IN-SEASON NITROGEN FERTILIZATION OF SOYBEAN

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Introduction

Nitrogen (N) fertilization is not a traditional nutrient management practice for soybean production in Iowa. Soybean is a legume plant and is assumed to adequately obtain needed N through symbiotic fixation. However, there has been interest over the years in using N fertilization to increase yield and grain protein due to the recognition of the large N requirement associated with high yields. Depending on the soil residual inorganic N level and soil N mineralization characteristics, approximately 40 to 75% of the N in a mature soybean plant is derived from the soil (Shibles, 1998). Also, soybean seems to require this soil derived N for high yield. Nitrogen fertilization research in the upper Midwestern U.S. (residual nitrate, preplant, in-season, or foliar) has shown that while soybean yield can be increased, responses are inconsistent, vary by variety, location, pest presence, or growing condition, and rarely are economical (Oplinger and Bundy, 1998; Randall and Schmitt, 1998; Lamb, et al., 2000).

Also of importance is the impact soil nitrate supply has on nodulation and symbiotic fixation. Despite the fact that soybean is a legume, it readily utilizes soil inorganic N and will do so preferentially in almost linear substitution to symbiotic N_2 fixation. This interrelated N acquisition via soil and fixation presents a difficult challenge to increasing N in soybean directly through fertilization. One area of focus is soil-applied fertilizer N at approximately the R3 growth stage (beginning pod, ISU, 1988). Interest in this application timing stems from the recognition that nitrate conversion to amino acids within the soybean plant declines rapidly after this stage (largely due to soil mineral N depletion by the growing soybean crop) and that the greatest N requirement is when seeds are developing. Therefore, increasing the soil supply of mineral N during this time period is an attempt to increase and sustain peak nitrate utilization, and to do so without reducing N_2 fixation (Shibles, 1998). Wesley et al. (1998) did measure yield increases from N applied at this timing (the R3 growth stage) at six of eight irrigated sites in Kansas with low organic matter soils. However, yield response was inconsistent and occurred only at the high yielding (> 55 bu/acre) sites.

The overall objective of this research was to determine the impact of soil applied N fertilizer at the beginning pod stage (R3) of soybean growth on grain yield and seed quality components. Additional objectives were to study response to N fertilizer placement, material (N release characteristic), and rate.

Methods

This study was conducted in 1999 and 2000 at five Iowa State University Research and Demonstration farms (Lewis - Armstrong, Southeast - Crawfordsville, Northern - Kanawha, Northeast - Nashua, Northwest - Sutherland) that represent the major soil and climatic areas of Iowa. Site characteristics are listed in Table 1. Cultural practices were those typically utilized for soybean production in the geographic area. Corn was the previous crop and soybeans were planted in 30-inch rows at all sites. Soil test P and K were either adequate, or fertilizer was

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applied as indicated by soil test. The soybean varieties were locally adapted and chosen by the farm superintendent.

Treatments were soil application of urea or poly coated urea fertilizer (PCU – POLYON®AG supplied by Pursell Technologies, Sylacauga, AL – with a polyurethane polymer coating and expected release duration of four weeks at 86º F) at approximately the late R2 to beginning R3 growth stage (late full bloom to beginning pod, usually applied the last week of July). Nitrogen rates were 40 and 80 lb N/acre, and the control had no applied N. Fertilizer was either broadcast by hand across the plant canopy, or placed into a narrow one to two inch deep band between every other soybean row. A complete factorial arrangement of N treatments, plus the control, was replicated four times in a randomized complete block design. Plot size was either 15 or 20 feet wide (6 or 8 rows) by 50 feet long.

Grain was machine harvested, taking 3 to 6 rows (varied by research farm) the length of the plots. Reported grain yields were corrected to 13% moisture. Grain samples were analyzed by near infrared spectroscopy (NIR) for protein, oil, and fiber concentration (corrected to 13% moisture) by the Iowa State University Grain Quality Lab (Rippke et al, 1995).

Results and Discussion

Nitrogen fertilizer application had minimal to no impact on grain yield. Average yield of N fertilized plots at each site were not significantly greater than the control. This lack of response to in-season N application is consistent with recent work by Lamb et al. (2000) in Minnesota. A few statistically significant differences between treatments were measured at some sites, but these were inconsistent and even though statistically significant, the yield differences were small. Averaged over all site-years (Table 2), there was no effect from N placement, material, or rate on grain yield. Rainfall amount or timing after N application did not relate to yield response or lack thereof. Also, soil nitrate concentrations in the top two feet of soil at N application were generally low at all sites (average of 4 ppm for the 0-12 inch depth and 2 ppm for the 12-24 inch depth). Site-year average grain yields ranged from 34 to 61 bu/acre, with 4 of 10 sites having yields 55 bu/acre or higher.

Soybean grain protein, oil, and fiber concentrations were not influenced by N application treatments (Table 2 – oil and fiber quality component data not shown). As with grain yield, a few statistically significant differences between treatments were measured at some sites, but they were small and inconsistent. Differences in soybean grain quality between sites/varieties were much larger than any N application effects. Site-year average grain protein concentrations ranged from 30.7 to 37.6 percent. The average N effect on grain quality across site-years was not different than the control.

Conclusion

The in-season application of N fertilizer at the R3 growth stage did not positively impact soybean grain yield or grain quality components. With Iowa's high organic matter soils and rain fed production system, it appears that in-season N application to soybean is not a yield or grain quality enhancing practice.

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Table 1. Site characteristics, rainfall after N application, and soybean variety.

Site	Days from Application to > 0.25 Inch Rain (Amount)	Application to Aug. 30 Rainfall	Soil Name	Soil Organic Matter	Soybean Variety	Tillage
	days (inch)	inch		%		
1999						
Lewis	10 (1.75)	5.13	Marshall sicl	3.9	Pioneer P93B01	No-Till
Crawfordsville	9 (1.10)	6.03	Kalona sicl	5.4	Stine 3398-8	Fall Chisel-Disk-F.C.
Kanawha	13 (0.26)	1.22	Canisteo cl	6.1	Midwest G1912	Fall Chisel-Disk-F.C.
Nashua	2 (1.34)	4.83	Kenyon l	3.5	Asgrow 1980-4	Fall Chisel-Disk-F.C.
Sutherland	27 (0.48)	0.75	Galva sicl	4.1	Kruger K2343+	Fall Chisel-Disk-F.C.
2000						
Lewis	2 (0.30)	1.58	Marshall sicl	4.0	Pioneer 93B01	No-Till
Crawfordsville	3 (0.58)	2.39	Mahaska sicl	5.3	Stine 3398-8	Fall Chisel-Disk-F.C.
Kanawha	10 (0.67)	3.99	Canisteo cl	6.0	Midwest G1912	Fall Chisel-Disk-F.C.
Nashua	8 (0.39)	3.46	Kenyon l	3.8	Asgrow 2301	Fall Chisel-Disk-F.C.
Sutherland	5 (0.58)	4.71	Galva sicl	4.1	Kruger K2343+	Fall Chisel-Disk-F.C.

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Table 2. Effect of in-season N application on soybean yield and grain protein, averaged across all site-years.

Nitrogen Material	Placement	N Rate, lb N/acre 40	N Rate, lb N/acre 80	Placement Mean	Material Mean	N Rate, lb N/acre 40	N Rate, lb N/acre 80	Placement Mean	Material Mean
		- - - - - - - grain yield, bu/acre - - - - - -				- - - - - - - grain protein, % - - - - - - -			
Urea	Broadcast	51.8	52.1	52.0		35.3	35.3	35.3	
	Band	51.5	52.2	51.8		35.2	35.3	35.3	
	Urea Mean	51.7	52.1		51.9	35.3	35.3		35.3
PCU	Broadcast	51.6	51.6	51.6		35.4	35.5	35.4	
	Band	51.1	51.2	51.2		35.4	35.4	35.4	
	PCU Mean	51.3	51.4		51.4	35.4	35.5		35.4
	Broadcast Mean	51.7	51.9	51.8		35.3	35.4	35.3	
	Band Mean	51.3	51.7	51.5		35.3	35.4	35.4	
	N Rate Mean	51.5	51.8			35.3	35.4		
	N Application Mean	51.6				35.4			
	Control (No N)	51.1				35.3			

No statistically significant treatment effects or interactions, P=0.05.

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