Kansas Agricultural Experiment Station Research Reports

Volume 7
Issue 5 *Kansas Field Research*

Article 13

2021

Yield Response to Nitrogen Management in a Corn-Soybean Sequence in North Central Kansas

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Summary

The aim of this study was to evaluate the response of corn (*Zea mays* L.) grain yield to nitrogen (N) fertilizer application and its residual effect on soybean (*Glycine max* (*L.*) Merr.) seed yield. During the 2020 growing season, a corn-soybean rotation study was continued at Scandia, KS (USA), evaluating five N fertilizer rates in corn under both dryland and irrigated conditions. Average corn grain yields ranged from 110 to 206 bu/a for dryland, and from 198 to 221 bu/a for irrigated conditions. Under dryland, maximum corn yields were achieved with an apparent soil N supply level of 350 lb N/a (fertilizer N plus soil N); while removing the water limitations with irrigation resulted in corn grain yields maximized with ca. 250 lb N/a. Average soybean seed yields varied from 66 to 72 bu/a for dryland and from 72 to 79 bu/a for irrigated conditions. A lack of significant residual effect from previous corn N management was observed on soybean yields.

Introduction

The objective of this study was to continue the assessment, under both rainfed and irrigated conditions in north central Kansas, of the response of corn (*Zea mays* L.) grain yield to N fertilizer and the residual effects of the N fertilization practice on this crop on the following soybean crop.

Procedures

A second year of a long-term study under a corn-soybean rotation was continued in the 2020 season at the North Central Kansas Research Station (Scandia, KS; 39°49'41.60"N, 97°50'22.07"W) in a Crete silt loam soil (fine, montmorillonitic, mesic Typic Argiduolls/Pachic Argiustoll). At corn planting time (April 27, 2020), six cores per soil sample were collected per plot at 0–6 inches soil depth in both corn and soybean plots under rainfed and irrigated areas. General soil fertility was evaluated by testing for pH, soil organic matter (SOM, %), soil texture (%), extractable (M-3) phosphorus (P, ppm), potassium (K, ppm), and N as nitrate (NO_3-N) and as ammonia (NH_4-N) (Table 1). Additionally, 3 cores per plot were collected at 0–24 inches to evaluate initial soil N availability. Seasonal weather data were gathered from the Kansas Mesonet (https://mesonet.k-state.edu/) (Figure 1) from the North Central Kansas Research Station (Scandia, KS).

The corn experiment consisted of a total of five fertilizer N rates (Table 2) under a randomized complete block design with five replications in plots 20 ft width by 50 ft length. Soybean served as the previous crop for corn plots. Under the same design, the N rate management on the previous corn crop (2019) was used as treatment for the 2020 soybean crop. Corn was planted on April 27, 2020, and soybean on May 15, 2020. Corn plots were mechanically harvested using a combine on September 30, 2020 from the two central rows then scaled to bu/a. Corn yields were corrected to 15.5% moisture content. Soybean plots were mechanically harvested using a combine on October 13, 2020, from the two central rows then scaled to bu/a. Soybean seed yields were corrected to 14% moisture content.

Data Analysis

The yield data analysis was executed by performing an analysis of variance (ANOVA) split by irrigation condition. For each condition, a mixed model was considered, with treatment (N rate) as the fixed factor and block as the random factor. When significant treatment effect was observed ($P \leq 0.05$), mean comparisons were performed using the Tukey's adjustment procedure. Analyses were carried out using the *nlme* and *emmeans* packages of R software (R Core Team, 2020). Nitrogen response curves were evaluated with regression analysis using a quadratic function using nls function from stats package.

Results

Soil Fertility

The topsoil fertility showed similar levels between dryland and irrigated areas, with slightly acidic soil pH, adequate SOM level (ca. 3%), medium soil P, and high K. Initial soil N availability at 0–24 inches (NO_3-N plus NH_4-N) were high in both cases ranging from 98 to 133 lb/a and from 115 to 132 lb/a for dryland and irrigated areas, respectively. In both cases, at least two thirds of N was in the NO_3 form.

Weather

The total precipitation during the planting-maturity period (May-September) was about 16 inches (Figure 1A). The precipitation distribution pattern denoted a dry period at the beginning of the season (< 3 in. during the first month). More regular and abundant precipitation events were registered during June-July, ending with a dry August but with very good radiation levels during the post-flowering period. No days with heat stress risks (T_{max} > 95°F) were registered (Figure 1B).

Corn Grain Yield

In spite of the high initial soil N availability, corn grain yield significantly responded to N fertilizer rate under dryland conditions (Figure 2). In contrast, no significant yield response to N was observed under irrigation, presumably due to a better soil N mineralization synchrony with crop N demand, possibly more limited due to water stress under rainfed management. Following adjusted N-response curves, the maximum yields were achieved at 214 lb N/a under dryland conditions, while approximately 110 lb N/a were enough to maximize yields under irrigation (Figure 2A). When initial soil N availability was added to the N rate, the apparent N supply to achieve maximum yields resulted ca. 350 lb N/a under dryland, while ca. 250 lb N/a under irrigation. The latter denotes a higher use efficiency of the initial N supply related to the better water conditions for

the crops, but also presumably due to greater levels of soil N mineralization during the season (Figure 2B).

Soybean Seed Yield

Soybean yields varied from 66 to 71 bu/a for dryland and from 72 to 79 bu/a under irrigation (Figure 3). Negligible effects of the corn N management from the previous season were evident for both water scenarios for soybean seed yield.

References

R Core Team. 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Table 1. Soil fertility (0–6 inches) at planting of corn and soybean crops at irrigated and dryland areas in Scandia, KS, for the 2020 cropping season

Crop	0–6 in. depth	pH	SOM	Clay	Silt	Sand	P	K	$N\text{-}NO_3$	$N\text{-}NH_4$
		-	%				ppm			
Corn	Dryland	5.8	3.1	28	60	12	14.9	510	15.4	5.9
	Irrigated	6.3	2.8	24	58	18	17.9	490	29.9	7.5
Soybean	Dryland	5.8	3.0	23	59	18	11.3	511	17.4	8.5
	Irrigated	6.1	2.8	22	59	19	16.9	488	20.8	5.6

SOM = soil organic matter.

Table 2. Crop management practices for corn and soybean crops at Scandia, KS, for the 2020 cropping season

Practices	Corn		Soybean	
Irrigation	Dryland	Irrigated	Dryland	Irrigated
Tillage	No-till			
Planting date	04/27/2020		05/15/2020	
Genotype	P1197YHR		P39A58X (RR2-Xtend)	
Seeding rate	29,000 seeds/a	35,000 seeds/a	110,000 seeds/a	140,000 seeds/a
Row spacing	30 in.			
P fertilization	23 lb P/a			
N fertilization	0, 53, 107, 161, 214 lb N/a		---	

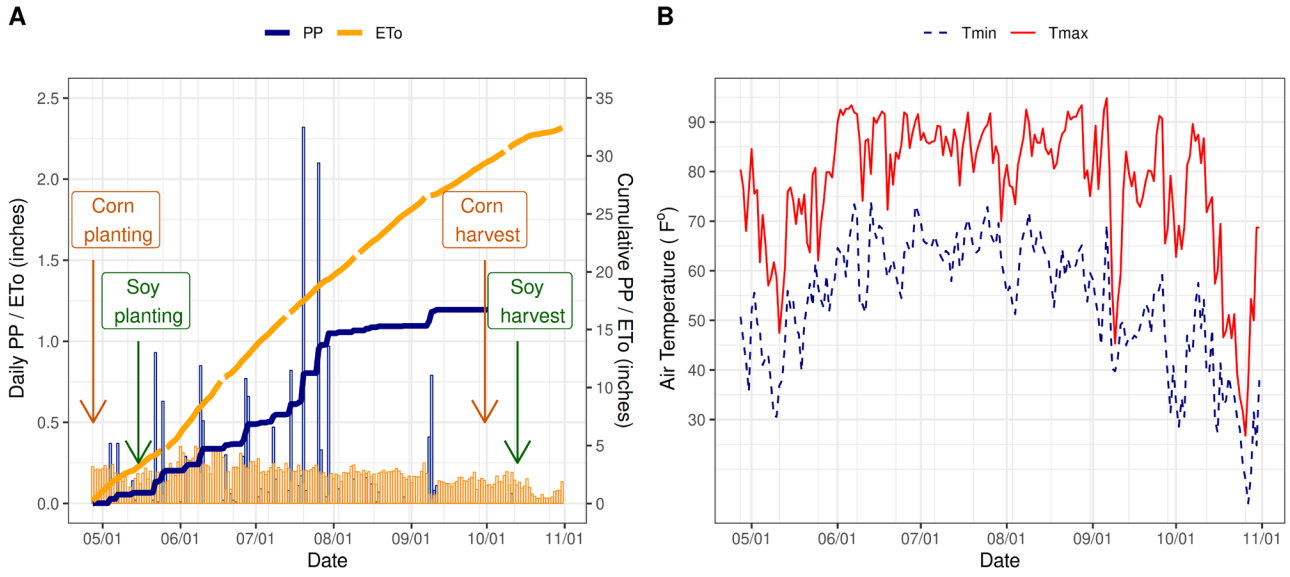

Figure 1. A: Daily and cumulative precipitation (PP) and reference evapotranspiration (ETo); B: daily minimum and maximum air temperature, on the right, for the 2020 cropping season at Scandia, KS.

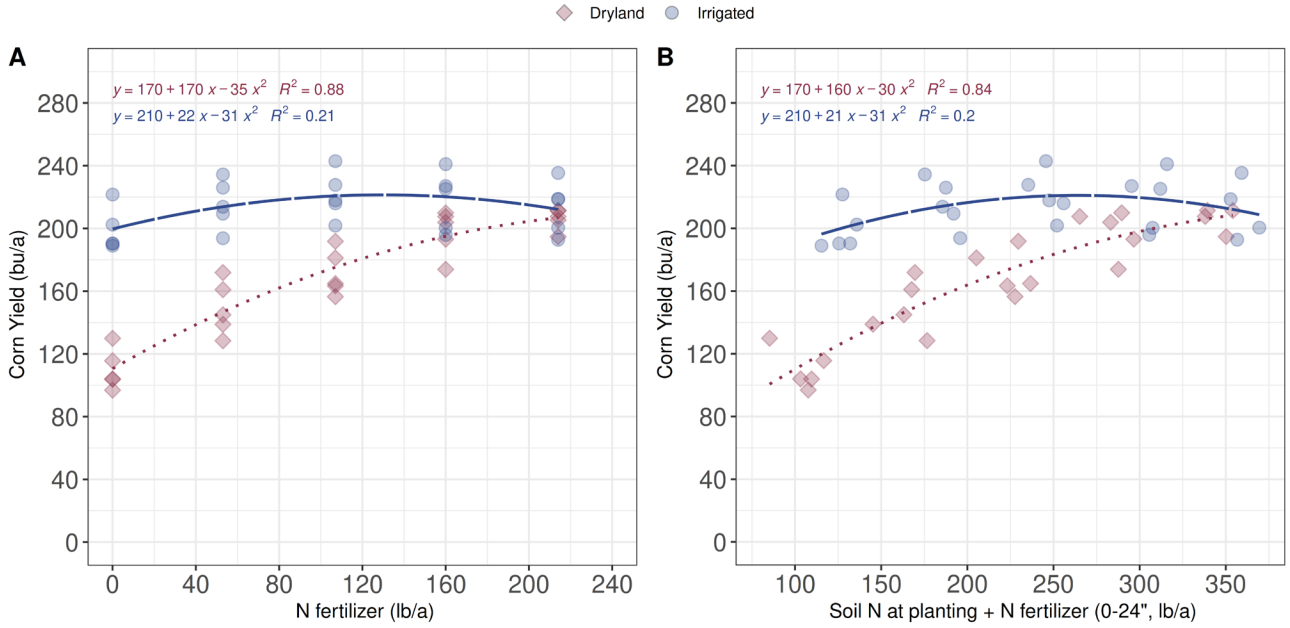

Figure 2. A: Corn grain yield (bu/a) versus nitrogen (N) fertilizer rate treatments; B: versus N availability as soil NO_3-N and NH_4-N (0–24 inches, lb/a) plus N fertilizer (applied as urea at V5 stage).

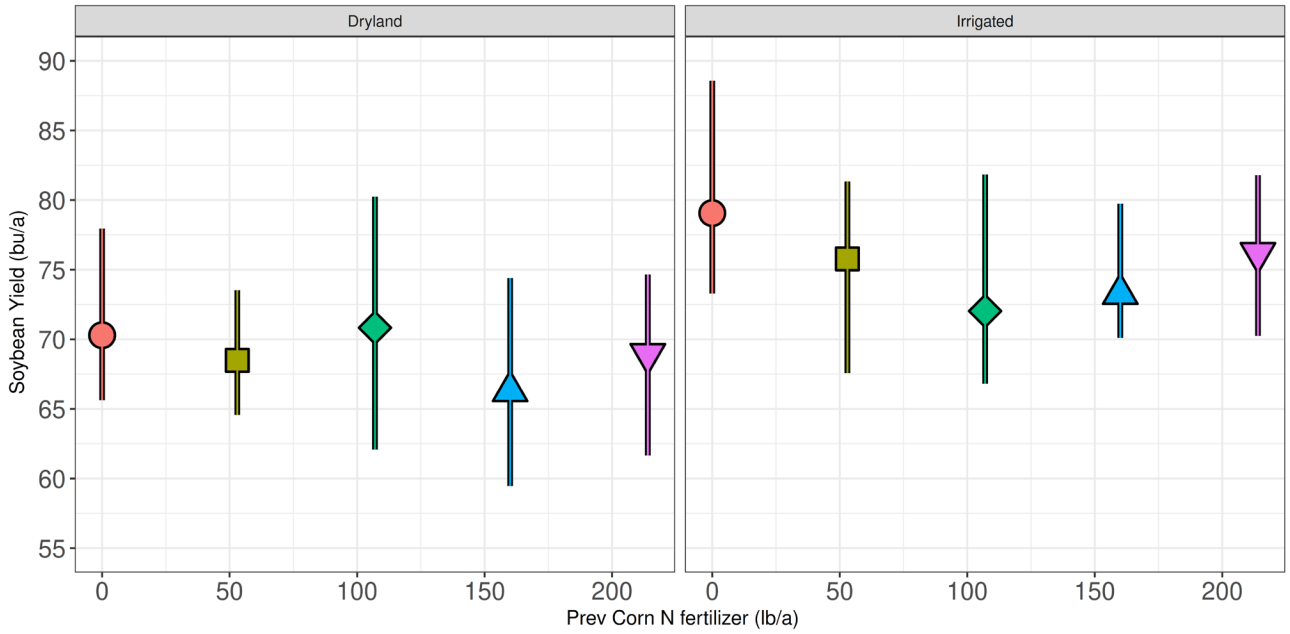

Figure 3. Soybean seed yield (bu/a) versus previous corn nitrogen (N) fertilizer rate treatments. Overlapping error bars indicate the absence of statistical differences (Tukey LSD 5%).