Illinois Biological Testing for Soybean Production

2022 Yield Report

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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

Eight different biological treatments 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 2022.

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

[1]Fertility 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 as Miravis Top (13.7 oz per acre; Syngenta) and Endigo (4 oz per acre; Syngenta). All plots were seeded to achieve a final plant population of 140,000 plants per acre.

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 and eight different biological products were evaluated (Table 2).

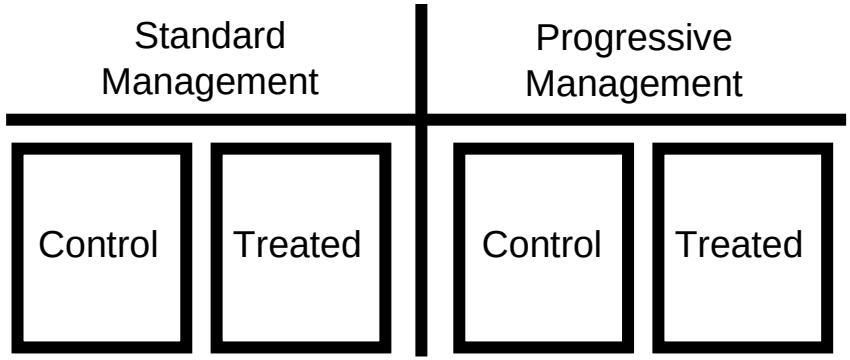

Figure 1. Pair-wise design used to evaluate biological products under different levels of agronomic management and with two different varieties. For each biological, plots were randomized across six replications.

Trial Implementation

Plots were planted at Champaign, IL (40°4'10"N, 88°14'08"W) on May 10th 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, pre-plant applications of Boundary (35 oz per acre; Syngenta) were made on 10 May. In-season weed control was applied 2 June as Zidua SC (4 oz per acre; BASF) and Fusilade (8 oz per acre; Syngenta).

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

Company Sponsor	Product Name	Biological Category	Application Rate	Application Method [1]
Acadian Plant Health	Envoy	Algae Extract	2 oz / acre & 11.2 oz / acre	In-Furrow & V5 Foliar
Azotic North America	Envita	N-Fixing Bacteria	3.2 oz / acre	In-Furrow
Groundwork BioAg	Rootella	Mycorrhizal Fungi	9 g / acre	In-Furrow
Plant Response	BioHP	Microbial Inoculant	16 oz / acre	In-Furrow
Azotic North America	Envita	N-Fixing Bacteria	3.2 oz / acre	R3 Foliar
Biolevel	PhosN	Microbial Inoculant	2.93 oz / cwt	Seed Treatment
Plant Response	BioPath	Microbial Inoculant	16 oz / acre	V5 Foliar
Sanovita	Classic, Flusian, Humin	Micronutrient, Algae Extract, Algae Extract	0.67 lb / acre, 0.7 oz / acre, 2.8 oz / acre	V5 (C, F, H) & R3 (C & H) Foliar

[1]In-furrow applied as 4 gallons/acre of ammonium polyphosphate (APP; 10-34-0) blended with water for total application volume of 12 gallons/acre. Foliar applications were applied with Masterlock surfactant (3.4 oz per acre, Winfield United) and blended with water for total application volume of 15 gallons per acre.

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

OM	CEC	pH	P	K	Ca	Mg	S	Zn
%	meq/100g		ppm					
3.7	21.4	6.5	48	198	2813	577	8	3

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 the unbiased comparisons among biological products that are applied as a seed treatment, in-furrow, or foliar spray. Seed treatments were treated 10 May and in-furrow applications were mixed within an hour of application on the date of planting. Vegetative growth stage (V5) foliar applications were made on 20 June. The reproductive foliar (R3) applications of individual biologicals and the foliar protection of the progressive management plots were applied on 27 July.

In-Furrow vs. Alternative Application Methods

In-furrow biological entries were applied with 4 gallons per acre of ammonium polyphosphate (APP; 10-34-0) to supply 16 lbs P_2O_5 per acre, and the respective control plots received the same rate of APP. Including the APP starter fertilizer with the in-furrow applications was based on our previous research findings showing the response to in-furrow biologicals was greater when applied with fertility. The plots receiving alternative biological applications that were not placed in-furrow did not receive APP as these biological placements would be representative of growers that do not have in-furrow capability on their planters.

Growing conditions

The season started wet with frequent precipitation events during April and early May, resulting in saturated soils which delayed planting until May 10th (Table 4). Adequate moisture and above average temperature after planting resulted in rapid, uniform seedling emergence followed by well below normal precipitation in June and July (3.9 and 2.0 inches below average, respectively) that slowed early season growth. August, however, received adequate rainfall, and cool nights during the second half of the month resulting in extended plant health during grain fill and a trial average yield of 76 bushels per acre.

Data Collection, Analysis, and Interpretation

At maturity, plots were harvested with a two-row plot combine (SPC40, ALMACO) and grain yield is reported as bushels per acre at 13% moisture (Table 5). Statistical analysis was performed using a linear mixed model approach with PROC MIXED in SAS (version 9.4; SAS

Institute, Cary, NC) and means were separated using Fisher's protected LSD test at the 0.10 level of significance. The biological product response was determined by the yield difference from paired control plots and significance tested using a paired t-test at alpha=0.1.

Table 4. Temperature and precipitation data for trial site at Champaign, IL in 2022.

	Precipitation		Temperature	
Month	**2022**	**Average[1]**	**2022**	**Average[1]**
	inches		°F	
April	3.2	4.0	50	53
May	3.2	5.0	66	63
June	0.8	4.7	75	72
July	2.4	4.4	76	75
August	4.9	3.5	73	74
September	4.6	3.3	67	67
Total	19.1	24.9	-	-

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

Soybean Response to Management was Limited in 2022

The minimal response to agronomic management was likely due to low June rainfall which limited soil N losses, and which slowed vegetative development. This meant that sufficient soil N was available during grain fill to supplement nodule-supplied N resulting in a limited response to the agronomic management factors of starter fertility and pre-plant ammonium sulfate. The slow canopy development paired with dry weather also markedly reduced leaf disease pressure, mitigating the response to foliar fungicide application. Variety AG38XF1 paired with starter fertilizer was the only combination to result in a notable 3.4 bushel per acre increase in grain yield in response to the progressive management (Table 5). The addition of starter fertilizer was only advantageous when applied under a progressive system, with a numerical increase of 1.0 and 1.4 bushels per acre for GH3762E3 and AG38XF1, respectively (Table 5).

Response to Biologicals Varied with Management and Placement

Yield responses to the biological products were variable with both positive and negative responses between the treated plots and their paired controls. In 7 of 8 comparisons, the four products applied as seed treatment or foliar applications with no applied starter all resulted in numerical increases in grain yield with the progressive management for both varieties (from +1.2 to +4.4 bushels). Conversely, under standard management there were trends of lower yield (from -6.0 to +1.0 bushels) indicating that these biological product applications perform better under full season management programs (Table 6). Foliar applications of the Sanovita products (Classic, Flusian, and Humin) tended to induce a positive yield response for both variety and management combinations (from +0.2 to 1.7 bushels). In contrast to the seed treatment and foliar applied products, the in-furrow biological applications tended to result in negative yield trends, with the BioHP application being the only in-furrow application to positively benefit yields for both variety and management combinations (average of +1.7 bushels) (Table 6).

Positive yield responses of 3.5 and 3.7 bushels per acre (averaged over both varieties) were observed for the PhosN seed treatment and foliar applied BioPath, respectively, when applied in a progressive management system. In contrast, there were significant decreases in yields for these applications in a standard management system, depending on the variety. The lack of weather-induced N losses combined with additional plant available N from soil N mineralization likely resulted in adequate supplies of N for soybean grain fill, mitigating the response to in-furrow or foliar applications of Envita.

Summary

In-furrow applications of the biological products tended to lower the response to starter fertilizer, while seed treatment and foliar applications positively influenced grain yield when applied with progressive management, indicating a full-season approach is needed to optimize response to in-season applied biologicals for soybean. These findings highlight the large impact that variety and management factors can have on the yield response of soybean to biological product applications, and growers must consider current on-farm agronomic practices when integrating a new biological product into their management system.

Table 5. Management and variety interaction effects on soybean grain yield at Champaign, Illinois in 2022. Management yields are presented as bushels per acre and standardized to 13% moisture.

In-Furrow Fertility[2]	Management Yields (bushels per acre)[1]			
	GH3762E3		AG38XF1	
	Standard	Progressive	Standard	Progressive
None	76.4	74.8	77.5	76.1
4 gallons of APP per acre	75.6	75.8	74.1	77.5

[1]Management yields are the average of n=24 observations.
[2]APP; Ammonium polyphosphate (10-34-0).
LSD (*P* ≤ 0.10): Variety (V), NS; In-Furrow (IF), NS; Management (M), NS; IF x M, 2.2; V x M, NS; V x IF, NS; V x IF x M, NS.

Table 6. Biological product effects on soybean grain yield at Champaign, Illinois in 2022. Individual biological responses are the change in yield compared to the adjacent management control for a given variety.

In-Furrow Fertility[2]	Biological Product	Application Method	Biological Yield Response (difference from untreated, bushels per acre)[1]				
			GH3762E3		AG38XF1		
			Standard	Progressive	Standard	Progressive	Average
None	Envita	R3 Foliar	- 2.0	+ 1.2	- 3.0	- 0.3	- 1.0
	PhosN	Seed Treatment	- 3.1*	+ 3.4	± 0.0	+ 3.6	+ 0.9
	BioPath	V5 Foliar	+ 1.0	+ 3.0	- 6.0*	+ 4.4	+ 0.6
	Classic, Flusian, and Humin	V5 (C, F, & H) and R3 (C & H) Foliar	+ 0.6	+ 1.3	+ 0.2	+ 1.7	+ 1.0
4 gallons of APP per acre	Envoy	In-Furrow and V5 Foliar	- 3.3	- 0.3	- 0.2	- 5.1	- 2.2
	Envita	In-Furrow	- 0.6	- 4.2	- 1.7	+ 3.4	- 0.8
	Rootella	In-Furrow	- 3.5	- 3.0	+ 2.4	- 6.8*	- 2.7
	BioHP	In-Furrow	+ 3.5*	+ 2.2	+ 1.0	+ 0.2	+ 1.7

[1]Biologcial 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.
[2]APP; Ammonium polyphosphate (10-34-0).
*Product response is significantly different from paired control plot using a paired t-test at alpha=0.1.