Illinois Biological Testing for Corn Production

2023 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

Twelve different biological applications were tested in two different management systems (standard or progressive) with two genetically diverse corn hybrids (G15J91 and DKC65-95). 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 corn at Champaign, IL in 2023.

Management System[1]	Side-dress N	Foliar Protection
Standard	None	None
Progressive	60 lbs N/acre applied Y-drop at V6	Fungicide and Insecticide at VT/R1

[1]Both management systems received a preplant broadcast fertilizer of 160 lbs N, 75 lbs P_2O_5, and 60 lbs K_2O per acre as urea (46-0-0), MAP (11-52-0), and MOP (0-0-60).

The 'standard' system has appropriate fertilizer applications made at planting (160 lbs N, 75 lbs P_2O_5, and 60 lbs K_2O per acre) with no subsequent in-season management, while the 'progressive' system has the at-planting fertility along with an extra 60 lbs N per acre Y-drop applied at V6 and a fungicide and insecticide application at VT/R1 for foliar protection (Table 1). Preplant fertility was provided as urea (46-0-0), monoammonium phosphate (MAP; 11-52-0), and muriate of potash (MOP; 0-0-60), side-dress fertility as urea ammonium nitrate (UAN, 32-0-0), and foliar protection as Miravis Neo (13.7 oz per acre; Syngenta) and Warrior II (1.6 oz per acre; Syngenta). All plots were seeded to achieve a final plant population of 36,000 plants per acre.

We also know that nonuniformity within fields causes field spatial variability that can mask the yield response to both agronomic management and to the biological product application. Thus, a pairwise field design was used where every treated plot had an adjacent untreated control, allowing 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 hybrid, and the sub-sub-plot was the management system. All treatments were replicated six times, and eleven different biological products were evaluated (Table 2).

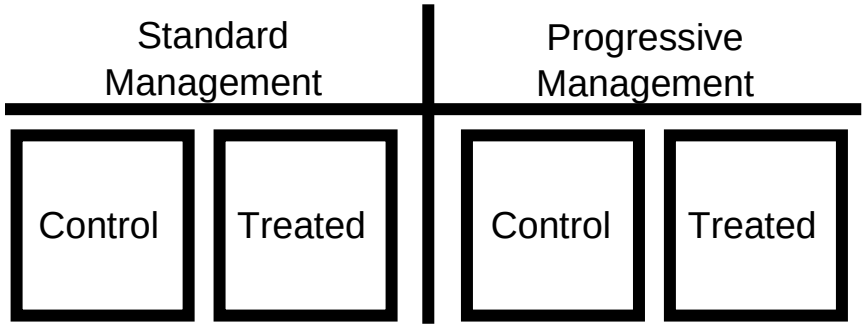

Figure 1. Pairwise design used to evaluate biological products under two levels of agronomic management and with two different hybrids. For each biological product, plots were randomized across six replications.

Trial Implementation

Plots were planted at Champaign, IL (40°4'10"N, 88°14'08"W) on 5 May using a precision plot planter (SeedPro 360, ALMACO). Preplant soil test levels are shown in Table 3. Plots were 37.5 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 below-ground insect protection, Force 6.5G soil insecticide was applied in-furrow (2.3 oz per 1000 ft; Syngenta) at

planting. For weed control, pre-emergence applications of Acuron (94 oz per acre; Syngenta) and Atrazine (20 oz per acre) were made on 6 May. In-season weed control was applied 5 June as Laudis (3 oz per acre; Bayer), Zidua SC (4 oz per acre; BASF), Atrazine (16 oz per acre; Growmark), and Roundup Powermax3 (30 oz per acre; Bayer) with AMS at 50 oz per acre.

Table 2. Twelve biological applications evaluated, including company sponsor, product category, application rate, and application method.

Company Sponsor	Product Name	Biological Category	Application Rate	Application Method[1]
Archer Daniels Midland	NeoVita 43	Sugar	1 gal / acre	In-Furrow
BioLevel	Maize*NP*	Bacterial Inoculant	100 g / acre	In-Furrow
DPH Biologicals	SP-1	Bacterial Inoculant	2 gal / acre	In-Furrow
IndoGulf BioAg	*Bacillus mucilaginosus*	Bacterial Inoculant	15 g / acre	In-Furrow
IndoGulf BioAg	*Rhizophagus intraradices*	Arbuscular Mycorrhizal Fungi	2 L / acre	In-Furrow
Groundwork BioAg	Rootella L	Arbuscular Mycorrhizal Fungi	6 ml / acre	In-Furrow
Agrocete	Amyno 15 & Organo Top	Amino & Humic Acid	27 & 13.5 oz / acre	V6 + VT Foliar
Amvac	iNvigorate	Bacterial Inoculant	1 L / acre	Y-Drop
Azotic North America	Envita	N-Fixing Bacteria	5 g / acre	VT/R1 Foliar
BioHumaNetics	Super Nitro	Carbon Biostimulant	2 gal / acre	V6 Foliar
DPH Biologicals	SP-1	Bacterial Inoculant	2 gal / acre	V6 Foliar
Sanovita	Herbagreen Classic, Herbagreen Humin, Herbagreen Fluisan	Foliar Micronutrient, Organic Acid, Hop Extract	0.6 lb / acre, 0.5 oz / acre, 1.4 oz / acre	V1 Foliar (C) & H), V6 Foliar (C & F), VT/R1 Foliar (C)

[1]In-furrow applied with 4 gallons/acre of ammonium polyphosphate (APP; 10-34-0) and blended with water for total application volume of 12 gallons/acre. Foliar applications were applied with Petrichor surfactant (4 oz per acre, Winfield United) and blended with water for total application volume of 15 gallons per acre at V6 and 20 gallons per acre at VT/ R1.

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

OM	CEC	pH	P	K	Ca	Mg	S	Zn
%	meq/100g		ppm					
3.6	22.1	6.1	42	150	2861	453	11	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 in-furrow, Y-drop, or foliar spray. In-furrow applications were mixed within an hour of application on the date of planting. V1 Foliar applications were supplied on 18 May. V6 foliar applications were applied on 7 June while the y-drop treatments were applied at the V6 growth stage on 9 June, the same growth stage as the early vegetative (postemergence herbicide timing) foliar sprays. The late vegetative/early reproductive (VT/R1) foliar applications of individual biologicals and the foliar protection of the progressive management plots were applied on 20 July.

In-Furrow vs. Alternative Application Methods

All 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 plot received the same rate of APP. APP starter was included with all the in-furrow applications based on our earlier findings showing a greater response to in-furrow biologicals when they are placed with fertilizer. Biological product applications that were not placed in-furrow did not receive APP as these product placements would be representative of growers that do not have in-furrow capability on their planters.

Replications Note Among Applications

The study was designed to equally apply all products to six replications with hybrid DKC65-95 and six replications with hybrid G15J91. Due to a randomization error in hybrid, some products were unbalanced in replication across hybrids. While hybrid distribution was unequal, all applications were supplied for a total of twelve replications of product application. Number of replications for each comparison is identified where unbalanced.

Growing conditions

The growing season started dry with below-average precipitation for April, resulting in well aerated soils and timely planting for the county in early May (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 growth stages and pollination. However, the month of August received adequate rainfall during seed fill, resulting in extended plant health and a final trial average yield of 264 bushels per acre.

Table 4. Temperature and precipitation data for the trial site in 2023.

	Precipitation		Temperature	
Month	**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	1.8	3.3	70	67
Total	13.7	24.9	-	-

[1]Refers 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 (R1, Almaco) and grain yield is reported as bushels per acre at 15.5% 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. Due to an error in hybrid randomization, there is unequal replication of biological applications across hybrids and therefore treatment responses are not directly compared to each other and statistical inference is only made regarding an individual application response over its respective untreated control for a given hybrid and management combination.

In-Season Management Enhanced Yields Regardless of Starter

Both hybrids responded similarly to progressive management, with an average increase of 14 bushels per acre (Table 5). Starter fertilizer provided no yield benefit, likely because of the high soil P test (Table 3) and the broadcast fertility. The responses to progressive management were less than we typically observe, likely because drought conditions in 2023 resulted in little preplant N losses and limited disease pressure.

Response to Biologicals was Hybrid and Management Dependent

When supplied to a standard management system, biologicals resulted in a positive response in sixteen of the twenty-four comparisons, equal to two thirds of the applications tested with this management (Table 6). The foliar Herbagreen Biostimulants or the in-furrow application of SP-1 resulted in a significant change in yield compared to their respective control treatments with hybrid G15J91, and numerical increases for hybrid DKC65-95. The DKC65-95 hybrid responded notably positively to in-furrow biologicals (positive response in seven of the eight applications that were not classified as AMF). Neither of the AMF products of Rootella L or *Rhizophagus intraradices* responded positively for hybrid DKC65-95. This hybrid is pre-treated with a biological LCO co-factor that signals native AMF, and this seed treatment is listed as incompatible with the Rootella product, confirmed by the responses observed here. Interactions between soil-supplied biologicals and seed treatments are a factor that must be considered when integrating products into a grower's management system. When supplied to a progressive management system, biologicals resulted in a negative response trend in fourteen comparisons. With hybrid G15J91 there was an even split of positive vs negative responses to biologicals, while hybrid DKC65-95 only responded positively in four of the twelve comparisons. Foliar supplied Super Nitro was the only product to induce a positive response in all four tested cases.

Summary

Despite the stringent pairwise experimental design, and the biological product evaluation at two levels of agronomic management and with two different hybrids, the impacts of management and biological product application on corn yield were minimal. These findings highlight the large impact that weather has on crop growth and development and as a result the response to both agronomic management and to the biological product applications.

Table 5. Management, hybrid, and in-furrow fertility interaction effects on corn grain yield at Champaign, Illinois in 2023. Management yields are presented as bushels per acre and standardized to 15.5% moisture.

In-Furrow Fertility[2]	Management Yields (bushels per acre)[1]			
	G15J91		DKC65-95	
	Standard	Progressive	Standard	Progressive
None	247	260	268	281
4 gallons of APP per acre	247	261	266	280

[1]Management yields are the average of n=36 observations.
[2]APP; Ammonium polyphosphate (10-34-0).
LSD ($P \leq 0.10$): Hybrid (H), 2.5; In-Furrow (IF), NS; Management (M), 2.5; IF x M, NS; H x M, NS; H x IF, NS; H x IF x M, NS

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

In-Furrow Fertility‡	Biological Product	Application Method	Biological Yield Response (difference from untreated, bushels per acre)†				
			G15J91		DKC65-95		
			Standard	Progressive	Standard	Progressive	Average
None	Amyno 15 & Organo Top	V6 + VT/R1 Foliar	- 8.4 [6]	+ 4.8 [6]	- 7.5 [6]	- 1.9 [6]	- 3.3
	iNvigorate	Y-Drop	+ 0.3 [7]	- 0.9 [7]	+ 2.1 [5]	- 6.6 [5]	- 1.3
	Envita	VT/R1 Foliar	- 6.0 [4]	- 8.8 [4]	+ 0.9 [8]	- 4.1 [8]	- 4.5
	Super Nitro	V6 Foliar	+ 0.7 [9]	+ 4.4 [9]	+ 11.9 [3]	+ 7.1 [3]	+ 6.0
	SP-1	V6 Foliar	+ 0.4 [8]	+ 7.0* [8]	- 8.5 [4]	- 6.9 [4]	- 2.0
	Herbagreen Foliar Products	V1, V6, and VT/R1 Foliar	+ 7.2* [7]	- 1.9 [7]	+ 3.0 [5]	- 1.6 [5]	+ 1.7
4 gallons of APP per acre	NeoVita 43	In-Furrow	- 1.8 [4]	- 4.9 [4]	+ 7.3 [8]	+ 1.1 [8]	+ 0.4
	Maize*NP*	In-Furrow	+ 0.9 [6]	- 2.6 [6]	+ 3.6 [6]	+ 1.5 [6]	+ 0.9
	SP-1	In-Furrow	+ 7.3* [5]	+ 3.1 [5]	+ 5.2 [7]	- 2.2 [7]	+ 3.4
	Bacillus mucilaginosus	In-Furrow	+ 0.3 [5]	- 5.0 [5]	+ 3.4 [7]	+ 0.2 [7]	- 0.3
	Rhizophagus intraradices	In-Furrow	- 2.5 [6]	+ 2.3 [6]	- 2.0 [6]	- 6.0 [6]	- 2.1
	Rootella L	In-Furrow	+ 2.9 [6]	+ 0.7 [6]	- 2.9 [6]	- 3.5 [6]	- 0.7

†Biological responses are the average of n observations and presented as the change in yield from an adjacent untreated control within the respective management and hybrid combination. Number of replications for a given comparison is represented by the exponent.
‡APP; Ammonium polyphosphate (10-34-0).
*Product response is significantly different from paired control plot using a paired t-test at alpha=0.1.