When, How, and Where Can Biological Products Improve Soybean Productivity?

Ava M. Isaacs, Connor N. Sible, and Frederick E. Below

Crop Physiology Laboratory, Department of Crop Sciences, University of Illinois Urbana-Champaign

Objective: ***To determine the influence of biological product applications on soybean growth and yield, and to assess if soybean responses to biologicals are management or environment specific.***

Introduction:

- Maximum soybean yield potential is yet to be realized, and biological products may present a potential tool in optimizing soybean productivity and maximizing farmer profitability.
- Biological products have become a prominent sector of the agriculture industry, claiming to enhance nutrient use, relieve plant stress, and/or improve soil health. However, little is known about where, how, and when to best use them for the greatest impact on yield.

Research Approach:

Five unique biological categories, each represented by two different products (Table 1), were tested using two genetically diverse, high-yielding, soybean varieties (AG38XF3 and GH3765XF) under two different management systems (Table 2). This experiment was conducted at three different sites in Illinois, each with unique soil and climate conditions. These include Nashville (South), Champaign (East Central), and Yorkville (North), IL.

Table 1. Biological product categories with product main active ingredients.

Biological Category	Active Ingredient
Bradyrhizobium	*Bradyrhizobium elkanii* + *Delftia acidovorans* *Bradyrhizobium japonicum*
Bacillus spp.	*B. licheniformis* + *B. subtillis* + *B. methylotrophicus* *B. Subtillis* + *B. licheniformos* + *Psuedomonas putida*
Arbuscular Mycorrhizal Fungi (AMF)	*Glomus intraradices* + *G. masseae* + *Glomus* spp. *Glomus intraradices* + *G. masseae* + *Rhizopogon* spp.
Bacterial Endophytes	*Gluconacetobacter diazotrophicus* *Methylobacterium symbioticum*
Non-Traditional	*Penicillium bilaiae* *Clostridium pasterianum* + *Azotobacter vinelandii*

Table 2. Agronomic management systems used to test biologicals in 2025.

Management System	Preplant Fertility	Foliar Protection
Standard	None	None
Progressive	19.6 kg/ha 22.4 kg/ha	Fungicide and Insecticide at R3

Design:

A pairwise field design was utilized to limit in-field variability, and the difference between the treated plot and its paired control was utilized as the response variable. The experimental plots were arranged using a split-split block design, where the main plot was biological product, the sub-plot was variety, and the sub-sub plot was management (Figure 1). All treatments were replicated six times using the ten distinct biological products.

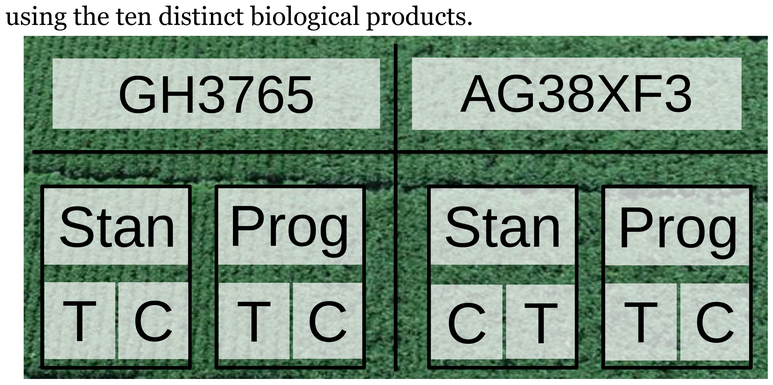

Figure 1. Pair-wise design to evaluate biological products under two varieties and two levels of agronomic management.

Results:

Table 3. Variety and management interaction effects on soybean grain yield at three Illinois locations in 2025. Yields are presented in kilograms per hectare at 0% moisture. Capital letters indicate significant differences due to management within a location.

Location	Variety	Management	
		Standard	Progressive
		---- kilograms per hectare ----	
South	GH3765XF	2071	2200
	AG38XF3	1989	2094
	Management Avg.	2030^{B}	2147^{A}
East Central	GH3765XF	5288	5388
	AG38XF3	5423	5517
	Management Avg.	5359^{B}	5452^{A}
North	GH3765XF	4382	4393
	AG38XF3	4522	4575
	Management Avg.	4452	4487

- Across the three locations, agronomic management significantly improved grain yields in Southern (+117 kg per hectare) and East Central (+93 kg per hectare), Illinois, but with no measurable effect in Northern Illinois.
- On average, biologicals only consistently induced a positive response for the GH3765XF variety when grown under standard management. Conversely, this variety was negatively responsive to biologicals when managed progressively.
- Across biological categories, *Bradyrhizobium* induced the greatest number of positive yield responses, resulting in a positive yield response in 14 of the 24 comparisons.

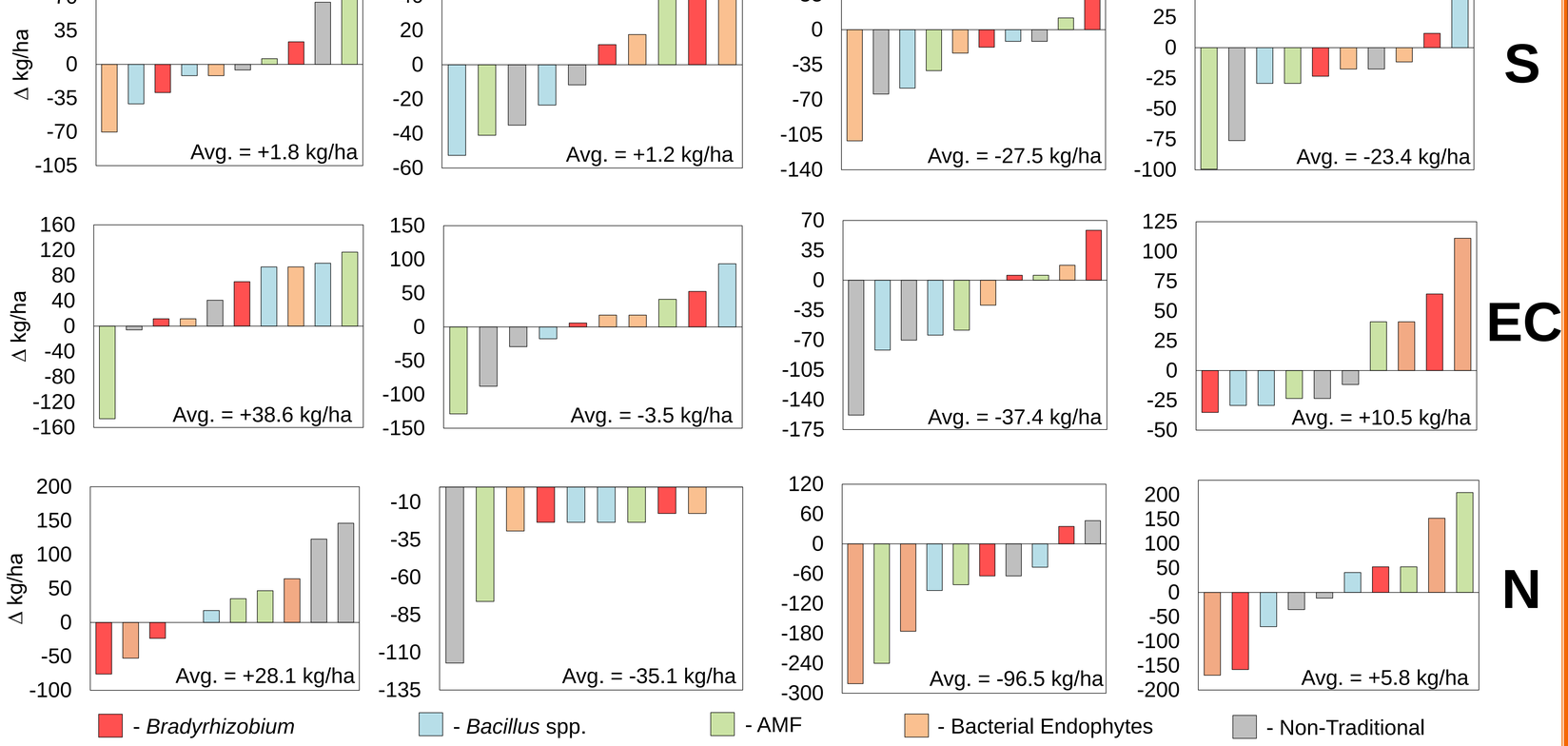

Figure 2. Yield response of 10 biological products applied to two different varieties at the three sites, with standard management shown on the left and progressive management shown on the right. Within these managements, the two varieties are displayed with Golden Harvest on the left and Asgrow on the right. The biological categories outlined in Table 1 are depicted using 5 distinct colors. Delta yield values are presented in kilograms per hectare at 0% moisture.

Conclusions:

- The efficacy of biological products varies across different environments, varieties, and management systems.
- At Champaign, biological treatments resulted in the most substantial positive yield responses, with 22 of the 40 treatment by management by variety comparisons exhibiting a numerical increase in yield compared to the control.
- Overall, biological products averaged +5 kg per hectare in the standard management system, and -28 kg per hectare in the progressive system, indicating that biologicals have a higher chance of success when supplied in low-input soybean systems. These returns, however, were not economical, and while biologicals represent a new and ever evolving agronomic input sector. Additional research is necessary to strengthen confidence in their effectiveness in soybean production systems.

United Soybean Board