EFFECT OF STARTER FERTILIZER AND PLANT DATE ON SOYBEAN GROWTH, NODULATION, AND YIELD

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Abstract

Environmental conditions at the time of planting are a crucial determinant to soybean (*Glycine max*) yield potential. In recent years, it has become common in Ohio to begin planting earlier in the growing season, as soon as mid- or late-April in some cases. However, soil conditions are typically cooler and wetter at this time as opposed to later planting dates, and nutrient availability may be limited. When planting soybeans into cool and wet soil, the application of a starter fertilizer may be beneficial in providing nutrients to assist in root and shoot development until soils warm in the spring and nutrients become more available. The objectives of this study were to evaluate the effect of starter nitrogen (N) and phosphorus (P) fertilizer on (i) soybean growth (above and below ground biomass), (ii) nodulation, (iii) plant nutrient concentrations; and (iv) soybean yield. Objectives were evaluated in 2013 and 2014 at Western Agricultural Research Station in South Charleston, Ohio. Four planting dates were evaluated in the study: before May 1, May 1 to 30, June 1 to 30, and after June 30. Five starter fertilizers were evaluated (urea, diammonium phosphate (DAP), urea + DAP, triple superphosphate (TSP), and none). Nitrogen was applied at a rate of 34 kg N ha^{-1} and phosphorus was applied at a rate of 45 kg P_2O_5 ha^{-1}. DAP was applied based on P rate. Fertilizer banded 5 cm beside and 5 cm below the row at planting. Results from 2013 indicated that nodulation at the R1 growth stage was reduced by both N and P starter fertilizer; however, root and shoot biomass were not affected at either the V2 or R1 growth stage. In 2013, there was a slight yield increase of 243 and 239 kg ha^{-1} in response to fertilizer-P in the TSP and DAP treatments, respectively, even though soil test P was above the maintenance range. Yield results have not been analyzed for 2014.

Introduction

The use of starter fertilizer can be a critical component of crop production management. Starter fertilizers are applied at the time of planting, providing a nutrient source within the rooting zone for young plants. They are typically recommended if soil fertility levels are considered low for the crop being grown, residue on the soil surface is high, and soil temperatures are low (Vitosh et al., 1995). Bermudez and Mallarino (2002) applied a starter fertilizer to no-till corn using precision agriculture technologies. They observed yield and early biomass increases of 2.4% and 32%, respectively, across all fields included in the experiment.

However, starter fertilizer is typically not used for soybean production. A primary reason for this is the lack application equipment on seed drills that are commonly used to plant the crop. While application of starter fertilizer may be an obstacle for growers, soils that are cold and wet can benefit from starter fertilizer, due to the slow mineralization of organic nutrients (Stanford et al., 1973; Stanford and Epstein, 1974). Nitrogen fixation by *Rhizobia* bacteria can begin as early as

14 days after planting in ideal soil conditions (Osborne and Riedell, 2006), and some studies have shown a response to nitrogen fertilizer applications (Boroomandan and Khoramivafa, 2009). Therefore, when planting soybeans into cool or wet conditions early in the growing season, N starter fertilizer applications could be beneficial in providing nutrients until nodulation begins.

In Ohio, no-tillage practices are common. In these no-till systems, nutrients can become stratified in upper layers of the soil profile (Crozier et al., 1999). Phosphorus has been shown to promote root growth in soybeans (Scheiner and Lavado, 2008). Applying phosphorus in a band next to the row at the time of planting could increase early root growth and biomass in fields under no-till management.

Due to Ohio weather patterns that can result in cold and wet spring soils, combined with the use of no-till systems, starter fertilizer applications at the time of planting may be beneficial to soybean growth and production. Therefore, the objective of this study was to evaluate the effects starter nitrogen and phosphorus applications on soybean growth, nodulation, and yield at several plant dates.

Approach

This study was conducted at the Western Agricultural Research Station of the Ohio Agricultural Research and Development Center (OARDC) in 2013 and 2014, near South Charleston, Ohio. In both years, the study was located on the Kokomo silty clam loam series (fine, mixed, superactive, mesic Typic Argiaquolls). Starter fertilizer treatments consisted of no fertilizer applied, urea, triple super phosphate (TSP), urea + TSP, and diammonium phosphate (DAP). These starter fertilizer treatments represent control, N only, P only (commercially unavailable), N + P (commercially unavailable), and N + P (commercially available) applications, respectively.

Soybeans (Asgrow 3231) were planted at 358,000 seeds ha^{-1} in 76 cm rows. Plots consisted of four rows and were 3 m by 12 m. The study was tilled with a chisel plow and soil finisher in the fall, and then planted directly in the spring. Starter fertilizer applications were banded 5 cm below and 5 cm beside each row at the time of planting. Treatments were applied at a rate of 45 kg P_2O_5 $ha^{-1}$and 34 kg N ha^{-1}.

At the V2 and R1 growth stages, plants from the non-harvested rows were sampled for nodulation and biomass accumulation measurements. Additionally, tissue samples were taken from the uppermost fully developed trifoliate and analyzed for total N and P concentration at the R1 stage. The center two rows of each plot were harvested and grain yield was corrected to 13.0% moisture.

The General Linear Model (Proc GLM) function was used to determine differences among means among starter fertilizer and plant date treatments. The Least Significant Difference (LSD) at $\alpha = 0.10$ was used to identify means in which treatments differed. All of the statistical procedures were done using SAS 9.3 (SAS Institute, 2012).

Results

There was no starter fertilizer by plant date interaction. Therefore, main effect of starter fertilizer is presented. Soybean grain yield was higher across all starter fertilizer application treatments in comparison to the control (4,923 kg ha^{-1}). However, only TSP (5,190 kg ha^{-1}) and DAP (5,182 kg ha^{-1}) applications were statistically significant at $\alpha = 0.10$. The 2014 trials have not yet been harvested (Figure 1).

In 2013, nodulation at the V2 stage was highest when no starter fertilizer was applied, averaging 24.3 nodules per plant sampled. However, variation among fertilizer treatments was not statistically significant in either 2013 or 2014 (Figure 2). In 2013, nodulation was significant at the R1 growth stage, with no fertilizer applied averaging 42.4 nodules per plant over urea, TSP, and DAP treatments, averaging 37.5, 37.2, and 34.9 nodules per plant, respectively (Figure 3). No significant differences were observed in tissue nutrient concentrations or biomass at both the V2 and R1 growth stages in 2013 or 2014 (data not shown).

Summary

Soybean yield was influenced by P starter fertilizer applications, with TSP and DAP treatments yielding approximately 243 and 239 kg ha^{-1} higher than when no fertilizer was applied in 2013. These yields were seen when initial soil P levels were 33 mg kg^{-1}, more than twice the current critical P level of 15 mg kg^{-1}. In 2014 initial soil P levels were 38 mg kg^{-1}. If similar yield results are obtained for 2014, this study may suggest that current soil fertility recommendations for soybean production in Ohio should be reevaluated. However, these yield increases came at the expense of reduced nodulation at the R1 stage. Despite increased yield and reduced nodulation, no significant differences in tissue nutrient concentrations or biomass production were detected at either V2 or R1 stage in both growing seasons.

As growers search for ways to improve soybean production, starter fertilizer applications may play a role in maximizing yield potential, particularly in years where soils are cool or wet at the time of planting and nutrient availability could be limited. While yield increases may be seen, it is important to consider the feasibility of such applications. Factors such as fertilizer costs, commodity prices, and equipment limitations could play critical roles in determining whether applying starter fertilizer to soybeans can be productive as well as profitable.

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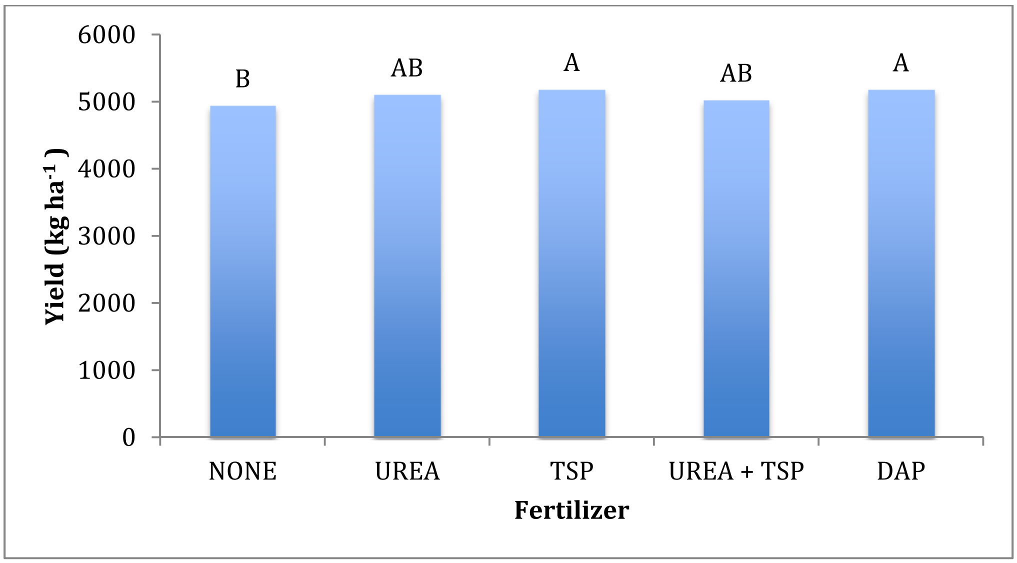

Figure1. Soybean yield by starter fertilizer application in 2013 at the Western Agricultural Research Station.

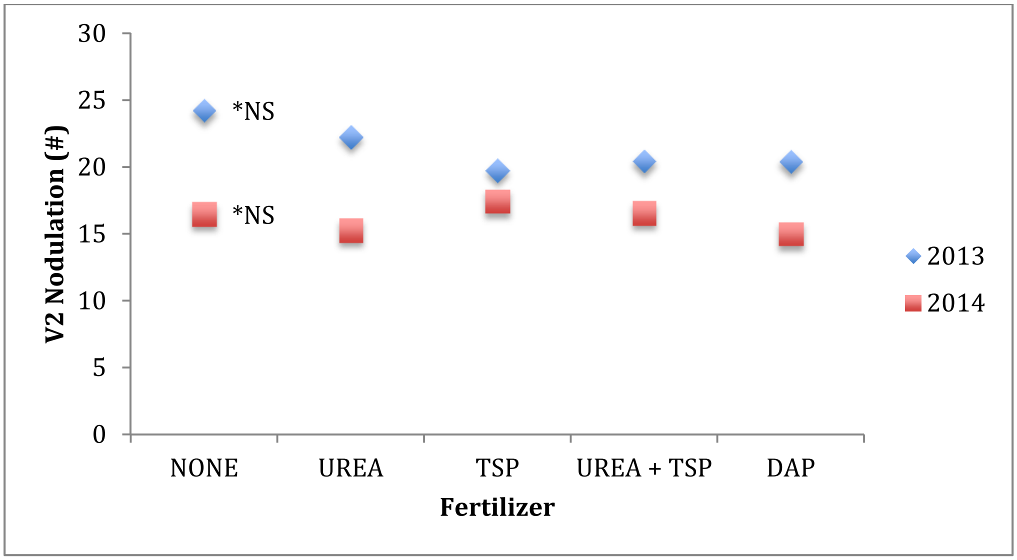

Figure 2. Soybean nodulation by starter fertilizer application at the V2 growth stage in 2013 and 2014 at the Western Agricultural Research Station.

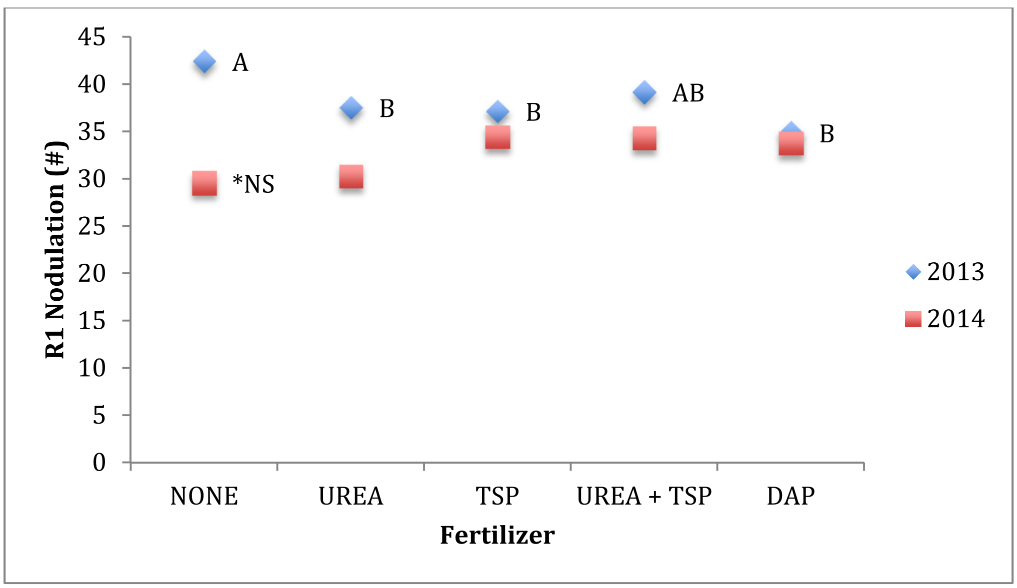

Figure 3. Soybean nodulation by starter fertilizer application at the R1 growth stage in 2013 and 2014 at the Western Agricultural Research Station.

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