicide and insecticide only).

Research Findings: The biostimulant seed treatments did not influence soybean yield. Among the tested biostimulant seed treatments, none of the products consistently improved soybean yield compared to the non-treated control (Figure 2).

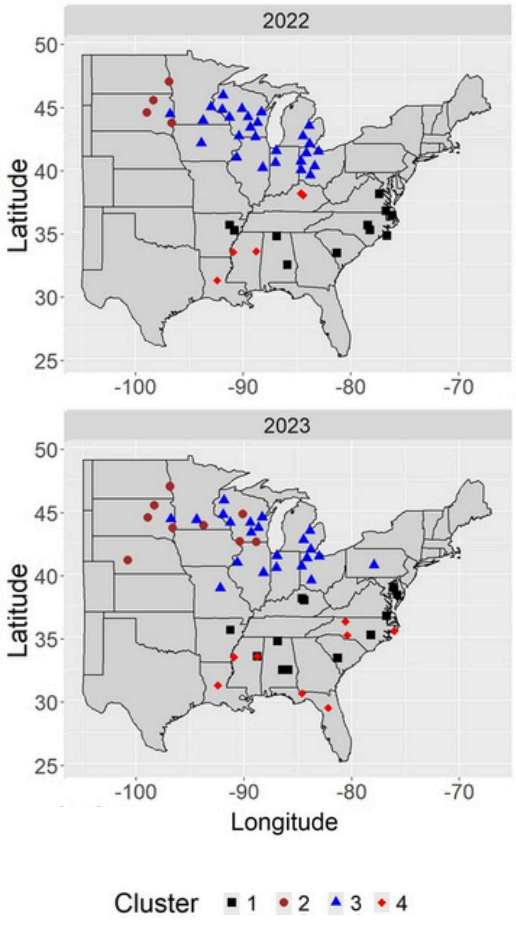


***Figure 1. Locations where biostimulant seed treatments were evaluated in 2022 and 2023**. Locations were grouped into similar growing environments, or clusters, based on a similar set of soil properties (soil pH, cation exchange capacity, organic matter, phosphorus, and potassium) and weather (30-year normal precipitation and temperature).*

Why was there a lack of yield response?

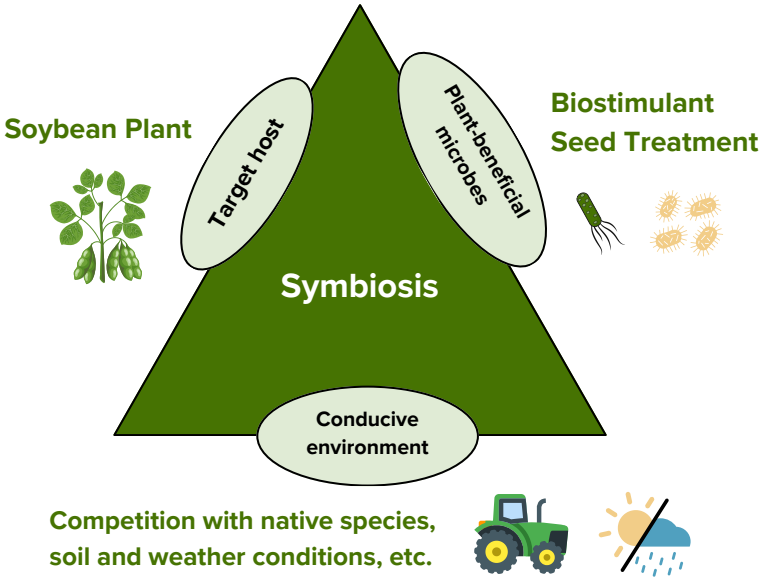
We have a few hypotheses about why biostimulant seed treatments had no positive yield response:

1 Conditions may not have been adequate for a successful symbiotic relationship between the microbe and soybean plant.

For a symbiotic relationship to occur, three conditions must be present at the same time: soybean plant, plant-beneficial microbe, and a conducive environment (Figure 3). If all of these factors don't exist at the same time, there will not be a symbiotic relationship between the microbe and plant.

Symbiosis Triangle

Figure 3. For a symbiotic relationship to occur, three conditions must be met, including the soybean plant, plant-beneficial microbe, and conducive environment.



2 The microbe may not have been alive.

In the case of biostimulant seed treatments, not only does the microbe need to be present, but it also needs to be applied on the seed at a high concentration and be alive.

3 The microbe may not have been able to outcompete the native microbial population in the soil.

One teaspoon of soil may contain 1 billion individual microscopic cells. *This is three times the number of people in the entire United States!* Microbes introduced as part of a seed treatment need to outcompete and survive among the native populations of microbes within the soil.

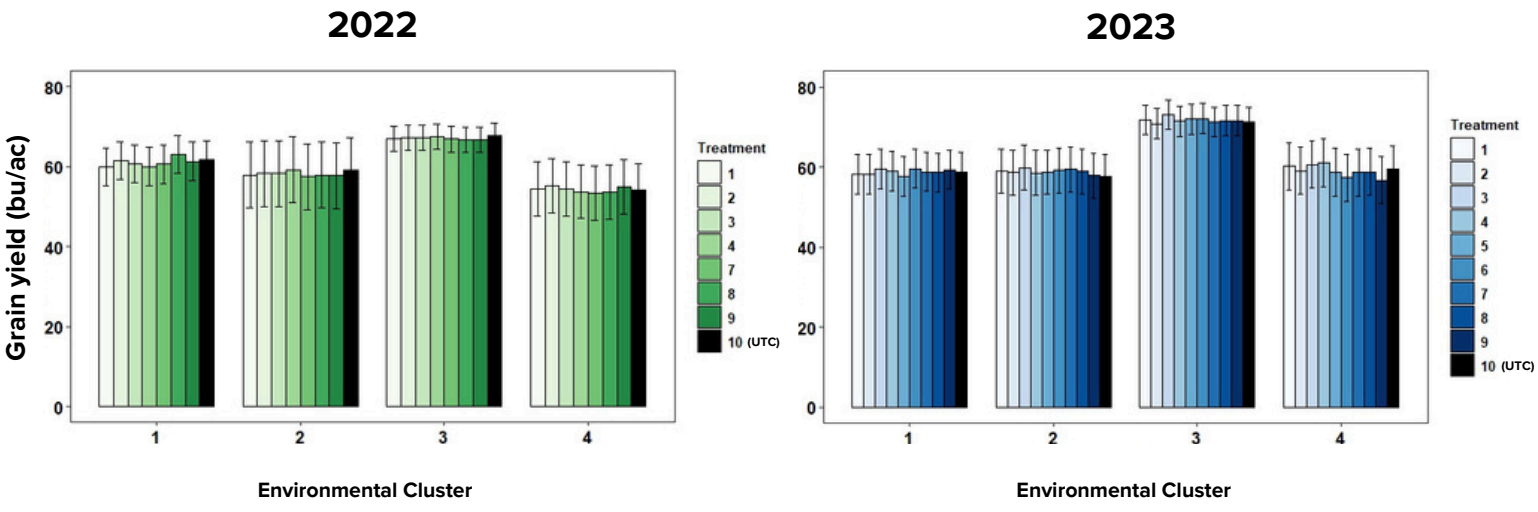


Figure 2. *Average soybean grain yield for each biostimulant seed treatment for each environmental cluster in 2022 and 2023 compared to the untreated control (UTC).*

⚠ Key Reminders

- Although our research showed that no product consistently improved soybean yield, there are many products available on the market, and **we were only able to test a subset** of the commercially available products.

- Companies are investing significant resources in new products and new application methods. If a farmer chooses to use a biostimulant seed treatment, it is extremely important they **follow handling and application guidelines** provided by the company.

- If possible, farmers should work with their university Extension system to **test products on-farm.**

Science for Success is funded by the United Soybean Board through the checkoff program. Additional funding for this research came from the USDA NIFA Agriculture and Food Research Initiative, 2023-6701339818.

Authors

Laura Lindsey & Fabiano Colet, **The Ohio State University**. *February 2025.*

Additional Authors

Eros Francisco
Auburn University

Shaun Casteel
Purdue University

David Moseley
Louisiana State University

Trent Irby &
Michael Mulvaney
Mississippi State University

Hans Kandel
North Dakota State University

Jeremy Ross
University of Arkansas

Mark Licht
Iowa State University

Nicole Fiorellino
University of Maryland

Andre Borja Reis
University of Missouri

Daniela Carrijo
Penn State University

Michael Plumblee
Clemson University

Emma Matcham
University of Florida

Chad D. Lee
University of Kentucky

Maninder Singh
Michigan State University

Nicolas Cafaro La Menza
University of Nebraska-Lincoln

Jonathan Kleinjan
South Dakota State University

Emerson Nafziger &
Giovani P. Fontes
University of Illinois Urbana-Champaign

Seth Naeve
University of Minnesota

Rachel Vann
North Carolina State University

David Holshouser
Virginia Tech

Shawn Conley &
Spyros Mourtzinis
University of Wisconsin—Madison