Research Study

BiOWiSH® Crop Liquid

Evaluation of BiOWiSH® Crop Liquid on Wheat/Soybean Double Crop Systems

Executive Summary

BiOWiSH Technologies, Inc. engaged University of Arkansas as a third-party Contract Research Organization (CRO) to conduct a study to determine effects of BiOWiSH® Crop Liquid coated on to fall-applied diammonium phosphate (DAP) to create an Enhanced Efficiency Fertilizer (EEF), as part of a winter wheat/spring soybean double crop system. The study took place in Fayetteville, Arkansas. The trial compared three treatments:

- Control, Standard Fertility Program
- Control + BiOWiSH® Crop Liquid
- Optimized Fertility Program + BiOWiSH® Crop Liquid

In winter wheat, the Control + BiOWiSH® Crop Liquid treatment was observed to have a 3.8% yield increase over the Control, while the Optimized Fertility Program + BiOWiSH® Crop Liquid treatment had a 1.5% increase. In soybeans, the Control + BiOWiSH® Crop Liquid treatment experienced a yield increase of 21.4% over the Control, and the Optimized Fertility Program + BiOWiSH® Crop Liquid had a yield increase of 13.3%.

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® 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® 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.

BiOWiSH® 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 the University of Arkansas
Located in Fayetteville, Arkansas, the University of Arkansas (U of A) is the state's flagship public research institution and a land-grant university committed to advancing knowledge, innovation, and practical solutions for society. Through the Division of Agriculture and its statewide research and extension network, the university plays a central role in supporting farmers, agribusiness, and rural communities. Its College of Agricultural, Food and Life Sciences and Agricultural Experiment Station conduct cutting-edge research on crop production, soil health, and sustainable farming practices, providing science-based insights to improve agricultural productivity and environmental stewardship. By combining world-class research with outreach and education, the University of Arkansas helps drive progress in agriculture and beyond. For more information, visit uark.edu.

Objectives

The purpose of this study was to evaluate soil and plant nutrients, yield, and biology carryover effects to the following cash crop in a winter wheat and soybean double cropping system. The study also set out to define the farmer's economic benefit on wheat and soybean production using fall applied DAP fertilizerr coated with BiOWiSH® Crop Liquid. This study's combination of data is used to determine whether BiOWiSH® Enhanced Fertilizer can economically increase yields in both winter wheat and soybeans in a single fall application.

Implementation Program

This trial was initiated with winter wheat planting in mid-October near Fayetteville AR. In this trial, the standard regional fertility program (Control) for wheat consisted of a fall application of DAP fertilizer at a rate of 152 lbs/acre (170 kg/ha) followed by a spring application of Muriate of Potash (MOP) fertilizer after wheat harvest and before soybean planting, applied at a rate of 73 lbs/acre (82 kg/ha). The Control program was compared to a program that included the addition of BiOWiSH® Crop Liquid coated onto DAP at the same rate as the Control, as well as an Optimized Fertility Program consisting of DAP at a 20% reduced rate compared to the Control + BiOWiSH® Crop Liquid. The trial consisted of three treatments with six replicates in a randomized complete block design (RCBD). At the trial site, both the winter wheat and soybeans were planted in accordance with local practices. The crop was non-irrigated. There was no significant disease or pest pressure at the trial location.

Soil samples were collected pre-planting of the winter wheat and after soybean harvest. For both wheat and soybeans, plant nutrients were assessed by pre-flowering leaf tissue sampling and at harvest grain samples.

Table 1. Treatments, Fertilizers, and Application Timings

Treatment	Fertilizer	Application Rate lbs/acre [kg/ha]	Application Phase
Control	DAP	152 [170]	Fall
	MOP	73 [82]	Spring
Control + BiOWiSH® Crop Liquid*	Coated DAP	152 [170]	Fall
	MOP	73 [82]	Spring
Optimized Fertility Program + BiOWiSH® Crop Liquid*	Coated DAP	122 [136]	Fall
	MOP	58 [65]	Spring

**BiOWiSH® Crop Liquid used at manufacturer's recommended rate.*

Results

Soil Analysis

The tables below contain the trial's assessment for soil nutrients, leaf tissue and grain nutrients, yield, and farmer economics.

Wheat

Compared to the Control, the soil analysis for the BiOWiSH® treatments demonstrated similar nutrient levels post-harvest as a percentage of pre-treatment values and a better utilization of soil available nitrates.

Table 2. Wheat Pre-plant and Post-harvest Soil Analysis

Treatment	Sample Timing	Nitrate-N ppm	Phosphorus ppm	Potassium ppm
Control	Pre-treatment	11.5	14.0	69.5
	Post-harvest	12.0	13.5	54.0
Post-Harvest Percentage of Pre-Treatment Value		**104.4%**	**96.4%**	**77.7%**
Control + BiOWiSH® Crop Liquid	Pre-treatment	11.5	14.0	69.5
	Post-harvest	10.0	12.5	48.5
Post-Harvest Percentage of Pre-Treatment Value		**86.9%**	**89.3%**	**69.8%**
Optimized Fertility Program + BiOWiSH® Crop Liquid	Pre-treatment	11.5	14.0	69.5
	Post-harvest	4.5	13.0	56.0
Post-Harvest Percentage of Pre-Treatment Value		**39.1%**	**92.9%**	**80.6%**

Soybean

Compared to the Control, the soil analysis for the BiOWiSH® treatments showed similar post-harvest nutrient levels relative to pre-treatment values, but with an opposite nitrogen trend — indicating greater soil accumulation of nitrates. This increase in soil nitrates may suggest more efficient microbial nitrogen fixation, potentially reducing the crop's reliance on soil-available N.

Table 3. Soybean Pre-plant and Post-harvest Soil Analysis

Treatment	Sample Timing	Nitrate-N ppm	Phosphorus ppm	Potassium ppm
Control	Pre-treatment	12.0	13.5	54.0
	Post-harvest	8.0	8.5	70.5
Post-Harvest Percentage of Pre-Treatment Value		**66.7%**	**63.0%**	**130.6%**
Control + BiOWiSH® Crop Liquid	Pre-treatment	10.0	12.5	48.5
	Post-harvest	8.5	8.5	65.0
Post-Harvest Percentage of Pre-Treatment Value		**85.0%**	**68.0%**	**134.0%**
Optimized Fertility Program + BiOWiSH® Crop Liquid	Pre-treatment	4.5	13.0	56.0
	Post-harvest	9.0	8.0	63.0
Post-Harvest Percentage of Pre-Treatment Value		**200.0%**	**61.5%**	**112.5%**

Leaf Tissue Analysis
The soil was a silt-loam texture with pre-plant analysis showing a low CEC level of ~8.4 meq/100g and low P, K, S, Zn, Cu, and B. This limited nutrient holding capacity soil condition is not conducive to optimal leaf tissue nutrient levels.

Wheat
Compared to the Control, the plant tissue analysis for the BiOWiSH® treatment demonstrated similar nitrogen, phosphorus and potassium levels.

Table 4. Wheat Leaf Tissue Analysis

Treatment	N (%)	P (%)	K (%)
Control	0.92	0.07	0.42
Control + BiOWiSH® Crop Liquid	1.04	0.07	0.38
Optimized Fertility Program + BiOWiSH® Crop Liquid	0.92	0.06	0.44

Soybean
Compared to the Control, the plant tissue analysis for the BiOWiSH® treatment demonstrated similar nitrogen, phosphorus and potassium levels.

Table 5. Soybean Leaf Tissue Analysis

Treatment	N (%)	P (%)	K (%)
Control	4.20	0.28	1.43
Control + BiOWiSH® Crop Liquid	4.23	0.31	1.58
Optimized Fertility Program + BiOWiSH® Crop Liquid	5.29	0.37	1.53

Grain N Content
Compared to the Control, the BiOWiSH® treatments exhibited similar to higher grain nitrogen, phosphorus, and potassium.

Table 6. Wheat Grain Nutrient Content

Treatment	N (%)	P (%)	K (%)
Control	1.74	0.38	0.46
Control + BiOWiSH® Crop Liquid	1.81	0.46	0.54
Optimized Fertility Program + BiOWiSH® Crop Liquid	1.82	0.44	0.53

Table7. Soybean Grain Nutrient Content

Treatment	N (%)	P (%)	K (%)
Control	6.51	0.66	1.84
Control + BiOWiSH® Crop Liquid	6.54	0.60	1.67
Optimized Fertility Program + BiOWiSH® Crop Liquid	6.61	0.64	1.68

Yield and Economic Analysis
Measurements of yield for wheat and soybeans are presented in the table below. For wheat, the Control + BiOWiSH® treatment was observed to have a yield increase of 2.5 bu/acre (0.17 MT/ha) over the Control, and the Optimized Fertility Program + BiOWiSH® had a 1.0 bu/acre (0.07 MT/ha) increase. On soybeans, the Control + BiOWiSH® treatment was observed to have a yield increase of 7.5 bu/acre (0.51 MT/ha) over the Control, and the Optimized Fertility Program + BiOWiSH® had a 4.7 bu/acre (0.32 MT/ha) increase.

Economic data on wheat and soybeans yield from the study is presented in the tables below. The Control + BiOWiSH® treatment had a profit change of $17 USD/acre ($41 USD/ha) greater than the Control while the Optimized Fertility Program + BiOWiSH® had a profit change of $19 USD/acre ($46 USD/ha) greater than the Control.

Table 8. Wheat 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	65.3 [4.39]	-	-	410 [1012]	-
Control + BiOWiSH® Crop Liquid	67.8 [4.56]	2.5 [0.17]	3.8	490 [1053]	17 [41]
Optimized Fertility Program + BiOWiSH® Crop Liquid	66.3 [4.46]	1.0 [0.07]	1.5	480 [1058]	19 [46]

**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 non-fertility expenses.*

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

Table 9. Soybean 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	35.0 [2.35]	-	-	440 [1088]	-
Control + BiOWiSH® Crop Liquid	42.5 [2.86]	7.5 [0.51]	21.4	538 [1328]	97 [241]
Optimized Fertility Program + BiOWiSH® Crop Liquid	39.7 [2.67]	4.7 [0.32]	13.3	504 [1245]	64 [157]

**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 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 fall regional standard fertility program, increased yields of a winter wheat and soybean double crop system grown in Fayetteville Arkansas. Wheat increased from 65.3 bu/acre (4.39 MT/ha) with the Control to 67.8 bu/acre (4.56 MT/ha) for the Control + BiOWiSH® and 66.3 bu/acre (4.46 MT/ha) for the Optimized Fertility Program + BiOWiSH treatments respectively. For soybeans, the yield increased from 35.0 bu/acre (2.35 MT/ha) in the Control to 42.5 bu/acre (2.86 MT/ha) for the Control + BiOWiSH® and and 39.7 bu/acre (2.67 MT/ha) for the Optimized Fertility Program + BiOWiSH® treatments respectively.

Economic data is based on fertilizer prices at planting and commodity prices at harvest. At the time of this trial, the ratio of fertilizer price to commodity price presented an industry wide challenge. The 3.8% wheat yield increase of 2.5 bu/acre (0.17 MT/ha) and the 1.5% yield increase of 1.0 bu/acre (0.07 MT/ha) over the Control increased profit to the grower by $17 USD/acre ($41 USD/ha) for the Control + BiOWiSH® and $19 USD/acre ($46 USD/ha) for the Optimized Fertility Program + BiOWiSH® treatments respectively.

The 21.4% soybean yield increase of 7.5 bu/acre (0.51 MT/ha) and the 13.3% yield increase of 4.7 bu/acre (0.32 MT/ha) over the Control increased profit to the grower by $97 USD/acre ($241 USD/ha) for the Control + BiOWiSH® and $64 USD/acre ($157 USD/ha) for the Optimized Fertility Program + BiOWiSH® treatments respectively.

BiOWiSH® treatments maintained soil nutrient levels comparable to the Control. In-season leaf tissue and post-harvest grain analyses (Tables 4–7) showed similar to higher concentrations of nitrogen, phosphorus, and potassium. Because yields were higher with BiOWiSH®, equal-to-higher concentrations combined with a greater mass of grain (uptake ≈ concentration × yield) resulted in greater total nutrient uptake/removal per acre. Importantly, the one-time fall application of DAP fertilizer treated with BiOWiSH® Crop Liquid served both crops—carrying over from winter wheat to the subsequent soybean crop—enabling a double-crop system that outperformed uncoated DAP under standard practices while maintaining soil fertility for future seasons.

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