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Soybean varietal response to late season nitrogen application at different plant populations

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ABSTRACT

Nitrogen is an abundant element important to many aspects of life as we know it. In plants, nitrogen is an essential macronutrient and is required by many agronomic crops, including soybeans [*Glycine max* (L.) Merr.], for multiple functions related to plant growth and development. Although abundant in the atmosphere, nitrogen uptake and utilization in plants is complex requiring nitrogen to be altered into forms available for plant uptake and assimilation. Legume crops, like soybeans, are able fix nitrogen from the atmosphere and utilize it for plant growth and development. However, as yields continue to increase in soybeans, the need for additional nitrogen might be necessary. This study was designed to evaluate the effectiveness of adding additional nitrogen to soybeans during the R3 growth stage.

Research was conducted in west central Missouri near Richards, Missouri. The study was a single-year study conducted in 2017 and was executed in a replicated strip-strip trial design. The study incorporated two other components in its evaluation as well, multiple soybean varieties, ranging from a 4.5 maturity group to a 4.9, as well as plant densities. Three different soybean varieties were planted at two different plant densities, 150,000 and 170,000. Each variety by density combination was left untreated, treated with 30 lbs/acre of nitrogen and lastly treated with 60 lbs/acre of nitrogen. Urea was the source of nitrogen utilized in this study.

Yield was significantly different between the three varieties utilized in this study. In addition, the three-way interaction of density by nitrogen rate by variety was also significantly different in yield. At the higher plant density, the two later maturity

varieties, yielded an average of over 4.5 bushels per acre better with 60 lbs per acre of nitrogen compared to the untreated control. At the lower plant density, no significant yield difference existed for any variety between either nitrogen rate when compared to the untreated control. In summary, at higher plant densities, this study concluded that later maturity varieties yielded more with an additional 60 lbs of nitrogen per acre applied as urea treated.

INTRODUCTION

Soybeans (*Glycine max*) are one of the most economically important grain crops in the world. They are used in many different food, feed and industrial products. A few examples of the many different products soybean components are used in include cooking oils, baking flour, ink, diesel fuel and swine feed. According to the USDA, processed soybeans are the largest source of animal protein feed and the second largest source of vegetable oil in the world (ERS-USDA, 2012).

Soybeans are produced all over the world in many different geographies and climates. In 2012, soybeans ranked number seven among all commodities in dollars of production in the world (FAOSTAT, 2012). The importance of soybeans for both food and industrial purposes, population growth, and limited land resources make it likely that we will need to produce more soybeans on the same or less acres in the future to meet the increasing demand.

Factors affecting soybean production

Soybean growth and development is influenced by many different environmental, genetic and management factors. Soybean plants are quite hardy when compared to many other crops, which is likely one of the reasons the crop is produced in as large of a geographical footprint. In addition, many genetic gains have been made in soybeans including added resistance to herbicides, resistance to certain pests and diseases, such as nematodes, and improvements in soybean oil stability and content. Management practices have evolved as well to compliment genetic gains and to mitigate some environmental risk. Such management tactics as irrigation, use of seed treatments and foliar fertilizer and fungicide applications have all impacted soybean production.

Like most other agricultural crops, soybeans have a large demand for nitrogen, phosphorus and potassium as well as other macro and micronutrients. Soybeans are capable of biologically fixing a large portion of the nitrogen required by the plant for growth and development. Given this ability, nutrient management, specifically for nitrogen, for soybeans has generally followed a "hands off" approach. However, while this approach might be adequate for lower soybean yield goals, when targeting higher soybean yield goals, a shortage in nitrogen likely occurs. At yields near 60 bu/acre, a nitrogen shortage occurs as nitrogen fixation cannot meet the nitrogen demand of the plant (Salvagiotti et al., 2008).

Nitrogen Fixation of Soybeans

Biological fixation of N in soybeans is the result of a symbiotic relationship between soybeans and *Bradyrhizobium japonicum* bacteria. The process involves the fixation of N_2 from the environment into NH_3, which is plant available. The bacteria infect the roots and forms nodules, where the process occurs. The bacteria rely on the plant for sugars as a source of energy. The plant utilizes the NH_3 produced by the bacteria for growth and development (Flynn and Idowu, 2012). Biological nitrogen fixation can be explained by the following equation:

$$\mathbf{N_2 + 8H+ + 8e^- + 16\ ATP = 2NH_3 + H_2 + 16ADP + 16\ Pi}$$ (Deacon, 2003)

Nitrogen fixation by soybeans comes at a cost to plants. Sugars are produced by soybeans during photosynthesis and are the main energy source used by soybeans for many different biochemical reactions. As shown above in the equation, nitrogen fixation requires 16 moles of ATP as well as electrons and hydrogen ions. Therefore, reactions and growth are sacrificed to some degree to supplement nitrogen fixation.

Ability of Biological Nitrogen Fixation to Supply N to Soybeans

Nitrogen fixation begins in soybeans during early vegetative stages, generally around the V2 growth stage. Fixation occurs by the plants up to late reproductive stages, generally around the R5 stage. During this period, soybeans are capable of fixing nitrogen available to the plant. Soil nitrogen processes can influence fixation and nodulation is usually reduced under higher nitrogen levels but increased under shortages. Fixation is slowed or stopped during late growth stages as the sugars and energy in soybeans are focused towards pods and seed fill and less on roots (Ruark, 2009).

Soybeans are able to produce a large portion of the total nitrogen required by plants through biological fixation. On average, soybeans are capable of acquiring 50-60% of their total nitrogen demand from biological fixation (Salvagiotti et al., 2008). Most notably, biological fixation is capable of supplying all of the nitrogen that is removed in harvested soybeans. Therefore, soybeans are considered to be neutral in nitrogen use and production. Figure 1 (Salvagiotti et al., 2008) shows the nitrogen budget of soybeans at different yield levels. As shown, N removal and N_2 fixation are very near the same with fixation supplying slightly more than is removed at all yield levels. However, N_2 fixation accounts for only a portion of the total N demand of soybeans as seen when compared to the total uptake. Approximately 40-50% of nitrogen demanded by soybeans comes from the soil.

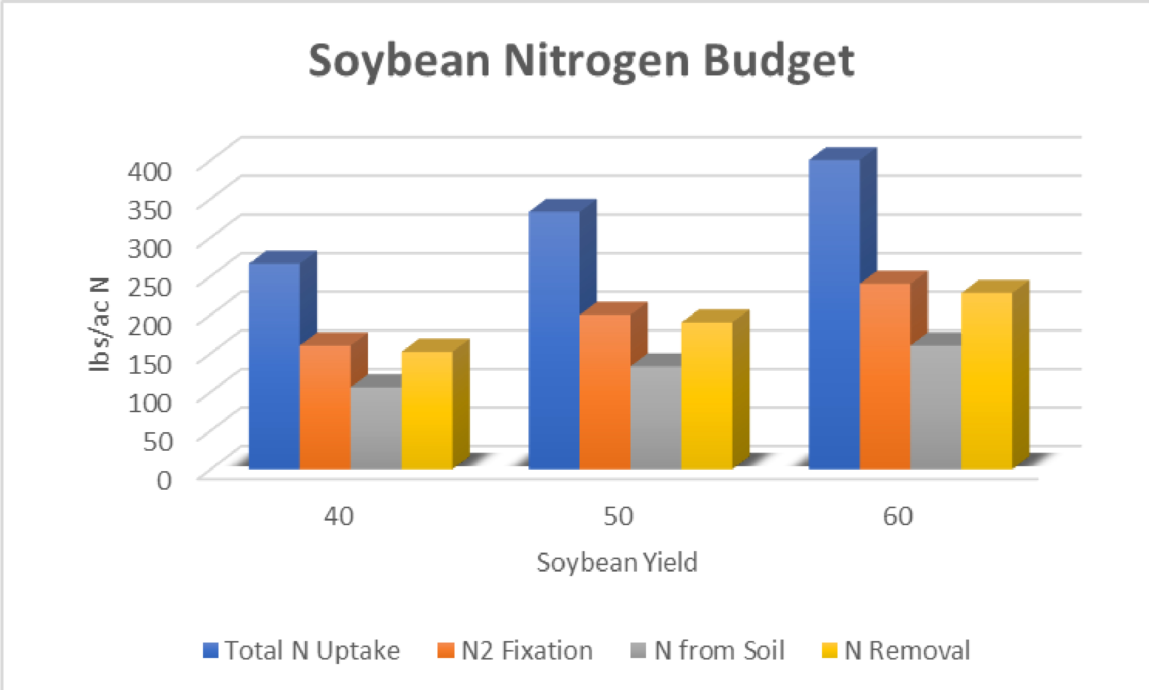

Figure 1. Soybean nitrogen budget and breakdown at different yield levels. (Salvagiotti et al., 2008)

Nitrogen Requirement by Soybeans

Nitrogen has many roles in plants. It is a major component of chlorophyll and therefore is very important to photosynthesis performed by plants. Nitrogen is also a main component of amino acids. Thus, protein formation is influenced by nitrogen. Proteins have both structural roles as well as roles in several biochemical reactions, mainly functioning as enzymes for these reactions. Lastly, nitrogen is a component of DNA, and thus is very important to growth, development and reproduction by plants.

Soybeans require a large amount of nitrogen for growth and development. Soybeans require nearly 5 pounds of nitrogen per bushel of grain produced. Of this nitrogen, approximately 60 percent is removed with harvested grain (Davidson, 2014). Even with the ability of soybeans to fix a portion of the nitrogen demanded, it is evident that additional nitrogen beyond fixed nitrogen is needed. This remaining nitrogen is obtained from the soil through mineralization and available nitrogen in solution.

Nitrogen Utilization by Soybeans

Soybeans use the largest portion of the total required nitrogen late in the growth cycle. Figure 2 below shows the cumulative proportion of nitrogen used at different growth stages by different plant parts. During the reproductive stages, nitrogen demand is the greatest with a majority of nitrogen being accumulated in seeds. Nitrogen at this stage is mainly contributing to seed yield and protein content.

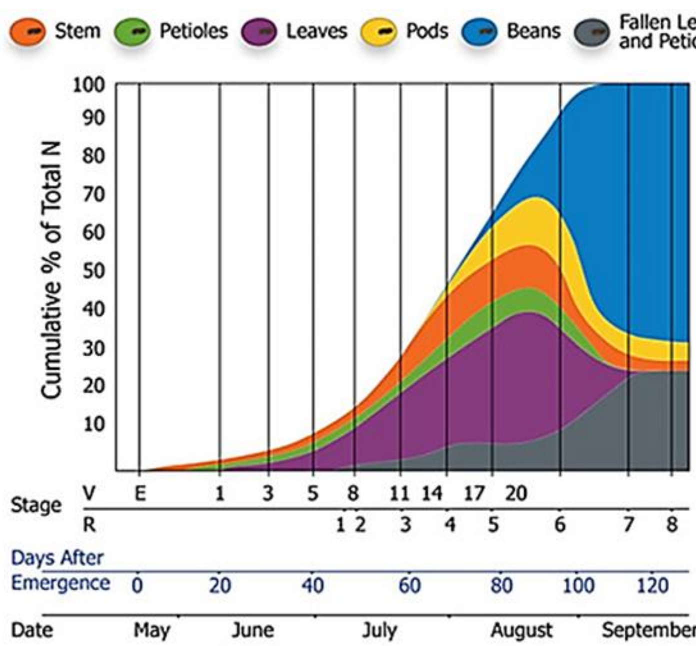

Figure 2. Nitrogen uptake of soybean by growth stage and part (Adapted from Ritchie et al., 1982).

When interpreting this graph with respect to nitrogen fixation, fixed nitrogen is likely capable of meeting plant demands up to later growth stages under normal conditions. During later growth stages when nitrogen demand is the highest and less resources are being devoted to the fixation process, the potential of a nitrogen shortage occurring increases.

Nitrogen Applications to Soybeans

Studies have been conducted on different forms of nitrogen applied to soybeans as well as different timings and methods of applications. Many different forms of nitrogen including ammonium nitrate, urea and UAN have been applied to soybeans in different studies. Studies have been performed on both early and pre-plant applications as well as late-season applications. In addition, application methods have been compared as well including broadcast, liquid streamed and fertigation. The outcomes of these studies vary greatly. Of the three variables listed, application timing seems to have the largest impact on results. Early and pre-plant applications generally do not prove to be beneficial as it delays nodulation and creates “lazy plants.” Late-season applications have generated the best yield responses, but can be inconsistent as well. Benefits from late-season applications are most consistent in higher yielding scenarios. An example of this can be observed in a study conducted in a higher yielding irrigation scenario in Kansas. Wesley et al. (1999) applied four nitrogen treatments to soybeans during reproductive growth stages. These treatments resulted in yield increases compared to the untreated check. Yield increases from application rates of 20 lbs of N and 40 lbs of N ranged from 3 to 10 bu/ac, depending on the nitrogen source and rate.

Application method and form do not seem to have as large of an impact on results. The main concern with these variables is negative side effects, such as burning of leaves, from either the nitrogen source, application method or a combination of both.

MATERIALS AND METHODS

This research evaluated the effect of an R2-R3 nitrogen application to different soybean varieties at different densities. The research was executed near Richards, Missouri. This research utilized three varieties, each exhibiting unique agronomic qualities relating to management recommendations and yield potential. Each variety was planted at a normal and high density for the area of research. Lastly, three different nitrogen rates were applied to each variety and density combination.

Location Description

Richards, Missouri was selected as the location to conduct this research trial in part due to the large presence of soybeans in the area. Richards is located in Vernon County, where in 2012 soybean acres totaled 72,742, making soybeans the leading crop for the county in terms of land occupied. The second crop, corn for grain, occupied 55,041 acres (USDA, 2017). The second factor leading to the selection of Richards was the availability of land to conduct the research on. Research was not conducted at multiple locations primarily due to land, machinery and time constraints.

The research was conducted on a rainfed farm that was managed using a corn-soybean rotation. Research was conducted on Parsons silt loam (Fine, mixed active, thermic Mollic Albaqualfs) (NRCS, 2015), a very common soil series for the area. Parsons silt loam is classified as a somewhat poorly drain soil with an A and E soil horizon less than 16 inches deep (NRCS, 2015).

Study Design

For this trial, a replicated strip-strip trial was utilized. Planting occurred in one direction and the nitrogen was applied perpendicular to planting. Each individual plot was 60 feet long, the width of a commercial spread pattern, by 40 feet wide, the width of the planter. Between each spreader pass, a 35 feet buffer was left to minimize overlap of fertilizer spread into the next pass. Every plot was replicated four times within the trial. This experimental design was used as it accommodated a nitrogen application method that could be used large scale. The design layout can be seen below in figure 3.

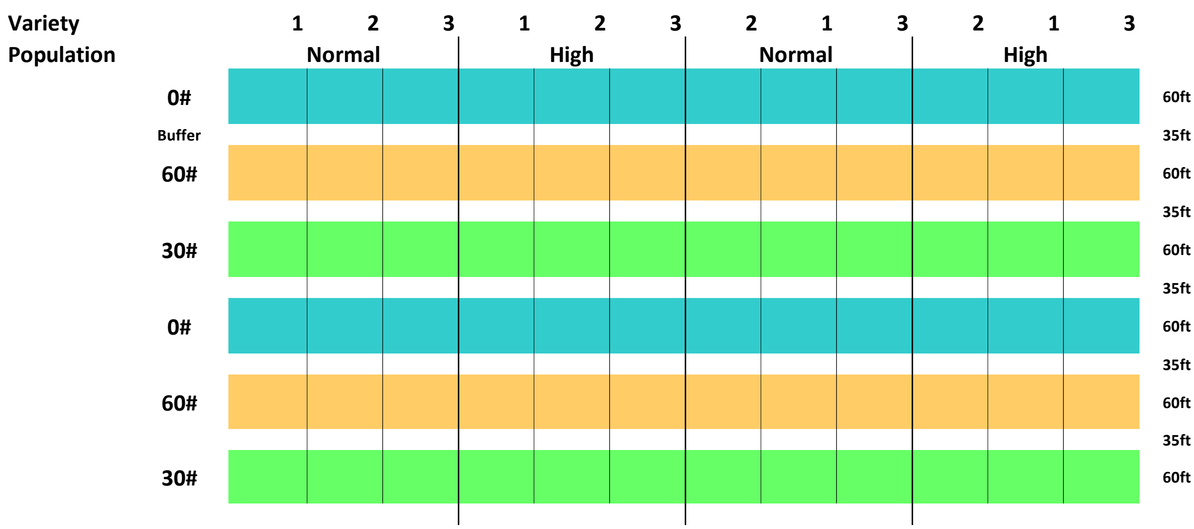

Figure 3. Experimental design. Replicated strip by strip by strip. Layout specific to trial conducted at Richards, Mo in 2017.

Study Management

This study was conducted using management practices common to the area where the research was located. The following information will provide guidelines as to how the research was initialized and executed.

Site Preparation

Little work was needed to prepare the site for the study. The location where the study was to be planted was selected in March based on several different criteria. For this study, a uniform area in the field was identified by looking at historical soil data and yield data to eliminate the potential for excessive uncontrollable effects. Once identified, the area was measured by the dimensions needed and marked with flags.

Prior to planting, a 27-70-70 fertilizer blend was applied to the entire plot area to provide adequate phosphorus and potassium for the soybean crop. This was broadcast over the field with a fan spreader in the fall and left unincorporated. A fall herbicide application was applied to the field as well. Autumn Super (iodosulfuron-methyl sodium, 6%, and thiencarbazone-methyl, 45%) was applied at a rate of 1 oz/acre.

Planting

The soybeans were no-till planted in 15-inch rows using a 40 foot Kinze 3660 planter (Kinze Manufacturing, Williamsburg, IA). Late group IV maturity soybeans were selected for the study. Planting occurred on May 30, right in the middle of the recommended planting window for the area. Conditions were ideal at planting with adequate soil moisture and warm conditions.

The varieties utilized in this study were selected based upon maturity as well as agronomic ratings. The three varieties selected were Asgrow 45X6, Asgrow 48X7 and Asgrow 49X6. Asgrow 45X6 is a medium tall plant with an agronomic package most suited for upland, more marginal growing conditions. Asgrow 48X7 has a tall plant structure and is agronomically more suitable for highly productive, irrigated ground or productive upland. Lastly, Asgrow 49X6 is the middle of the road compared to the other two and more diverse in its utility in different growing conditions (AgSeedSelect, 2019). These classifications were developed from an evaluation of several agronomic and plant characteristics, such as standability, disease tolerance, heat and moisture tolerance, etc.

Each variety was also planted at two planting densities, a normal density for the area and a rate approximately 15 percent higher. This component was included in the research as increasing plant populations has historically been a strategy utilized to increase crop yields. Higher populations and higher yields generally require more nutrients and other resources. Therefore, including the higher population provided opportunity to compare the additional nitrogen to a higher plant population as well as a lower population.

Crop Maintenance

In-season maintenance included a preemergent herbicide application just prior to planting. Authority Maxx (sulfentrazone, 62.12%, and chlorimuron ethyl, 3.88%) was applied at a rate of 6.4 oz/ acre, Xtendimax (3,6-dichloro-*o*-anisic acid, 42.8%) at a rate of 22 oz/acre and Roundup PowerMax (glyphosate, N-(phosphonomethyl)glycine, 48.7%) at a rate of 32 oz/acre. The application was made on 16 May. Approximately three weeks after planting, a post herbicide application was made. Roundup PowerMax was applied at 32 oz/acre and Warrant (acetochlor, 2-chloro-N-ethoxymethyl-N-(2-ethyl-6-methylphenyl acetamide, 33.0%) at 48 oz/acre. The trial remained clean of weeds throughout the growing season and hand-hoeing was not required.

Stand counts were also taken in two of the replications to confirm the population difference.

Nitrogen Application

The urea nitrogen used in this study was treated with a urease inhibitor (Agrotain®, Koch Industries, Inc., Wichita, KS). Two rates of application, 30 lbs and 60 lbs of actual nitrogen, or 65 lbs and 110 lbs of urea, respectively, were used. An untreated control was the third application treatment.

The urea was applied with a commercial high clearance fan spreader. Application width was 60 feet. As noted in the design layout above, a 35-foot buffer was left between each strip of urea to eliminate overlap. The 35 feet was selected as a buffer width as it is adequate to eliminate overlap and is the width of the combine head used to harvest, so the buffer could be easily removed from the study. The urea was applied to the soybeans at the R3 growth stage. The urease inhibitor was included to reduce the risk of ammonia volatilization.

Harvest

The study was harvested on October 27, 2017. The strips were harvested with a commercial combine and header, and each plot was weighed with a scale wagon and a moisture sample taken. Prior to harvest, both the combine and scale wagon were calibrated to ensure accurate results. A Case IH 8120 combine (CNH Industrial N.V., Amsterdam, Netherlands) and MacDon FD70 draper header (MacDon, Winnipeg, Canada) was used to harvest the plot.

Statistical Analysis

A statistical analysis was performed on the results of the study using the Statistical Analysis System (SAS). The GLM procedure was used to calculate the analysis of variance (AOV) and the LSMEANS procedure was used to determine the significance of mean comparisons at P=0.05. The analysis of variance and mean comparisons are included below in the results followed by discussion of the results.

Economic Analysis

The following information was used to provide an economic analysis of the additional seed and nitrogen required at the time the trial was conducted. A soybean price of $9 per bushel was used in the calculations, equivalent to what local grain merchandisers were paying at the time of harvest the year the study was conducted. In addition, a soybean seed cost of $55 per 140,000 seeds was used. The cost of urea treated with Agrotain® at the time of this study was $405 per ton. With an analysis of 46 percent, 920 lbs of actual nitrogen exist in a ton of urea, making the cost per pound of actual nitrogen $0.44.

RESULTS

Average yield across all nitrogen and population treatments for each variety can be seen below in table 1. Average yield across all varieties in the trial was 63.1 bu/acre. The earlier maturity variety, Asgrow 45X6, yielded 3.25 bu/acre less than the later maturing varieties.

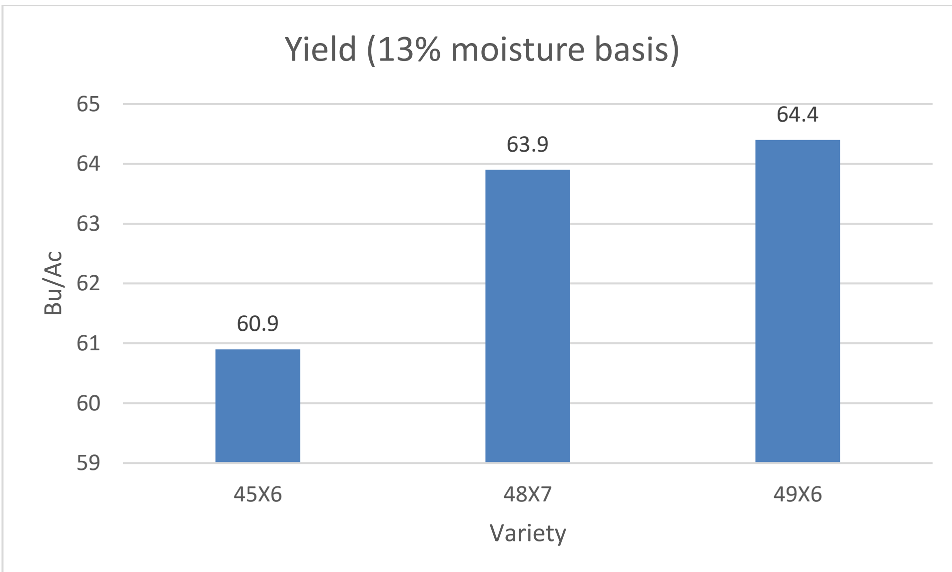

Table 1. Mean yield by variety across all population and nitrogen treatments.

Variety influenced grain yield (Table 2). Asgrow 45X6 yielded significantly less than Asgrow 48X7 and Asgrow 49X6 (*P*=0.0001). The effect of the three-way interaction of population by nitrogen rate by variety was significant on grain yield as well (*P*=0.017) (Table 2). The interaction means and means separations are captured in Table 3. At the high population (170,000), Asgrow 48X7 yielded 6.15 bu/ac more between the 30 lbs/acre of nitrogen and 60 lbs/acre of nitrogen treatments when compared to 0 lbs/acre at that population. Yield with 60 lbs/acre and 30 lbs/acre of nitrogen were 11.5% and 9.0% greater, respectively, than the 0 lbs/acre of nitrogen. Asgrow 49X6 yielded an average of 3.95 bu/ac more with 60 lbs/acre of nitrogen at the high population compared to 30 lbs/acre and 0 lbs/acre at the same population. With 60 lbs/acre of nitrogen, Asgrow 49X6 yielded 67.1 bu/acre, the highest yield in the trial, vs 61.6 bu/acre and 64.7 bu/acre with 30 lbs/acre and 0 lbs/acre of nitrogen.

No significant difference existed for population or nitrogen on yield or moisture as independent variables. Similarly, population by nitrogen rate (P × N), population by variety (P × V) and nitrogen rate by variety (N × V) did not differ significantly for yield or moisture.

For moisture, the population by variety interaction (P × V) was significant (P=0.0001) (Table 4). Both Asgrow 48X7 and 49X6 were significantly greater in moisture at the low population compared to the high population. Asgrow 45X6 was significantly higher in moisture at the high population compared to the low population. Asgrow 45X6 was also significantly lower in moisture compared to the other two varieties at the low population, and significantly higher in moisture at the higher population when compared to the other varieties.

Table 2. Analysis of variance of soybean grain moisture and yield (13% moisture basis) for three soybean varieties planted at three densities with three nitrogen fertilization rates. Richards, MO, 2017.

Parameter	Grain moisture	Grain yield
	%	bushel/acre
Population (P)		
150,000	9.7	62.8
170,000	9.7	63.4
N rate (N)		
0	9.7	62.2
30	9.7	62.8
60	9.7	64.2
Variety (V)		
45X6	9.7	60.9 b
48X7	9.7	63.9 a
49X6	9.7	64.4 a
Significance	*P* > F	
Population	0.813	0.439
N rate	0.536	0.328
P × N	0.348	0.582
Variety	0.321	0.0001
P × V	0.0001	0.619
N × V	0.667	0.101
P × N × V	0.987	0.017
CV (%)	1.4	3.9
R^2	0.57	0.79
RMSE	0.14	2.47

Table 3. Interaction means for grain yield (13% moisture) for the population by N rate by variety interaction.

	Population					
	150,000			170,000		
	Variety					
N rate	45X6	48X7	49X6	45X6	48X7	49X6
lbs/acre	bushel/acre					
0	58.2 a†	63.5 a	65.1 a	61.9 a	59.9 b	64.7 ab
30	61.5 a	63.0 a	64.5 a	60.6 a	65.3 a	61.6 b
60	60.9 a	65.1 a	63.1 a	62.2 a	66.8 a	67.1 a

† Means within rows followed by different letters differ significantly at $P<0.05$

Table 4. Interaction means for grain moisture for the population by variety interaction across N rate.

Population	45X6	48X7	49X6
seed/acre	—— bushel/acre ——		
150,000	9.6 b†	9.8 a	9.8 a
170,000	9.9 a	9.7 b	9.6 b

† Means within rows followed by different letters differ significantly at *P*<0.05.

DISCUSSION

Soybean yields from this study were above average for the respective area. Compared to the 2017 Vernon county average soybean yield of 43 bu/acre, the soybeans in this study were 32% above the average county yield (USDA, 2017). This can be attributed to the favorable growing conditions experienced in 2017 at the location where this trial was conducted. The 2017 growing season near Richards, MO included above average precipitation during the growing season. The 2017 precipitation was more than 7.5 inches above the 15-year average at harvest time for the trial field (Figure 4) (Climate, 2019). Temperatures during the 2017 were near average for the season as a whole, with slightly cooler than normal temperatures during late summer, but above average temperatures occurred during late September and early October (Climate, 2019).

Adequate soil moisture contributes to higher yielding crops in multiple ways. Nutrient availability in the soil and absorption by plant roots is directly affected by moisture in the soil (Viets, 1967). Both mass flow and diffusion, the two methods of nutrient movement to and into plant roots, are affected by soil moisture (Viets, 1967). Soil biological activity, mineralization and nitrification are all dependent on soil and environmental conditions as well.

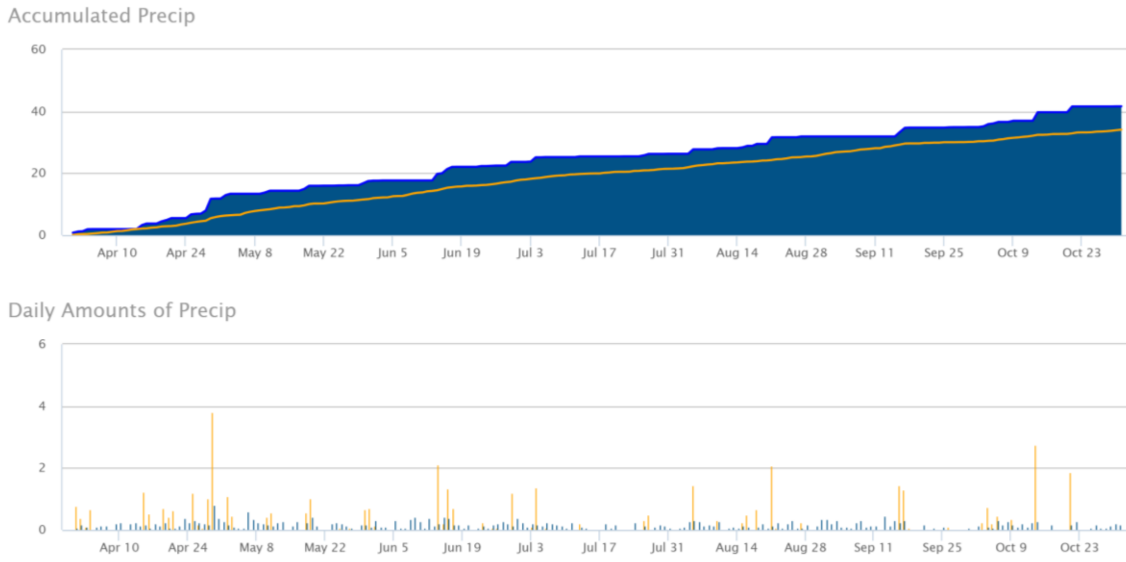

Figure 4. 2017 accumulated precipitation for growing season with daily precipitation amounts (Climate, 2019).

As soybean yield increases, demand for nutrients, both macro and micro, increase as well. Soybean yield has been demonstrated to be limited by nitrogen, particularly in high yielding scenarios (Cafaro La Menza et al., 2017). Biological nitrogen fixation has been shown to supply on average 50 percent of a soybean's nitrogen need (Salvagiotti et al., 2008). Many factors can limit biological nitrogen fixation, including but not limited to soil rhizobia populations, root growth and development, etc. Given that a soybean plant is not capable of fulfilling its entire nitrogen need by biological nitrogen fixation, soil nitrogen and other potential sources are needed for higher soybean yields (Bender et al., 2015).

Nitrogen mineralization from organic matter provides opportunity for nitrogen uptake as well. Studies have shown that each percent of soil organic matter will provide approximately 20 lbs/ac a year in the upper 17 cm of the soil profile (Fernández et al., 2012). From soil tests collected in 2016, the trial location average 2.4% organic matter content, with a range from 2.2% to 2.6%. Therefore, approximately 57.5 lbs of N could become available for uptake, depending on environmental and soil conditions.

Other sources of nitrogen include additions from fertilizer applications. Results from this study found a yield increase from applied nitrogen ranging from 2.4 bu/ac to 6.9 bu/ac. In a similar study conducted in 2015 by the University of Illinois, Crop Physiology Laboratory, urea applied at the R3 growth stage resulted in an average increase of 3.1 bu/ac across three locations in Illinois (Mann et al., 2015). The average yield treated with urea was 74.6 bu/ac, whereas the untreated control was 71.5 bu/ac. In another study conducted in Nebraska in 2006 and 2007, a yield increase of 3.39 bu/ac was obtained from the addition of nitrogen to soybeans when compared to the untreated check (Salvagiotti et al., 2009). Nitrogen was applied in this study both late season and early season.

In contrary, a 3-year study conducted in the late 1990s in Virginia did not result in a yield increase from the addition of nitrogen to soybeans at the R3 and R5 growth stages (Freeborn et al., 2001). This multi-year study had yields ranging from 35 bu/ac to 78 bu/ac.

Profitability

While the higher population combined with additional nitrogen resulted in greater yields, more costs are associated with these treatments when compared to the untreated check. The cost per acre for the normal population, 150,000 seeds per acre, was $58.90. For 170,000 seeds per acre, seed costs increased to $66.80 per acre. The difference in seed cost alone from the normal to the high population was $7.90 per acre. For the nitrogen application, a rate of 30 lbs/N per acre cost an additional $13.20 per acre, and for 60 lbs/N per acre, $26.40 per acre.

Given this information, both nitrogen rates applied to Asgrow 48X7 planted at 170,000 plants per acre did not generate a positive ROI. Compared to 48X7 planted at 150,000 plants per acre and untreated, neither treatment showed a positive ROI. At 150,000 plants per acre and no additional nitrogen, Asgrow 48X7 generated $512.60 per acre (yield multiplied by price less seed cost). Planted at 170,000 plants per acre and 30 lbs/N acre, $507.70 was generated and $508.00 for 60 lbs/N acre. Asgrow 49X6 also did not generate a positive ROI from the additional population and nitrogen. Asgrow 49X6 planted at 150,000 with no additional nitrogen generated $527 per acre, compared to $510.70 for the high population with the high nitrogen rate.

This research is in agreement with a study conducted in Mississippi near Stoneville in 2014 and 2015. Multiple nitrogen sources were used as well as timings from V4 to R1. Yield was found on average to increase from the addition of 90 kg N ha^{-1} and 179 kg N ha^{-1} by 9 and 7% when compared to the unfertilized soybean (McCoy et al., 2018). However, net returns decreased by \$50 ha^{-1} and \$220 ha^{-1} respectively for the two treatments resulting in higher yields. In another multi-year, multi-state study, nitrogen fertilizer addition to soybeans resulted in a 3.9% (4.27 vs. 4.11 Mg ha^{-1}) increase in seed yield in the states of Michigan, Minnesota and Wisconsin (Orlowski et al, 2016). However, this did not generate a breakeven return opportunity in these states, or in any of the other states included in the study in different regions of the U.S. as well.

CONCLUSIONS

The goal of this study was to evaluate the effect of an R3 nitrogen application to three soybean varieties planted at a normal population and high population relative to Southwest Missouri. As the results show, an increase in yield can result from additional nitrogen applied to soybeans planted at a higher population. However, not all varieties showed the same response. In addition, the higher rate of nitrogen generated significant yield increases by multiple varieties, while the lower rate only generated one.

While more yield resulted from a higher population and additional nitrogen, no higher population and nitrogen treatment combination proved to be economically viable over the normal population with no additional nitrogen. This economic viability was calculated at current costs and soybean prices at the time of the study and would be subject to change if costs or soybean prices changed.

Therefore, in conclusion, some varieties planted at higher populations will respond positively in terms of yield to nitrogen fertilization, however it would not be recommended to increase planting rates and apply additional nitrogen at the current market and cost levels.

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