ASSESSING FALL APPLIED PHOSPHORUS SOURCES AND WHEAT COVER CROP ON THE FOLLOWING SOYBEAN PERFORMANCE

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ABSTRACT

Growers often maintain soil test phosphorus (STP) using ammonium phosphate fertilizers, such as diammonium phosphate (DAP, 18-46-0) or monoammonium phosphate (MAP, 11-52-0) and employ fall application to avoid competition for time and wet field conditions, both prevalent in the spring. However, fall application of nitrogen (N) with these P fertilizers presents a risk of N loss over the fallow period. One source that could minimize N loss during the fallow period is triple superphosphate (TSP; 0-46-0). This experiment evaluates wheat (*Triticum aestivum* L.) cover crop use of fall-applied P sources and the following soybean (*Glycine max* L.) yield and yield component in rotation to evaluate the response of soybean to wheat as a cover crop in different P management scenarios in the fall. Treatments are arranged in split plot design with cover crops as the main effects (with and without) and four fertilizer treatments [three P sources (DAP, MAP, and TSP) a no-P control] as subplots. Our results indicated that wheat biomass was similar among all treatments in an April sampling date but greater in DAP than other treatments when sampled in May, reflecting greater N use and demand as these cover crops grow during the spring period. Soybean yields were higher in the cover crop treatments than the no-cover crop control which could be explained by moisture preservation during the dry July and August in that year. More study years are needed to conclude the best fall-applied fertilizer practices in soybean seasons.

INTRODUCTION

According to the U.S. Department of Agriculture's National Agricultural Statistical Service (USDA-NASS), Illinois is the largest producer of soybean (*Glycine max* (L.) Merr.) in the United States. However, Studies in Illinois have shown that after the corn (*Zea mays* L.) and soybean harvests, there is a significant amount of nitrate-N leaching, which concerns the environment, especially the water quality. The Illinois Nutrient Loss Reduction Strategy (INLRS) suggests winter cereal cover crops (WCCC) as a management strategy that may effectively minimize nutrient loss and protect Illinois waters and the Gulf of Mexico (Sadeghpour et al., 2021). In Illinois, wheat is a common WCCC that offers several agronomic benefits. In addition to helping control weeds, it protects soil, reduces erosion, and minimizes nitrate-N leaching (Adeyemi et al., 2020). Farmers often use ammonium phosphate sources, such as diammonium phosphate (DAP) and monoammonium phosphate (MAP), to apply P fertilizers in the fall to meet their phosphorus (P) requirements. However, nitrogen (N), also present in these fertilizers, is vulnerable to leaching and denitrification during late fall and early spring fallow periods, which might result in environmental losses. When combined with various P sources, this study examines how these cover crops affect future soybean production and yield components and assesses whether a wheat (*Triticum aestivum* L.) cover crop can efficiently use N from fall-applied P sources.

MATERIALS AND METHODS

The experimental design was a randomized complete block design with split plot arrangements and four replicates in 2022-2023. The Main plots were cover crop treatments (wheat cover crop vs. a no-cover crop control). The subplots were four fertility treatments, including a no-fertilizer control, diammonium phosphate (DAP), mono ammonium phosphate (MAP), and triple superphosphate (TSP).

Wheat was planted in mid-October in fall 2022. The seeding rate for wheat was 1.6 million plant ac^{-1} with a row spacing of 7.5 inches. The wheat cover crop was terminated in mid-May 2023 before soybean planting. The plots were 10 ft wide and 40 ft long. In mid-May, a no-till drill was used to plant soybeans at 100,000 seeds ac^{-1}. The P fertilizer application occurred in the fall of 2022 when wheat was established. All plots, excluding the no-fertilizer control, received 200 lbs P2O5 ac^{-1}. This means that DAP and MAP treatments received 78 and 42 lbs of N ac^{-1}, respectively. The soybean was harvested on October $20^{th,}$ and at that time, plant population and yield components were measured. Data were evaluated for normality of the residuals and then analyzed with SAS statistical software at $p<0.05$, considered significant.

RESULTS AND DISCUSSION

Wheat Cover Crop Biomass and Nitrogen Uptake

Wheat cover crop biomass was similar among fertility treatments in April sampling (Fig. 1). Wheat cover crop termination timing is important for nitrogen (N) absorption. There was no statistically significant difference in wheat biomass between the fertilizer treatments when the wheat was terminated early in April, indicating that the wheat did not uptake sufficient nitrogen. Compared to other treatments, a significant increase in biomass was observed in the DAP-treated plots when termination was postponed until May. The difference could be explained by the fact that DAP has a higher N content than MAP, allowing wheat in DAP-treated plots to uptake more N as it grows. Delaying termination allowed the wheat cover crops in DAP plots to use the available N better, producing higher biomass than other treatments.

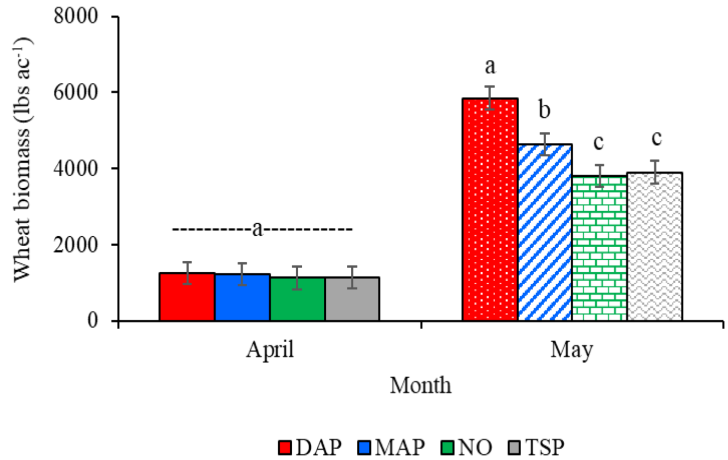

Fig 1. Wheat response to different fertility treatments in April and May (prior to planting soybeans). Bars are standard error, and similar letters indicate no statistical differences (Tukey ≤ 0.05).

Soybean Biological Yield, Grain Yield, and Harvest Index

Soybean biological yield (aboveground biomass including grain and plant parts) was influenced by cover crop treatment in which fallow had higher soybean biological yield than the wheat cover crop treatment (Fig. 2).

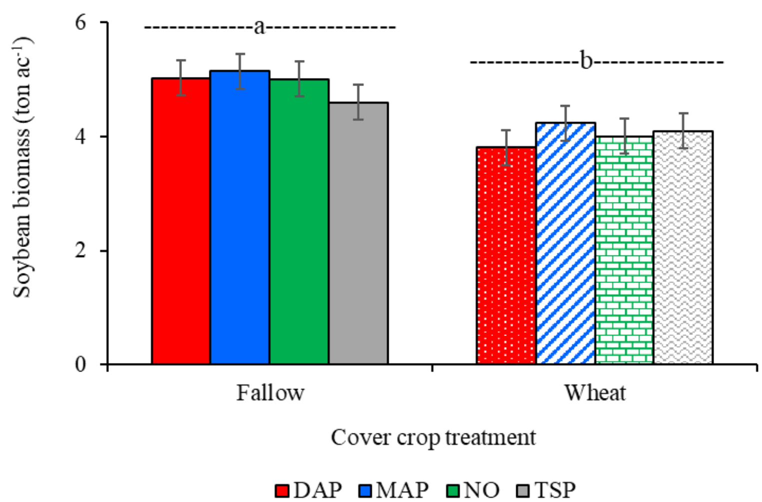

Fig 2. Soybean biological yield as influenced by cover crop and fertility treatments. Bars are standard error, and similar letters indicate no statistical differences (Tukey ≤ 0.05).

Soybean grain yield was higher in wheat treatments than the fallow treatments, but there was no fertility effect in each cover crop treatment (Fig. 3).

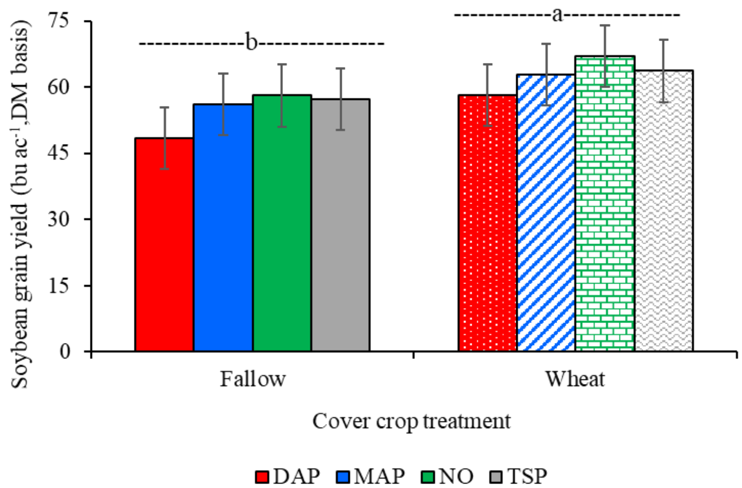

Fig. 3. Soybean grain yield (dry matter basis) as influenced by cover crop and fertility treatments. Bars are standard error, and similar letters indicate no statistical differences (Tukey ≤ 0.05).

Harvest index

Harvest index (%) affected by cover crop and fertility treatments. The harvest index was in the typical range for soybeans, with lower HI in fallow than wheat cover crop treatment (Fig. 4).

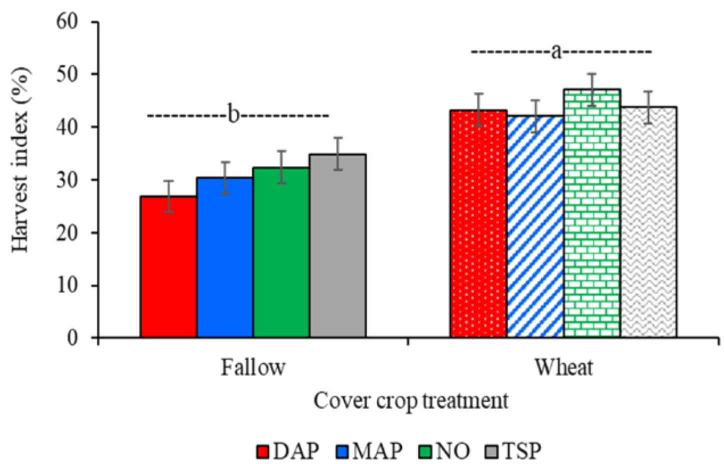

Fig. 4. Harvest index (%) affected by cover crop and fertility treatments. Bars are standard error, and similar letters indicate no statistical differences (Tukey ≤ 0.05).

Wheat Cover Crop Biomass and Nitrogen Uptake

Our results showed that wheat cover crop biomass was significantly higher in plots treated with ammonium phosphate fertilizers (DAP and MAP) than in those receiving TSP or no fertilizer. This suggests that the wheat cover crop used some of the N available in DAP and MAP, reducing the risk of nitrate leaching by capturing N during the fallow period. Additionally, N uptake by wheat was greatest in DAP-treated plots due to its higher N content relative to MAP. These findings emphasize the wheat cover crops' role in N maintenance, supporting its use as a winter cover to mitigate N losses.

Soybean Biological Yield, Grain Yield, and Harvest Index

Soybean biological and grain yields were higher in wheat cover crop treatment than the fallow control, particularly in treatments that received DAP and MAP. This finding suggests that cover crops help keep N during the fallow period and support following crop performance by preserving soil moisture and enhancing soil structure. The higher harvest index (HI) in plots with wheat cover-crop shows that a greater proportion of aboveground biomass was allocated to grain production, underscoring the potential of cover crops to improve resource use efficiency and yield outcomes in following cash crops.

Comparison with Previous Studies

Our findings align with those of Sadeghpour et al. (2021), who reported the benefits of winter cereal cover crops in reducing nutrient losses in Illinois, particularly in no-till systems where N holding is important for the following crop. Similarly, Adeyemi et al. (2020) noted that wheat cover crops help decrease nitrate-N leaching and promote soil conservation, consistent with the observed N uptake in this study. Vaughn et al. (2022) emphasized that cover crops mitigate N loss but may not reduce N leaching risks associated with fall-applied N. Our results support this, showing that although wheat cover crops reduce N loss, their effect is maximized when paired with high-N sources like DAP.

The soybean yield responses in this study align with Fernández et al. (2010), who verified positive yield impacts of ammoniated phosphates, particularly when N loss was managed effectively through cover crop integration. The higher harvest index in cover-cropped plots shows that wheat may contribute to better yield components by retaining soil N and moisture, at last supporting the cash crop’s productivity.

CONCLUSION

This study highlights the role of winter wheat cover crops in reducing N loss from fall-applied phosphorus fertilizers and enhancing soybean yield. Our findings show that ammonium phosphate fertilizers (DAP and MAP) used with wheat cover crops help retain N and reduce nitrate-N leaching. Notably, soybean grain yield, biomass, and harvest index were enhanced by cover crop presence, reflecting improved resource efficiency and environmental sustainability.

These results support the integration of winter cover crops with fall-applied phosphorus fertilizers, particularly in systems utilizing ammonium phosphates, to mitigate N loss, especially during the fall and spring periods. Future research should further explore the long-term effects of different phosphorus sources on N dynamics and crop performance to refine sustainable nutrient management practices in soybean systems.

ACKNOWLEDGMENT

This research was funded by OCP North America and the Illinois Nutrient Research Education Council (NREC). The authors thank Randy Lange and Chris Vick for their invaluable technical support throughout the study. Special thanks to the field crew at Southern Illinois University for their assistance in data collection.

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