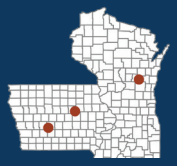
PRACTICAL FARMERS OF IOWA
COOPERATORS' PROGRAM Farmer-Led Research

EXPERIMENT



2024

Biostimulant Effects on Corn

PFI Contact:

Graham Giesting
(515) 232-5661 ext.1052,
graham.giesting@practicalfarmers.org

In a Nutshell:

- Biostimulants are products that intend to introduce beneficial microbes to crops, to harness the microbes' biological processes to boost plant performance.
- The aims of this project were to determine whether biostimulant products 1) improve corn yield; 2) can possibly reduce N fertilizer rate; and 3) are cost-effective.
- The three products studied in this project were EnSoil Algae on Jack Boyer's farm; Utrisha N on Robert Harvey's farm; and Biolife Liquilife+ on Josh Hiemstra's farm.

Key Findings:

- Boyer performed two trials. He saw a significant, 49%, increase in his corn yield in one trial with EnSoil Algae, but no significant change in the other.
- Harvey saw no significant yield differences between Utrisha and control treatments.
- Hiemstra saw a significant, 4%, yield decrease with his combined treatment of Liquilife+ and reduced N-fertilization rate, compared to control.

Cooperators

Jack Boyer – Reinbeck, IA

Robert Harvey – Redfield, IA

Joshua Hiemstra – Brandon, WI

Funding

Cargill

BACKGROUND

The soil in which plants grow is home to an enormous variety of microbes, which drive the nutrient cycles which enable plant growth. Numerous commercial products have been developed to try to leverage these microbes to boost plant performance. Previous PFI trials have examined biostimulants for corn production [1], [2]. None have found the biostimulants to have had significant effects. But the claimed benefits of the products — healthier soil, healthier plants, and free nutrients — motivated cooperators to try again this year. There may be a high degree of specificity in matching the right microbe to the right conditions. Bacteria that are found to be beneficial to a certain plant in a certain set of circumstances will change their strategy if the circumstances change. For example, the nitrogen fixation rates of the rhizobium bacteria in soybean root nodules decreases when soybeans are artificially N fertilized, because the plant invests less energy (in the form of sugars exuded from the root) in the relationship [3].

Harvesting Hiemstra's trial. Photo taken October 15, 2024

Nitrogen fixation is one of the most valuable ecosystem services provided by soil bacteria that many commercial products claim to tap into, activate, or boost. Nitrogen fixation results from the chemical reduction of atmospheric nitrogen (N_2) into ammonium (NH_4+) which the plant can readily take up and use to build amino acids. Atmospheric nitrogen thus converted and taken up is as free as air, displacing artificial fertilizer inputs and saving farmers money.

Different products have different strategies for leveraging this ability, and each cooperator sourced a different biostimulant to test for this project. Boyer hoped to find a way to significantly reduce commercial N inputs and improve profitability, as well as improve soil health. Hiemstra hoped to improve yields with less inputs. The trial was designed to enable return on investment (ROI) calculations on their chosen biostimulant product. Harvey hoped to learn "whether or not some of these products actually work".

METHODS

Design

To determine the effectiveness of their respective biostimulants (**Table 1**), the cooperators compared corn yields under a combination of the following treatments:

1) Control: Cooperator's typical practice rate of manure/fertilizer applied.
2) Biostimulant: Cooperator's typical practice rate of manure/ fertilizer applied. Biostimulant applied as directed by manufacturer.
3) Biostimulant with reduced N: Reduced applied N paired with biostimulant application.

Cooperators randomly assigned four replications of each treatment in pairs for a total of eight treatment strips. Field management practices for each cooperator/field are detailed in **Table 2.**

Measurements

Cooperators harvested corn from each strip and recorded yields and percent moisture. Yields were adjusted to 15.5% moisture. Cooperators also kept notes on the cost of management operations relevant to this trial, including the costs of fertilizer and fertilizer application, and the costs of biostimulants and biostimulant application.

TABLE 1. Biostimulant additives trialed by cooperators and relevant attributes in 2024.

PRODUCT	MICROBE	MODE OF ACTION	COOPERATOR	ADDITIONAL DETAILS
EnSoil Algae [4]	*Chlorella vulgaris*	Soil enrichment	Jack Boyer	Live algae
Utrisha N [5]	*Methylobacterium symbioticum* SB23	N_2 redux to NH_4+	Robert Harvey	Study (Toras Vera et al 2024) 1.0*10^5cfu/ plant
Biolife Liquilife+ [6]	Diverse microbiota	Nutrient, biocontrol, etc.	Joshua Hiemstra	Nitrifying bac., *Trich. Pseud. Mortierella* (P_1 solubilization.)

TABLE 2. Management practices for each farm in 2024.

	BOYER 1	BOYER 2	HARVEY	HIEMSTRA
Strip size (ft^2)	54,000	54,000	16,095	9,100
Previous crop	Soybeans	Soybeans	Soybeans	Wheat
Cover crop	Cereal rye 50 lb/ac, broadcast	Cereal rye 50 lb/ac, broadcast	Cereal rye 65 lb/ac, drilled	Oats 40 lb/ac, radish 2 lb/ac, red clover 5 lb/ ac; broadcast, vertical tilled
Cover crop termination dates	Apr. 17, Roundup 40 oz/ac	Apr. 17, Roundup 40 oz/ac	Apr. 14, 24 oz Roundup and 6 oz 2,4-D per acre	May 17, 24 oz Buccaneer Plus, 2 gal Boost, 32oz Liberty per acre
Corn planting	Apr. 18, 34,000 seeds/ ac, 30-in. rows	Apr. 18, 34,000 seeds/ ac, 30-in. rows	Apr. 24, 32,000 seeds/ ac, 30-in. rows	May 12, 32,800 seeds/ ac, 30-in. rows
Corn RM (days)	111	111	113	100
N fertilization at planting	30 lb N/ac UAN(32)	30 lb N/ac UAN(32)	--	70 lb N/ac manure, fall 2023; May 12, 18 lb N/ac urea
N sidedress	June 7, 106 lb N/ac UAN(32)	June 7, 89 lb N/ac UAN(32)	June 2, 130 lb N/ac UAN(32)	June 27, 27.2 lb N/ac UAN(32) (control only)
Biostimulant applied	EnSoil Algae 24 oz/ac	EnSoil Algae 24 oz/ac	Utrisha N 5 oz/ac	Liquilife+ from Purple Cow Organics
Weed control	Not provided	Not provided	June 11, 32 oz/ac Roundup	June 27, 2 gal Boost, 24 oz Buccaneer 5, 1 qt Liberty, in 13 gal H_20 per acre
Harvest	Oct. 15	Oct. 15	Oct. 14	Oct. 15

Data analysis

We used Fischer's LSD at a 95% confidence level to determine if there were significant differences in in strips treated with biostimulants. For each metric, the difference between the control and biostimulant yield means is compared with the LSD. A difference greater than or equal to the LSD indicates the presence of a statistically significant treatment effect, meaning one treatment outperformed the other and the farmer can expect the same results to occur 95 out of 100 times under the same conditions. A difference smaller than the LSD indicates the difference is not statistically significant and the treatment had no effect. We can perform this analysis because the cooperators had completely randomized and replicated experimental designs (**Figure A1**).

RESULTS AND DISCUSSION

Boyer saw large, significant increases in yield in the strips treated with EnSoil Algae in his first trial, which was fertilized at a higher level than his second trial (**Table 3**). Boyer observed that the corn in the EnSoil Algae-treated strips were much taller and greener than the control strips.

In his second trial, in a separate field from the first trial, no significant difference was found between the control and biostimulant treatments (**Table 3**). The field with the lower nitrogen fertilizer rate was less well drained and suffered from water pooling during the wet months of spring and early summer (**Figure A2**). Although the yield of the EnSoil Algae-treated strips were not significantly higher than the control in his second trial, Boyer remarked that the treatment plants looked greener. Boyer saw large increases in revenue from his EnSoil Algae-treated strips in trial 1, which outweighed the increased cost of the biostimulant.

Josh Hiemstra planted into green clover and volunteer wheat cover crops seeded in 2023. Photo taken May 12, 2024.

In Harvey's trial, the difference between the Utrisha-treated and control strips' yields was 10 bu/ac. The LSD with 95% confidence was 14 bu/ac, so the results cannot be considered significant (**Table 4**). As such, the cost of purchasing and applying Utrisha reduced the profitability of the treated strips by $26.12/ac.

Hiemstra saw a significant decrease in yield under treatment conditions (**Table 5**). Because he also decreased the N applied with the Liquilife+ treatment, the effects of the biostimulant are unclear. Hiemstra blamed the weather for low yields this season (**Figure A2**). He said that his overall yields were lower than usual, and that he would resist drawing conclusions about the effectiveness of the Liquilife+ treatment in a year that was so wet. Hiemstra commented that if there had been less wash-out of N fertilizer, he suspects that the results would have been even more lopsided.

CONCLUSIONS AND NEXT STEPS

Plant microbiomes include a vast array of bacteria and fungi that live on, in, and around plants. Some of these are harmful, some are beneficial, and many have no clear effect on the plant. Furthermore, none of these relationships are fixed, with microbes' roles shifting depending on the conditions for each party.

Overall, Jack Boyer was pleased with the effect that he saw from EnSoil algae in his field, even though he thought "there were environmental issues that confounded the results".

Hiemstra said, "I've tried this product in the past with better results. It does give me questions about weather and yield, and we need more variable years to determine if it's giving ROI in poor weather years or just good ones."

This trial will be repeated in 2025, as we continue to explore the relationships among crops, biostimulants, management practices and weather.

TABLE 3. Boyer's results, yield comparisons and ROI calculations in 2024.

TRIAL	TREATMENT	N (lb/ac)	YIELD (bu/ac)	CORN PRICE ($/bu)	N COST ($/ac)	ENSOIL ALGAE ($/ac)	REVENUE ($/ac)	NET INCOME ($/ac)
1	Control	136	192	$3.76	$65.28	--	$720.79	$655.92
	EnSoil Algae	136	287	$3.76	$65.28	$18.00	$1,080.15	$997.28
	LSD (95)		5					
	Difference		95					
	Significant?		Yes					
2	Control	119	201	$3.76	$0.48	--	$762.48	$705.72
	EnSoil Algae	119	204	$3.76	$0.48	$18.00	$762.48	$687.72
	LSD (95)		6					
	Difference		3					
	Significant?		No					

Corn price, Biostimulant and fertilizer cost obtained from Boyer.
Where the difference between treatment means is not greater than or equal to the Least Significant Difference (LSD), there is no statistically significant difference.
Revenue is calculated as the product of Yield and Corn Price.
N Cost is calculated as the product of the amount of N applied and N cost ($0.48/lb).
EnSoil Algae cost includes both product and application costs.
Net Income is calculated as Revenue less total fertilizer and biostimulant costs.
Because there was no statistically significant difference in Trial 2, revenue is the product of Corn Price and the average yield.

TABLE 4. Harvey's results, yield comparisons and ROI calculations in 2024.

TREATMENT	N (lb/ac)	YIELD (bu/ac)	CORN PRICE ($/bu)	N COST ($/ac)	UTRISHA N COST ($/ac)	REVENUE ($/ac)	NET INCOME ($/ac)
Control	130	189	$4.10	$102.70		$753.58	$650.88
Utrisha	130	179	$4.10	$102.70	$26.12	$753.58	$624.76
LSD (95)		14					
Difference		10					
Significant?		No					

Corn price, Biostimulant and fertilizer cost obtained from Harvey.
Where the difference between treatment means is not greater than or equal to the Least Significant Difference (LSD), there is no statistically significant difference.
Revenue is calculated as the product of Yield and Corn Price.
N Cost is calculated as the product of the amount of N applied and N cost ($0.79/lb).
Utrisha N cost includes both product and application costs.
Net Income is calculated as Revenue less total fertilizer and biostimulant costs.
Because there was no statistically significant difference, revenue is the product of Corn Price and the average yield.

TABLE 5. Hiemstra's results, yield comparisons and ROI calculations in 2024.

TREATMENT	N (lb/ac)	YIELD (bu/ac)	CORN PRICE ($/bu)	N COST ($/ac)	LIQUILIFE+ COST ($/ac)	REVENUE ($/ac)	NET INCOME ($/ac)
Control	115	123	$3.85	$46.20	--	$474.32	$428.12
Liquilife+	88	118	$3.85	$27.70	$25.60	$452.76	$399.46
LSD (95)		2					
Difference		5					
Significant?		Yes					

Corn price, Biostimulant and fertilizer cost obtained from Hiemstra.
Where the difference between treatment means is not greater than or equal to the Least Significant Difference (LSD), there is no statistically significant difference.
Revenue is calculated as the product of Yield and Corn Price.
N Cost is calculated as the sum of different N fertilizers costs throughout the season.
Liquilife+ cost includes both product and application costs.
Net Income is calculated as Revenue less total fertilizer and biostimulant costs.
Where there is no statistically significant difference, revenue is the product of Corn Price and the average yield of all statistically similar treatments in a trial.

APPENDIX — TRIAL DESIGN AND WEATHER CONDITIONS

	Control	Biostimulant	Biostimulant	Control	Control	Biostimulant	Control	Biostimulant
STRIP	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
REP	**1**		**2**		**3**		**4**	

FIGURE A1. Experimental design used by Boyer, Harvey, and Hiemstra.

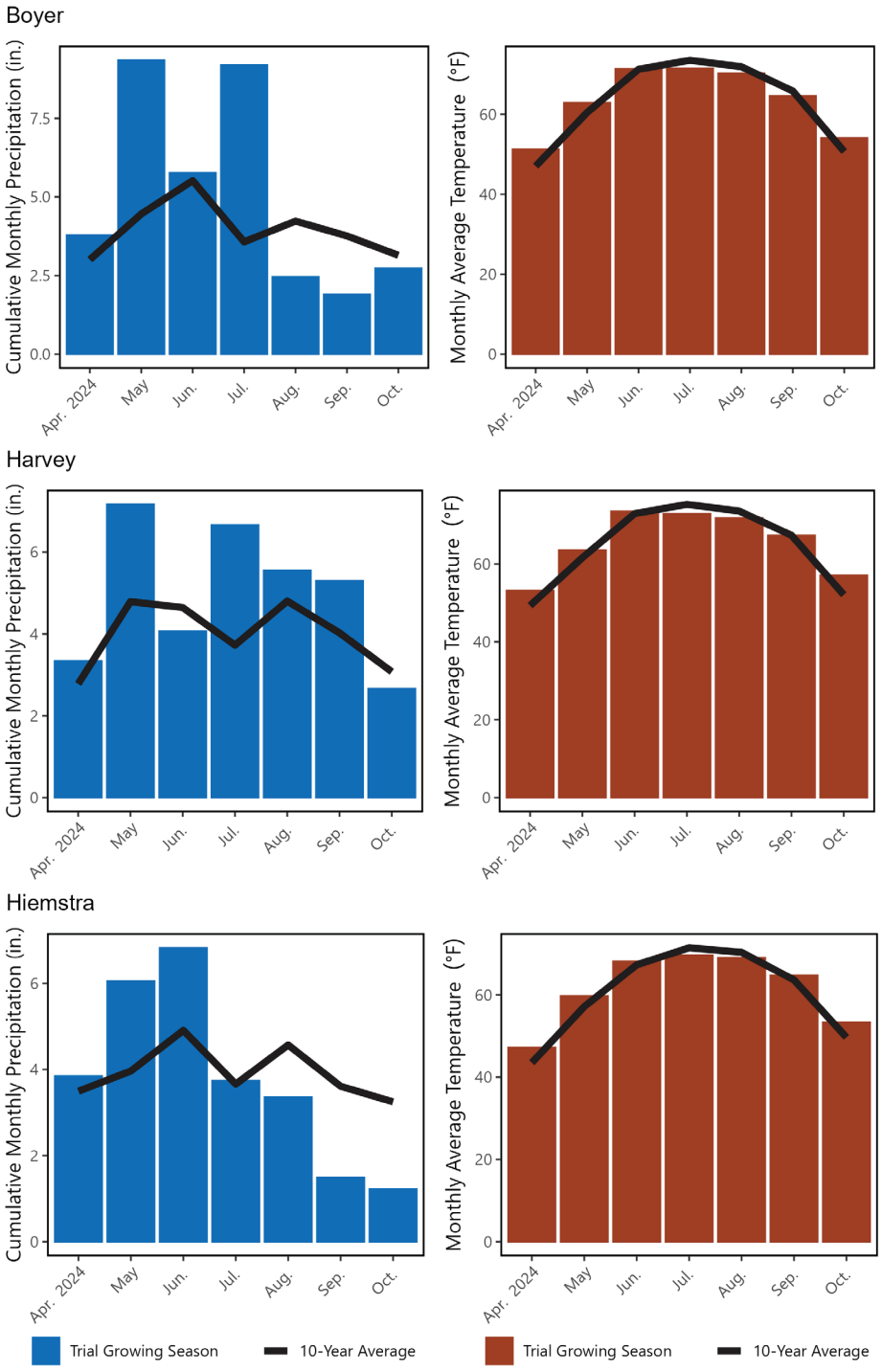


FIGURE A2. Monthly cumulative precipitation (left) and temperature (right) in Reinbeck IA, Redfield IA, and Brandon WI, during the rye cover crop growing season, April–October 2024 [7], [8].

REFERENCES

[1] "Utrisha N Biological Nitrogen Supplement for Organic Corn - Practical Farmers of Iowa." Accessed: Feb. 07, 2025. [Online]. Available: https://practicalfarmers.org/research/utrisha-n-biological-nitrogen-supplement-for-organic-corn/

[2] "Holganix Bio 800+ Compost Tea for Corn," Practical Farmers of Iowa. Accessed: Feb. 07, 2025. [Online]. Available: https://practicalfarmers.org/research/holganix-bio-800-compost-tea-for-corn/

[3] G. Santachiara, F. Salvagiotti, and J. L. Rotundo, "Nutritional and environmental effects on biological nitrogen fixation in soybean: A meta-analysis," *Field Crops Res.*, vol. 240, pp. 106–115, Jul. 2019, doi: 10.1016/j.fcr.2019.05.006.

[4] "Home," EnSoil Algae. Accessed: Feb. 28, 2025. [Online]. Available: https://ensoilalgae.com/

[5] "Utrisha N." Accessed: Feb. 28, 2025. [Online]. Available: https://www.corteva.us/products-and-solutions/crop-protection/utrisha-n.html

[6] "Ag-Bioactive LiquiLife+TM," Purple Cow Organics. Accessed: Feb. 28, 2025. [Online]. Available: https://www.purplecoworganics.com/pages/ag-liquilifeplus

[7] A. H. Sparks, "nasapower: A NASA POWER Global Meteorology, Surface Solar Energy and Climatology Data Client for R," *J. Open Source Softw.,* vol. 3, no. 30, p. 1035, Oct. 2018, doi: 10.21105/joss.01035.

[8] A. Sparks, *nasapower: NASA-POWER Data from R.* (2024). [Online]. Available: https://CRAN.R-project.org/package=nasapower

PRACTICAL FARMERS of Iowa

PFI COOPERATORS' PROGRAM

PFI's Cooperators' Program helps farmers find practical answers and make informed decisions through on-farm research projects. The Cooperators' Program began in 1987 with farmers looking to save money through more judicious use of inputs. If you are interested in conducting an on-farm trial contact Stefan Gailans @ 515-232-5661 or stefan.gailans@practicalfarmers.org.