

## BiOWiSH<sup>®</sup> Crop Liquid

### Evaluation of BiOWiSH<sup>®</sup> on Cover Crop Biomass and Corn Yields in Central Iowa



#### Executive Summary

BiOWiSH Technologies engaged Iowa State University to conduct a study to determine the effects of BiOWiSH<sup>®</sup> Crop Liquid coated onto fall-applied monoammonium phosphate (MAP) to create an Enhanced Efficiency Fertilizer (EEF), as part of a cover crop and corn rotation. The study took place in the U.S. midwestern state of Iowa.

The trial compared three treatments:

- Control, Standard Fertility Program
- Control + Cover Crop
- Control + BiOWiSH<sup>®</sup> Crop Liquid coated onto MAP + Cover Crop

The Control + BiOWiSH<sup>®</sup> Crop Liquid treatment was observed to have a cover crop biomass increase of 9.7% over the Control, followed by a marketable grain yield 7.9% (14 bu/acre, 0.9 MT/ha) higher in the following growing season. Overall, the BiOWiSH<sup>®</sup> Crop Liquid treatment helped to mitigate the yield loss often experienced with a first-year cover crop program when applied in the fall as an EEF.

#### Background

##### About BiOWiSH Technologies

Headquartered in Cincinnati, Ohio, BiOWiSH Technologies, Inc. is a global provider of biotechnology solutions. As a leader in the agricultural market, we help farmers increase crop production sustainably, safely, and cost effectively. Our revolutionary BiOWiSH<sup>®</sup> Crop Liquid is a blend of proprietary microbial cultures that can be coated onto dry fertilizer or mixed with liquid fertilizers to create an enhanced efficiency fertilizer. BiOWiSH<sup>®</sup> endophytic *Bacillus* deliver soil nutrients to crops through the rhizophagy cycle creating a symbiotic relationship between the plant and soil microbes. This helps farmers achieve consistent results across a broad range of operating conditions, climates, and environments. By unifying nature and science, BiOWiSH reinvents the way food is grown. For more information, visit [biowishtech.com](http://biowishtech.com).

### BiOWiSH<sup>®</sup> Crop Liquid



- Optimizes yield potential by improved nutrient uptake
- Increases nutrient use efficiency and supports nutrient uptake
- Optimizes soil conditions for greater root mass
- Improves soil conditions for increased plant vigor
- Enhances beneficial microbes in the rhizosphere

#### Available Size

- 264 gal/1000 L

## About Iowa State University

Iowa State University comprises a community of students, faculty, and staff who constantly strive to understand our world, impart new knowledge, and solve the most pressing challenges facing humanity today. Our identity as a leading science and technology land-grant university requires us to think innovatively about strategic planning and develop a framework that focuses our future endeavors. Iowa State University will create, share, and apply knowledge to make our students, Iowa, and the world better.

## Objectives

The purpose of this study was to evaluate the effects of BiOWiSH® Crop Liquid coated onto MAP to create an EEF as part of a cover crop into a corn rotation. The evaluation focused on biomass yield of the cover crop, soil nutrient analysis, carry over corn grain yield effects, corn tissue analysis, and the farmers' economic benefit on corn production.

Regenerative agriculture programs emphasize the incorporation of cover crops into crop rotations as a key practice to promote soil health, biodiversity, and overall ecosystem resilience. While cover crops are generally beneficial for soil health and long-term crop productivity, there are instances where first-year cover crops might result in a temporary yield loss. Several factors may contribute to this phenomenon:

- Nitrogen Tie-Up
- Competition for Resources
- Allelopathic Effects
- Timing of Cover Crop Termination
- Weather Conditions
- Crop Selection and Management
- Transition Period

This study's combination of data is to determine whether the addition of BiOWiSH® Crop Liquid as an EEF can increase cover crop biomass and grain yield while preserving soil benefits gained by cover cropping.

## Implementation Program

This trial was initiated in mid-October following harvest of soybean on a low fertility site by local standards near Ames, Iowa, USA. A cover crop rotation had never been implemented on this site prior to this study. In this trial, the standard regional fertility program (Control) for corn consisted of a fall application of MAP at a rate of 230 lbs/acre (258 kg/ha) followed by pre-plant spring application of urea applied at a rate of 109 lbs/acre (122 kg/ha) followed by 196 lbs/acre (220 kg/ha) at the V4 corn growth stage. This was compared to a Control + Cover Crop program, which included winter rye (*Secale cereale*) as a fall-planted cover crop seeded at a rate of 60 lbs/acre (67 kg/ha). It was also compared to the same program with the addition of BiOWiSH® coated onto MAP at the manufacturer's recommended rate and fall-applied. The trial consisted of three treatments with six replicates in a randomized complete block design (RCBD).

For the Control + Cover Crop and Control + BiOWiSH® Crop Liquid + Cover Crop treatments, the cover crop biomass per acre was estimated via drone imaging in late April. At the beginning of May, glyphosate was applied to terminate the cover crop fully, with corn sowed 8 days later. Prior to corn sowing, pre-plant urea was broadcast at a rate of 109 lbs/acre (122 kg/ha) and applied again as a topdress at the V4 growth stage at a rate of 196 lbs/acre (220 kg/ha). The site was non-irrigated. There was no significant disease or pest pressure at the trial location.

Corn yield was collected at harvest for each plot and analyzed comparing the BiOWiSH® treatment to the Control + Cover Crop treatment. Corn leaf samples were collected at tasseling for nutrient analysis. Soil sample cores were taken pre-MAP application in the fall, pre-urea application in the spring, and post-harvest. For each treatment, replicates were individually sampled, mixed together, and chemically analyzed. Nitrogen Recovery Efficiency (NRE) values were calculated for the Control + Cover Crop and Control + BiOWiSH® Crop Liquid + Cover Crop treatments relative to the Control using the formula below:

- $NRE = ((\text{Grain N (treatment)} - \text{Grain N (Control)}) / \text{Fertilizer N}) * 100$
- Where Grain N = yield \* percent N (from grain analysis results)

Figure 1. Spring Image of Trial Site, Prior to Cover Crop Termination in the Spring

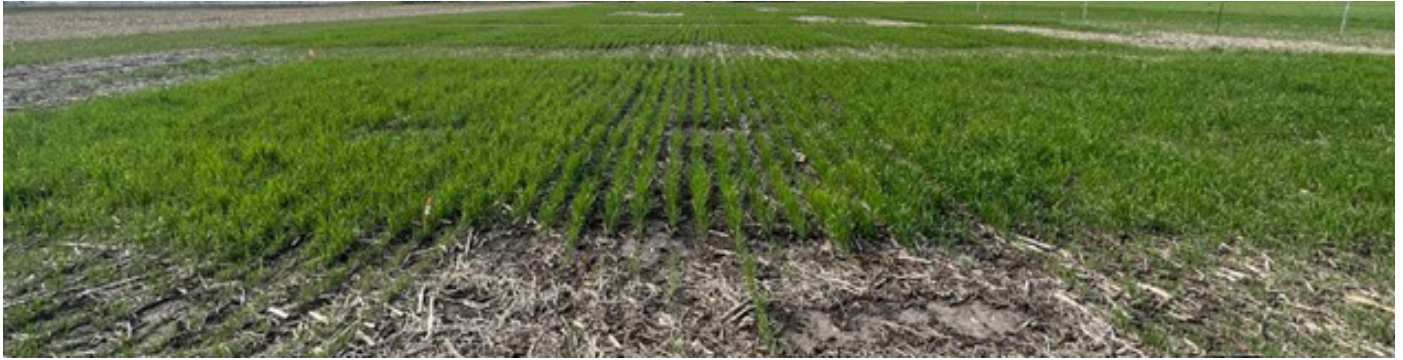


Table 1. Fertilizer, Treatments, and Application Timing

Treatment	Fertilizer	Application Rate lbs/acre [kg/ha]	Application Timing
Control, Standard Fertility Program	MAP	230 [258]	Broadcast (Fall)
	Urea	109 [122]	Pre-Plant (Spring)
	Urea	196 [122]	Topdress (Summer - V4)
Control + Cover Crop	MAP	230 [258]	Broadcast (Fall)
	Urea	109 [122]	Pre-Plant (Spring)
	Urea	196 [122]	Topdress (Summer - V4)
Control + BiOWiSH® Crop Liquid + Cover Crop	MAP	230 [258]	Broadcast (Fall)
	Urea	109 [122]	Pre-Plant (Spring)
	Urea	196 [122]	Topdress (Summer - V4)

\*BiOWiSH® Crop Liquid Fertilizer Enhancement was added at manufacturer's recommended rate.



## Results

### Cover Crop Biomass

The Control + BiOWiSH® treatment had an average total biomass of 1051 lbs/acre (1178 kg/ha), an increase of 9.7% or 93 lbs/acre (104 kg/ha) over the Control + Cover Crop treatment at the time of termination, suggesting improved soil conditions for increased plant vigor. Cover crop biomass was low overall for the site, given the dry fall conditions and late spring snowmelt during the trial year.

Table 2. Cover Crop Biomass Yield Results

Treatment	Cover Crop Biomass lbs/acre [kg/ha]
Control, Standard Fertility Program	0 [0]
Control + Cover Crop	958 [1074]
Control + BiOWiSH® Crop Liquid + Cover Crop	1051 [1178]

Figure 2. Cover Crop Representative Sample Comparison at the Time of Termination



Left: Control + Cover Crop

Right: Control + BiOWiSH® + Cover Crop

### Soil Analysis - Cover Crop

The table below compares the soil analysis results taken prior to the fall MAP application against the nutrient levels remaining in the spring at the time of the cover crop termination (prior to the fertilizer application for the subsequent corn crop).

The spring soil analysis for both cover crop treatments showed lower percentages of remaining fall-applied nutrient levels than the Control treatment. However, the BiOWiSH® Crop Liquid treatment retained higher amounts of Phosphorous and Potassium in the soil, compared to the Control + Cover Crop alone. This indicates that while the cover crop utilized soil nutrients over the winter and early spring, BiOWiSH® increased nutrient use efficiency and supported nutrient uptake for the cover crop, which appears to have helped mitigate nutrient loss coming into the next crop cycle.

Table 3. Soil Analysis Table, Spring Pre-Application Percentage of Fall Value

Treatment	Sample Timing	N ppm	P ppm	K ppm	OM %	pH
Control, Standard Fertility Program	Fall Pre-Application	7	11	122	3.7	6.1
	Spring Pre-Application	15	20	98	4.2	5.9
Spring Pre-Application Percentage of Fall Value		207%	186%	80%	114%	97%
Control + Cover Crop	Fall Pre-Application	7	11	122	3.7	6.1
	Spring Pre-Application	12	15	95	4.1	6.0
Spring Pre-Application Percentage of Fall Value		164%	143%	77%	109%	95%
Control + BiOWiSH® Crop Liquid + Cover Crop	Fall Pre-Application	7	11	122	3.7	6.1
	Spring Pre-Application	11	17	113	4.3	6.0
Spring Pre-Application Percentage of Fall Value		150%	162%	92%	115%	98%

### Corn Tissue Data

Similar to the soil data above, both cover crop treatments had similar or lower macronutrient levels in corn leaf tissue overall compared to the Control, with the exception of Potassium (K) in the Control + Cover Crop treatment.

Table 4. Corn Leaf Tissue Analysis Table

Treatment	N (%)	P (%)	K (%)
Control, Standard Fertility Program	3.39	0.31	1.33
Control + Cover Crop	3.32	0.30	1.47
Control + BiOWiSH® Crop Liquid + Cover Crop	3.10	0.29	1.29

## Soil Analysis - Corn

For nitrogen especially, the carry over effect of the BiOWiSH® Enhanced Fertilizer treatment improved nutrient use efficiency and supported nutrient uptake of the corn crop, resulting in higher yield than the Control + Cover Crop treatment.

Table 5. Soil Analysis Table, Post Corn Harvest

Treatment	Sample Timing	N ppm	P ppm	K ppm	OM %	pH
Control, Standard Fertility Program	Fall Pre-Application	15	20	98	4.2	5.9
	Spring Pre-Application	7	14	103	4.0	6.0
Spring Pre-Application Percentage of Fall Value		48%	69%	105%	95%	102%
Control + Cover Crop	Fall Pre-Application	12	15	95	4.1	6.0
	Spring Pre-Application	6	13	91	4.0	6.0
Spring Pre-Application Percentage of Fall Value		52%	87%	96%	99%	100%
Control + BiOWiSH® Crop Liquid + Cover Crop	Fall Pre-Application	11	17	113	4.3	6.0
	Spring Pre-Application	12	13	76	4.1	6.2
Spring Pre-Application Percentage of Fall Value		114%	74%	67%	95%	103%

## Nitrogen Recovery Efficiency (NRE)

Relative to the Control treatment, the Control + Cover Crop had a 10% reduction in NRE (less grain N per unit of applied fertilizer), and the Control + BiOWiSH® + Cover Crop treatment had only a 3.4% reduction in NRE. This is another indicator that BiOWiSH® increased nutrient use efficiency and supported nutrient uptake in the subsequent corn crop, relative to the cover crop alone.

## Corn Yield and Economics

Cover crops serve as a valuable tool for promoting soil health, addressing various challenges encountered by farmers. They contribute significantly to enhancing water infiltration, elevating organic matter levels, weed suppression, maintaining cool soil temperatures amid hot summer days, nutrient scavenging, and fostering soil biology. Nevertheless, it is crucial to note that in certain instances, cover crops may temporarily tie up essential nutrients during the initial growth stages of row crops, potentially impacting the ultimate yield potential.

Economic data on corn yield from the study is presented in the table below. The Control yielded 210 bu/acre (13.18 MT/ha). When instituting a cover crop for the first time, the yield was 178 bu/acre (11.16 MT/ha) for the Control + Cover Crop treatment, or a 32 bu/acre (2.02 MT/ha) yield loss. However, the addition of the BiOWiSH® to the cover crop program had a yield of 192 bu/acre (12.06 MT/ha), reducing the yield loss to only 18 bu/acre (1.12 MT/ha). Therefore, the Control + BiOWiSH® + Cover Crop program boosted the profitability of instituting the cover crop program by \$96 USD/acre (\$237 USD/ha).

The following table represents a typical impact of first-year cover crops on corn yield that was captured in this study, and for this reason it is appropriate to perform economic calculations between the two cover crop treatments.

Table 6. Yield and Net Income Table

Treatment	Yield bu/acre [MT/ha]	Yield Increase bu/acre [MT/ha]	Yield Increase %	Net Income USD/acre [USD/ha]	Profit Change USD/acre [USD/ha]
Control, Standard Fertility Program	210 [13.18]	-	-	1344 [3320]	-
Control + Cover Crop	178 [11.16]	-	-	1123 [2776]	-
Control + BiOWiSH® Crop Liquid + Cover Crop	192 [12.06]	14 [0.90]	7.9	1219 [3013]	96 [237]

\*Calculations for conversions between imperial and metric units are based on the original source data; slight rounding differences may occur within reported publication values.

\*\*Net income is the crop value minus the fertility program cost. It does not account for the non-fertility expenses.

\*\*\*Profit change is the difference between net income of the respective program and the Control.

## Conclusion

BiOWiSH® endophytic *Bacillus* deliver soil nutrients to crops through the rhizophagy cycle creating a symbiotic relationship between the plant and soil microbes. BiOWiSH® Crop Liquid, when added to a regional standard fertility program for fall applied MAP in a first-year cover crop program, optimized yield potential by improved nutrient uptake via a carryover effect in corn during the following season. The addition of BiOWiSH® resulted in a 14 bu/acre (0.9 MT/ha) yield increase over the Control + Cover Crop (an increase of 7.9%), which increased profit to the grower by \$96 USD/acre (\$237 USD/ha). While both cover crop treatments had lower yields than the Control, the BiOWiSH® treatment mitigated the typical yield impacts of a first-year cover crop rotation.

Relative to the Control + Cover Crop treatment, the BiOWiSH® treatment maintained similar or greater percent changes to soil/tissue nutrient levels and properties over both of the other treatments. This indicates that BiOWiSH® increased nutrient use efficiency and supported nutrient uptake across both the cover crop and the corn crop of this crop rotation system.

BiOWiSH® Crop Liquid subsequently emerges as a valuable ally in climate-smart programs, offering a significant contribution to a farmer’s toolkit for overcoming challenges associated with the adoption of innovative farming practices. BiOWiSH® allows farm operations to gain additional opportunities for increased income through various regenerative ag programs. Its potential to improve cover crop vigor by improved nutrient uptake, optimize soil conditions for greater root mass, and improve nutrient use efficiency makes it a powerful agent in maximizing the advantages of cover crops. In doing so, it not only amplifies the benefits derived from cover crops, but also acts as a mitigating factor against potential yield losses for this transitional practice.



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