Effect of Starter Phosphorus Fertilizer in Soybean (2024), following P Applications to Corn (2023)

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Objective

Evaluate the agronomic and economic impacts of phosphorus (P) fertilizer applications in a soybean crop (2024), following P applications to corn (2023).

Background

The addition of P to a cropping system has been a longstanding practice within the agricultural industry. Phosphorous is often the nutrient of concern regarding water quality and the formation of toxic algal blooms (LaBarge, 2023). This study was conducted in the Western Lake Erie Basin, an area where producers are actively exploring strategies that are agronomically, economically, and environmentally sound when contemplating P amendments. This study took place in Fulton County, Ohio on a farm with Blount loam soil. This farm's management includes no-till across all acres, pattern drainage tile, and a soybean seeding rate of 168,000 seeds per acre. In 2023, the producer wanted to reintroduce P into this system after nine years of no P applications to evaluate potential yield advantages with added P. In 2024, no additional phosphorus was added to the system, and soybean yields were monitored in the same strips from the 2023 trial. The optimal P levels for Ohio field crops range from 20-40 parts per million Mehlich-3 for a traditional corn and soybean rotation (Culman et al., 2020).

Methods

This study was designed as a second-year study from the report published in 2023 titled "**Effect of Starter Phosphorous Fertilizer on Corn Yield – 1**". The 2023 study included seven replications arranged in a randomized complete block design (RCBD). The two treatments in the study were 1.) No P added to the starter fertilizer and 2.) 5 gallons of 10-34-0 added to the starter fertilizer at corn planting. In 2024, soybeans were planted in the same treatment strips and 2024 data was collected according to the location of 2023 treatments. No additional P was applied in 2024.

The strip treatments were 20 feet wide by 1330 feet long. All treatments received the same inputs except for starter P fertilizer. On September 12, 2023, a cereal rye/barley cover crop was flown on at a rate of 65 lbs/acre before corn harvest. At the V3 growth stage, soil cores were pulled for a standard soil test, Haney soil health test, and phospholipid fatty acid (PLFA) test. Soil samples were collected at 0–6-inch of depth from a composite sample of each treatment. Plant tissue samples were collected and analyzed at the R1 growth stage for each treatment. Yields and moisture values were obtained by using a calibrated yield monitor. Yields were adjusted to 13% moisture.

Results

Table 1. Soybean Yield Response to Phosphorous Application				
Starter P Rate (gal/ac 10-34-0)	**Soybean Yield (bu/ac)**	**Value of Grain ($/ac)**	**Cost of P ($/ac)**	**Return over P ($/ac)**
0	45.2a	452	0	452
5	46.1a	461	23	438
C.V. = 1.99				**LSD (0.05) .95**

Based on $10.00/bu soybean price in 2024 and $800/ton (10-34-0) in 2023.

Table 2. Weather Data		
	2024 Local Rainfall (Border View Weather Link)	**Historic Rainfall (Archbold, OH)**
May	2.52 in	2.28 in
June	2.98 in	2.6 in
July	2.68 in	2.17 in
August	5.19 in	2.13 in
Total	**13.37 in**	**9.18 in**

Table 3. Standard Soil Test (V3)					
Test Parameter	**Baseline (Pre-Plant)**	**No P**	**5 gal (10-34-0)**	**CV%**	**LSD (P<.05)**
OM %	2.8	3.8	4.2	14.98	NS
Phosphorus P-M3 (ppm)	23.3	33.8	33.3	11.4	NS
Potassium (ppm)	76.3	134.8	145.3	19.87	NS
pH	6.3	6.1	6.0	4.72	NS
CEC	11.8	15.8	16.4	15.0	NS
Ca %	64.8	66.6	65.9	8.21	NS
Mg %	17.1	12.6	13.4	9.12	NS

Table 4. Haney Soil Health Test (V3)				
Test Parameter	**No P**	**5 gal (10-34-0)**	**CV%**	**LSD (P<.05)**
CO_2 (ppm) Respiration	237.3	207.3	31.36	NS
Organic Carbon (ppm)	250.3	241.8	11.4	NS
MAC% (Microbially Active C)	94.9	84.2	23.14	NS
C:N	12.4	12.2	2.78	NS
Soil Health Score	24.0	21.7	18.21	NS
Available N (lbs./ac)	57.73	58.9	16.54	NS
Available P (lbs./ac)	38.4	35.4	40.72	NS
POxC (ppm) Active Carbon	481.8	499.8	12.71	NS

Table 5. Phospholipid Fatty Acids (PLFA) Test (V3)				
Test Parameter	**No P**	**5 gal (10-34-0)**	**CV%**	**LSD (P<.05)**
Total Biomass (ng/g) soil	4023	4635	21.2	NS
Functional Group Diversity	1.4	1.4	7.25	NS
Total Bacteria (% Biomass)	54.3	52.5	4.89	NS
Total Fungi (% Biomass)	7.1	6.8	44.45	NS
Protozoa (% Biomass)	0.8	0.3	76.2	NS
Undifferentiated (% of Biomass)	37.8	40.4	5.91	NS

Table 6. Plant Tissue Analysis (R1)					
Test Parameter	**Normal Range**	**No P**	**5 gal (10-34-0)**	**CV%**	**LSD (P<.05)**
Nitrogen %	3.25-5.00	5.1	4.8	13.25	NS
Phosphorous %	0.3-0.6	0.5	0.4	7.57	NS
Potassium %	1.5-2.25	2.1	2.1	10.11	NS
Magnesium %	0.25-.070	0.4	0.4	10.03	NS
Calcium %	0.80-1.40	1.2	1.3	5.83	NS
Sulfur %	0.25-0.60	0.3	0.3	8.79	NS

Summary

There was no statistically significant difference in 2024 soybean yield with the addition of P fertilizer to corn in 2023. Additionally, there was an economic disadvantage to the amendment. The P amendment returned a $14 per acre loss after the cost of the treatment was realized (Table 1). Soil and plant testing showed no significant difference with P fertilization (Table 3-6). Soil test P did not change significantly between treatments; differences between the baseline and in-season treatments are attributed to soil variation and different labs providing results. All samples were extracted using Mehlich-3 where appropriate.

These findings suggest that when STP is already above the agronomic critical level (20 ppm), additional P applications may offer no yield benefit, while posing potential environmental risks. Reducing or eliminating P inputs under these conditions could minimize unnecessary nutrient loading and improve water quality outcomes. Long term research suggests that it takes 20 pounds of P2O5 to increase (or decrease) STP 1 ppm. With no P application, research trials in Ohio corn-soybean rotations show a 0.8-2.1 ppm drawdown annually (LaBarge & Cochran, 2023). Future research should explore varying P rates, sources, and application timing to better understand their effects on both yield response and STP drawdown.

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