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STARTER FERTILIZER EFFECTS ON SOYBEAN GRAIN YIELD AND QUALITY

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ABSTRACT

Fertilizing soybeans (*Glycine max* (L.) Merrill) is not an entirely new concept; for a number of years, scientists have investigated the effect of nitrogen (N) fertilizer on yield and quality of soybeans. The objective of this research was to investigate the effect of starter fertilizer N rates and sources on soybean yield, protein, and oil content in the cool soils of the Northern Great Plains. A field experiment was established within a two-year corn (*Zea mays* L.) soybean rotation. Using a split-plot design with four replications. Whole plots were no-till (NT) and conventional tillage (CT) and the split plots were starter fertilizer (two sources x four rates) treatments. Nitrogen sources were either ammonium nitrate (AN) or urea (UR) each applied at 0, 7.8, 15.7, and 23.5 kg N ha^{-1}. Grain yields were higher for 2000 growing season compared to 2001 largely due to differences in rainfall. A yield reduction resulted from the 7.8 kg N ha^{-1} rate during 2000. Maximum yield occurred at the 23.5 kg N ha^{-1} AN treatment. Application of UR had no significant effect on grain yield regardless of N rate. The only yield difference for the 2001 season was between the tillage treatments. Similar to 2000 data the 7.8 kg N ha^{-1} AN treatment had the lowest yield with maximum yield occurring at the 23.5 kg N ha^{-1} AN treatment, but the difference was not significant. We speculate that the former results could be due to a decrease in nodulation in the early growth stages and subsequent decrease in N fixation. Perhaps the 15.7 and 23.5 kg treatments provided enough soil N to overcome a delay in nodulation. Similar to the yield data, the 7.8 kg N ha^{-1} AN rate had the lowest N concentration, with the 15.7 kg N ha^{-1} AN rate having the highest. Oil content was significantly affected by tillage and N rate with the NT resulting in higher oil content. There was no significant difference for N concentration or oil content for 2001. Although there were few significant differences in the 2001 growing season and the differences in the 2000 were small, it is important to note that applying N as starter has the potential to increase soybean yield and quality when soil temperatures are cool.

INTRODUCTION

Although it is not a common practice to apply N fertilizer to soybeans some researchers speculate that the ability of soybeans to fix atmospheric N, is not always adequate for maximum yield. For this reason scientists have investigated the effect of N fertilizer on soybean yield and quality, but reseached mixed conclusions. The majority of this research was conduct when N was applied during the growing season, or in the southern United States where soil temperatures are adequate for early microbial activity. In the Northern Great Plains soil conditions at time of planting can limit microbial activity and thus delaying N fixation. Bergersen (1958) concluded that N fertilization before planting gave plants a better start, considering nodules were not

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present until nine days after planting. Nitrogen fixation begins 14 days after planting only under optimum moisture and temperature conditions (Hardy et al., 1971). Therefore adverse environmental conditions such as cool soil temperature could delay nodulation even more making N applied as starter increasingly important. The objective was to determine the effect of starter fertilizer N sources and rates on soybean yield, protein, and oil content in cool soils of the Northern Great Plains.

MATERIALS AND METHODS

A two-yr corn-soybean rotation experiment was established in the spring of 2000. The field experiment was located at the Eastern South Dakota Soil and Water Research Farm near Brookings, SD. Soil types included a Barnes clay loam (fine-loamy, mixed, superactive, frigid Calcic Hapludolls), and a Vienna-Brookings complex (Vienna - fine-loamy, mixed, superactive, frigid Calcic Hapludolls; Brookings - fine-silty, mixed, superactive, frigid Aquic Hapludolls).

Pioneer variety 91B01 soybeans were seeded at a rate of 95,000 seeds ha^{-1}. Planting occurred on 22 May 2000 and 30 May 2001 with an 8 row JD 7200 planter. The experimental design consisted of a split-plot design with four replications. Whole plots were tillage (no-tillage (NT) and conventional tillage (CT)) and the split plots were fertilizer (source x rate) treatments. Conventional tillage was performed with a chisel plow in the fall of each year and seedbed repaired in the spring using a field cultivator. Crop cultivation was performed in early July of each year. Starter fertilizer treatments were placed in a 2 x 4 factorial arrangement with two N sources, either ammonium nitrate (AN) or urea (UR), each at four rates (0, 7.8, 15.7, and 23.5 kg N ha^{-1}). Phosphorus (P) and potassium (K) were applied at 112 kg ha^{-1} of 0-36-13 (N-P_2O_5-K_2O) to all experimental units. All starter fertilizer was applied at planting in a 2 X 2 band. Plots were 6 X 15 m with 0.76 m row spacing.

Grain yield was estimated by harvesting 15 m of the two middle rows from each plot using a plot combine. Grain moisture and test weights were determined. Soybean grain yield was adjusted to 13 % moisture. Grain samples were oven dried at 125^0F, ground, and analyzed for N concentration using dry combustion and for oil content using near infrared reflectance spectroscopy. Data analysis was performed using the GLM procedure in SAS (SAS Institute, 1988).

RESULTS AND DISCUSSION

Grain Yield

Overall grain yields were higher for 2000 growing season compared to 2001, largely due to differences in rainfall; 5370 mm and 2835 mm for 2000 and 2001, respectively (Fig 1 and 2). There was a significant effect of N rate, source and interaction between N rate and source for the 2000 growing season, but only between the tillage treatments for the 2001 season (Table 1).

Results for the 2000 growing season found that the 7.8 kg N ha^{-1} decreased yield compared with all other treatments (208 kg ha^{-1} less than the zero N rate and 302 kg ha^{-1} reduction compared to the average of the other treatments). Maximum yield occurred at the 23.5 kg N ha^{-1} AN treatment, with at increase of 148 kg ha^{-1} over the zero N rate (Fig 2). Application of AN increased yield compared to UR for the two highest N rates, but there was no significant effect on yield for varying N rates within UR. There was no significant difference between the two tillage treatments, but the NT treatments had a slightly higher overall grain yield compared to the CT. This was possibly due to the decrease in precipitation from the normal during July and August (864 mm compared to 1397 mm). Cultivation during the early part of July for the CT could have resulted in a decrease in water holding capacity compared to the NT.

Table 1. Significance level from the analysis of variance for soybean grain yield, N concentration, and oil content, Brookings, SD, 2000 and 2001.

		--------------2000--------------			--------------2001--------------		
		Yield	N	Oil	Yield	N	Oil
Source	df	kg ha^{-1}	g kg^{-1}	g kg^{-1}	kg ha^{-1}	g kg^{-1}	g kg^{-1}
Rep	3	ns	ns	ns	ns	ns	ns
Tillage	1	ns	ns	*	**	ns	ns
Error a	3						
N Rate	3	***	***	***	ns	ns	ns
Source	1	**	*	ns	ns	ns	ns
N Rate*Source	3	***	***	*	ns	ns	ns
N Rate*Tillage	3	ns	ns	ns	ns	ns	ns
Source*Tillage	1	ns	ns	ns	ns	ns	ns
Nrate*Source*Tillage	3	ns	ns	ns	ns	ns	ns
Error b	63						

***, **, * - significant at the 0.001, 0.01 and 0.05 probability levels, respectively.
ns - not significant; df - degree of freedom.

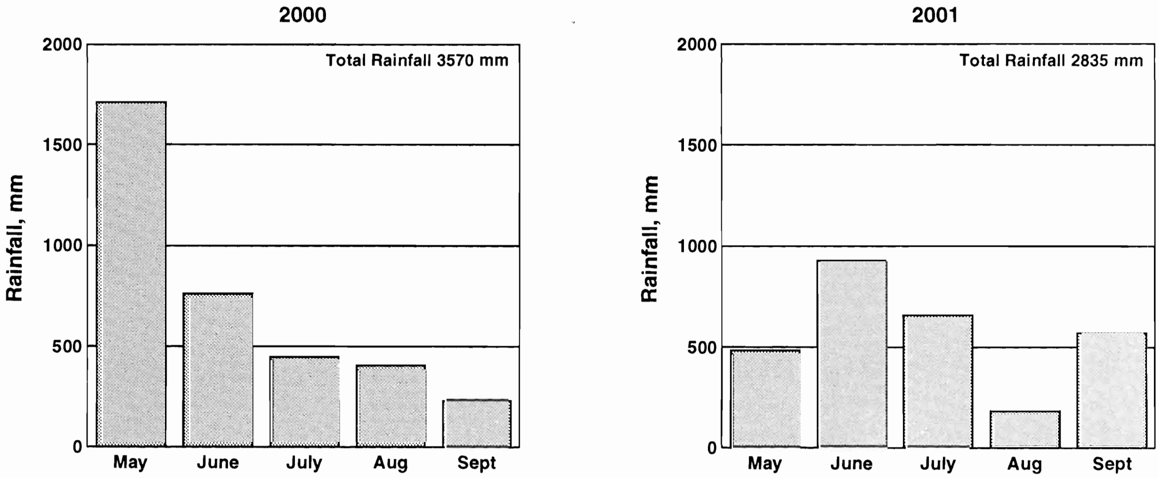
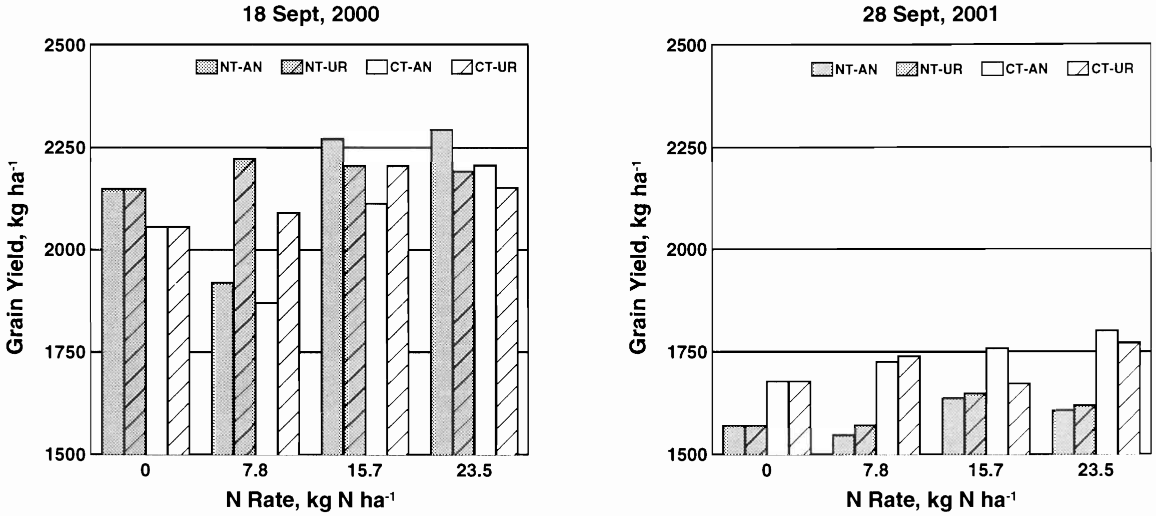


Figure 1. Monthly precipitation during the 2000 and 2001 growing season, Brookings, SD.

Lack of precipitation for the 2001 season was correlated with decreased yields (Fig 1). Better emergence in the CT compared to the NT could have cause the significant difference in grain yield (1733 vs 1597 kg ha^{-1} respectively). Although there was no significant effect N rate, there was a tendency for yield to increase with increasing N rate (Fig 2). Although not significant, but similar to 2000 data the 7.8 kg N ha^{-1} AN treatment had the lowest yield with maximum yield occurring at the 23.5 kg N ha^{-1} AN treatment. Because of cool soil temperature at time of planting there could have been a decrease in nodulation in the early growth stages with a subsequent decrease in N fixation. It is possible that the higher N rates provided enough additional N to the plant to overcome a delay in nodulation.

Figure 2. Soybean grain yield, by starter N rate, source and tillage, 2000 and 2001.



Grain Nitrogen

Grain N concentration was significantly affected by N rate, source and the interactions between N rate and source for the 2000 growing season, while there was no significant difference for the 2001 season (Table 1). As with grain yield the 7.8 kg N ha^{-1} resulted in the lowest N concentration, while the maximum N concentration was the 15.7 kg N ha^{-1} rate.

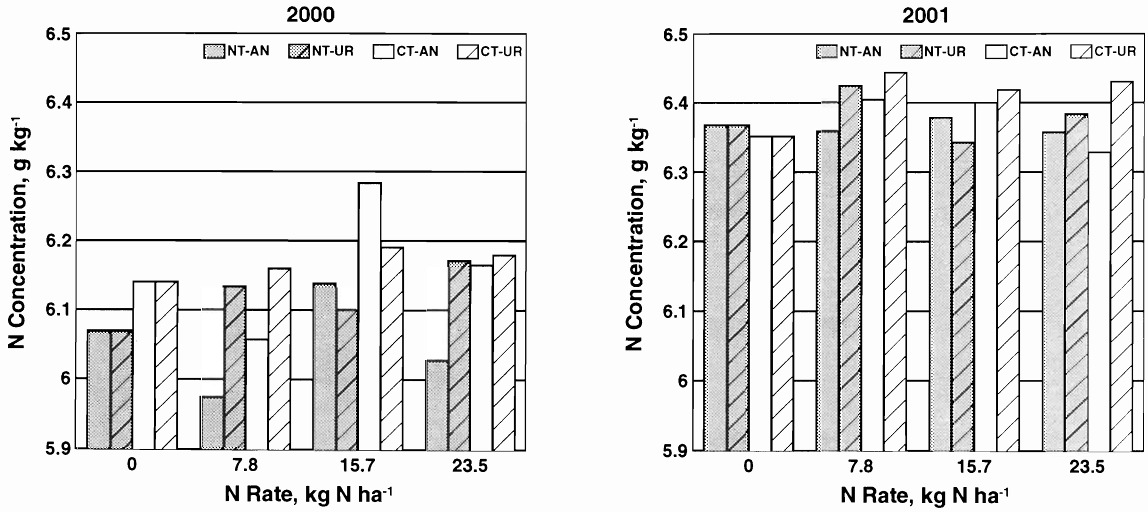


Figure 3. Grain N concentration, by starter N rate, source and tillage, 2000 and 2001.

Grain Oil

In contrast to the grain yield and N concentration there was a significant affect of tillage for oil content for the 2000 growing season, with the NT having the higher oil content (Table 1 and Fig 4). The 7.8 kg N ha^{-1} treatment had the highest and the lowest oil content with the NT having the highest and the CT having the lowest (Fig 4). There were no differenced for oil content for 2001 (Table 1), however the CT treatments generally had higher oil content compared to the NT treatment (Fig 4).

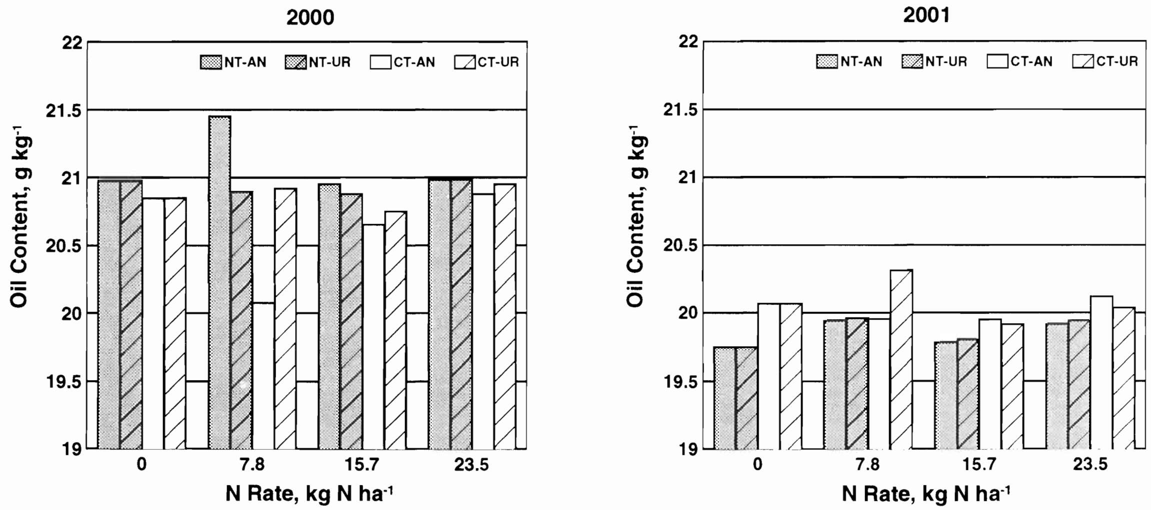


Figure 4. Soybean oil content by starter N rate, source and tillage, 2000 and 2001.

CONCLUSIONS

Adverse climate conditions decreased yield significantly in 2001 compared to 2000 and could have masked differences due to starter fertilizer. Grain yield and N concentration was reduced by applying 7.8 kg N ha^{-1} AN compared to other treatments. In general if N concentration increased oil content decreased. There seemed to be the potential to increase soybean yield and quality although small in certain environmental conditions as illustrated by the significant differences in the 2000 data and the trend in the data for 2001. Small differences in yield and quality may not be sufficient to offset additional fertilizer cost if starter fertilizer is not in the current management technique.

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