

Illinois Biological Testing for Soybean Production

2023 Yield Report

Connor N. Sible and Fred E. Below

Crop Physiology Laboratory

Department of Crop Sciences

University of Illinois at Urbana-Champaign



Crop
Physiology

2023 Biological Testing for Soybean Production Report

We examined different biological products, application methods, and agronomic management systems with the goal of showing which products have the greatest chance of success.

Research Approach

Six different biological products were tested in two different management systems (standard or progressive) with two genetically diverse soybean varieties (GH3762E3 and AG38XF1). This approach allows for a comprehensive evaluation of product performance and can help to decide if, how, and where to use a specific biological product.

How Biological Products were Evaluated

From our previous experience evaluating biological products, we know that a given product may enhance early season growth and the potential yield, but often not the final yield when other in-season factors like nutrient deficiency or leaf disease are present. Thus, biological products were evaluated in both 'standard' and 'progressive' management systems (Table 1)

Table 1. Agronomic management systems used in the evaluation of biological products for soybean at Champaign, IL in 2023.

Management System	Preplant Fertility ¹	Foliar Protection
Standard	None	None
Progressive	17.5 lbs N/acre 20 lbs S/acre	Fungicide and Insecticide at R3

¹Preplant fertility supplied as ammonium sulfate (21-0-0-24S) broadcast with a Gandy drop spreader.

The 'standard' system for soybean includes no upfront fertility with no subsequent in-season management, while the 'progressive' system has at-planting fertility of nitrogen and sulfur along with a fungicide and insecticide application at R3 for foliar protection (Table 1). Pre-plant fertility was provided as ammonium sulfate (21-0-0-24S) and foliar protection (fungicide with insecticide) as Miravis Top (13.7 oz

per acre; Syngenta) with Endigo (4 oz per acre; Syngenta). All plots were seeded to achieve a final plant population of 140,000 plants per acre.

Trial Design

We also know that non-uniformity within fields causes field spatial variability that can mask the yield response to both agronomic management and to the biological product application. Thus, a pair-wise field design was used where every treated plot had an adjacent untreated control, and this allows for an unbiased comparison of biological products and their efficacy under different levels of agronomic management (Figure 1). Experimental plots were arranged in a split-split block design where the main plot was the biological product, the sub-plot was variety, and the sub-sub-plot was the management system. All treatments were replicated six times. Using this design, eight different biological products were evaluated (Table 2).

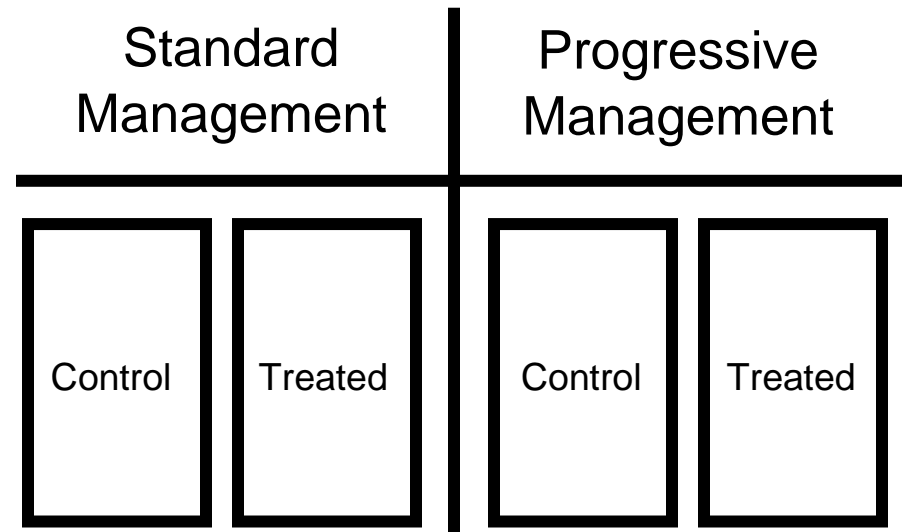


Figure 1. Pair-wise design used to evaluate biological products under different levels of agronomic management and with two different hybrids. Each biological product was evaluated in a similar approach, with twelve main plots randomized across six replications.

Table 2. The six biological products evaluated, including company sponsor, product category, application rate, and application method.

Company Sponsor	Product Name	Biological Category	Application Rate	Application Method ¹
BioHumanetics	Super Nitro	Carbon Stimulant	2 gal / acre	V4 Foliar
BioLevel	PhosN	Microbial Inoculant	2.3 oz / cwt	Seed Treatment
Groundwork BioAg	Rootella L	Arbuscular Mycorrhizal Fungi	6 ml / acre	In-Furrow
Plant Response	BioPath	Microbial Inoculant	16 oz / acre	In-Furrow
Plant Response	BioPath	Microbial Inoculant	16 oz / acre	V4 Foliar
Sanovita	Classic,	Micronutrient,	0.67 lb / acre,	V4 (C, H),
	Flusian,	Hop Extract,	0.7 oz / acre,	R1 (C, F),
	Humin	Humic Extract	2.8 oz / acre	& R3 (C) Foliar

¹In-furrow applications blended with water for total application volume of 12 gallons/acre. Foliar applications were applied with Petrichor surfactant at 4 oz per acre for the BioPath and Super Nitro treatments while Li700 was supplied at 2.4 oz per acre for the Sanovita applications. All foliar applications were blended with water for total application volume of 15 gallons per acre.

Trial Implementation

Replicated blocks of the experimental plots were planted at Champaign, IL (40°3'35"N, 88°14'13"W) on 19 April using a precision plot planter (SeedPro 360, ALMACO). Preplant soil test levels are shown in Table 3. Plots were 36 feet in length and four rows in width, with rows 1 and 4 serving as border and rows 2 and 3 harvested for yield. For weed control, a pre-plant application of Boundary (34 oz per acre; Syngenta) was made on 17 April. In-season weed control in was applied 18 May as FirstRate (0.5 oz per acre; Corteva) and FlexstarGT (3.5 pt per acre; Syngenta) and on 7 June as Zidua (3.25 oz per acre; BASF), Liberty (36 oz per acre; BASF), FusiladeDX (8 oz per acre; Syngenta), and RoundUp Powermax 3 (30 oz per acre; Bayer Crop Science).

Table 3. Preplant soil test levels for trial site at Champaign, IL.

OM	CEC	pH	P	K	Ca	Mg	S	Zn
%	Meq/100g				ppm			
4.1	20.9	6.5	38	139	2832	528	12	2

Soil samples were taken from each replication at the 0-6 inch depth before planting and extracted using Mehlich III. Presented values are the average of the six replications.

Biological Product Applications

The unique pairwise design allows for unbiased comparisons among biological products that are applied as a seed treatment, in-furrow, or foliar spray. Seed treatments were treated 19 April and in-furrow applications were mixed within an hour of application on date of planting. Early vegetative growth stage (V4) foliar applications were supplied on 3 June. The reproductive foliar (R1) applications of individual biologicals were supplied on 30 June and the R3 applications along with the foliar protection of the progressive management plots were applied on 30 July.

Application Methods

Seed treatments were blended with water for a total application of 6 oz per cwt using a Hege11 seed treater (Wintersteiger). Both in-furrow biological entries were blended with water for a total application volume of 12 gallons per acre and supplied using a planter-attached liquid application system (SureFire Ag Systems). Foliar applications were balanced with water for a total application volume of 15 gallons per acre and supplied using a pressurized CO₂ backpack sprayer.

Growing conditions

The growing season started dry with below-average precipitation for April, resulting in well aerated soils and early planting for the county (Table 4). The months of May, June, and July all ended with below-normal precipitation (3.1, 1.9, and 1.5 inches below average, respectively), resulting in a moderate drought during the vegetative and early reproductive growth stages. However, the month of August received adequate rainfall during seed fill, resulting in extended plant health and a final trial average yield of 86 bushels per acre.

Table 4. Temperature and precipitation data for trial site at Champaign, IL in 2023.

Month	Precipitation		Temperature	
	2023	Average ¹	2023	Average ¹
	inches		°F	
April	1.5	4.0	53	53
May	1.9	5.0	66	63
June	1.8	4.7	72	72
July	2.9	4.4	76	75
August	3.8	3.5	73	74
September	3.1	3.3	70	67
Total	13.7	24.9	NA	NA

¹Refers to the average climate data from Champaign IL from 1989-2020. Data obtained from the Illinois State Water Survey.

Data Collection, Analysis, and Interpretation

At maturity, plots were harvested with a two-row plot combine and grain yield is reported as bushels per acre at 13% moisture (Tables 5 and 6). The experimental design was a split-split plot arrangement in six randomized complete blocks. Statistical analysis was performed using a linear mixed model approach with PROC MIXED in SAS (version 9.4; SAS Institute, Cary, NC) and means between treatments were separated using Fisher's protected LSD test at the 0.10 level of significance. Paired T-tests were conducted to evaluate an individual product's yield response to the respective untreated controls.

Soybean Response to Management was limited in 2023

The response to agronomic management was minimal, with only a 0.6 bushel per acre response when averaged across the two varieties (Table 5). Multiple university studies and farmer testimonials highlight the value of early planted soybean (three to four weeks ahead of normal) to improve field average yields when compared to previous years and later plantings. In 2023, only 15% of Illinois soybean acres had been planted by 23 April (USDA-NASS), placing this study among early planted acres. As a result, the trial average yield of 86 bushels per acre was well above regional yield averages reported in previous years. In a dry year with little sulfate leaching and limited disease pressure, along with improved yield potential due to early planting, there was less need for management to maximize grain yields in 2023.

Response to Biologicals was Variety and Management Dependent

Yield responses to biologicals varied with both positive and negative responses observed between the treated plots and their respective paired controls. The GH3762E3 variety resulted in a positive yield response in seven of the twelve comparisons while the AG38XF1 only responded positively to applications in three of the twelve comparisons (Table 6).

Two of the positive responses for AG38XF1 variety were with the in-furrow application of BioPath or the seed treatment application of PhosN to the standard management system, resulting in a 3.2 or 2.0 bushel response, respectively. Each of these products were placed in the root zone and contain *Bacillus spp.* bacteria that enhance soil nutrient availability, in particular phosphorus, which can be a limiting nutrient for high-yielding soybean during grain fill. The PhosN seed treatment also significantly improved the yield of the GH3762E3 variety under standard management by 5 bushels, providing a consistent response across varieties for low-input systems. Conversely, these applications resulted in negative responses for both varieties under progressive management where supplied nitrogen and sulfur fertility may have stimulated native microbial release of soil phosphorus, negating the effect of the biologicals.

Foliar supplied biologicals were most responsive when applied to the GH3762E3 variety with progressive management, where the Super Nitro, BioPath, and Herbagreen products numerically improved yields by 3.2, 3.7, and 3.0 bushels, respectively. These applications were less responsive with the standard management for this variety with responses of 0.7, -1.0, or 2.3 bushels, respectively, and induced negative responses when supplied to the AG38XF1 variety in five of the six comparisons.

Conclusions

This study shows that early planted soybean can result in a high yield potential, and with an extended growing season the response to additional management factors of fertility, foliar protection, or biologicals was limited. The findings here highlight the impact that variety and management system can have on soybean response to other agronomic inputs like biologicals, and that the addition of a given product type and/or application method must take into consideration other agronomic practices being utilized on the farm.

Table 5. Management and variety interaction effects on soybean grain yield at Champaign, Illinois in 2023. Yields are presented as bushels per acre and standardized to 13% moisture.

Variety	Management Yields (bushels per acre) ¹		Variety Average
	Standard	Progressive	
GH3762E3	84.1	84.5	84.3 ^B
AG38XF1	87.6	88.5	88.0 ^A
Management Average	85.9	86.5	

¹Management yields are the average of n=36 observations. LSD ($P \leq 0.10$): Variety (V), 2.3; Management (M), NS; V × M, NS.

Table 6. Biological product effects on soybean grain yield at Champaign, Illinois in 2023. Individual biological responses are the change in yield compared to the adjacent management control for a given variety.

Company Sponsor	Biological Product	Application Method	Biological Yield Response (difference from untreated, bushels per acre) ¹				
			GH3762E3		AG38XF1		Average
			Standard	Progressive	Standard	Progressive	
BioHumanetics	Super Nitro	V4 Foliar	+ 0.7	+ 3.2	- 1.7	- 0.9	+ 0.3
BioLevel	PhosN	Seed Treatment	+ 5.0*	- 3.2	+ 2.0*	- 0.3	+ 0.9
Groundwork BioAg	Rootella L	In-Furrow	- 0.1	+ 2.2	- 4.0	- 1.9	- 1.0
Plant Response	BioPath	In-Furrow	- 2.6	- 0.4	+ 3.2	- 1.0	- 0.2
Plant Response	BioPath	V4 Foliar	- 1.0	+ 3.7	- 3.5	+ 1.0	+ 0.1
Sanovita	Classic, Flusian, Humin	V4 (C, H), R1 (C, F), & R3 (C) Foliar	+ 2.3	+ 3.0	- 0.7	- 1.2	+ 0.9
LSD ($P \leq 0.10$)			NS	NS	5.9	NS	NS
P > F			0.1287	0.2099	0.0856	0.9207	0.7968

¹Biological responses are the average of n=6 observations and presented as the change in yield from an adjacent untreated control within the respective management and variety combination.

*Product response is significantly different from paired control plot using a paired T-Test at alpha=0.1.