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Yield Response to Nitrogen Management in a Corn-Soybean Sequence in North Central Kansas – 2021 Season

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Yield Response to Nitrogen Management in a Corn-Soybean Sequence in North Central Kansas – 2021 Season

Abstract

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 2021 growing season, a corn-soybean rotation study was continued at Scandia, KS (USA), evaluating the effect of five N fertilizer rates (0, 53, 107, 161, and 214 lb N/a) applied in corn under both dryland and irrigated conditions. Average corn grain yields ranged from 124 to 147 bu/a for dryland, and from 159 to 203 bu/a for irrigated conditions. However, no significant grain yield response to fertilizer N rate was observed in either dryland or irrigated plots. Average soybean seed yields varied from 46 to 59 bu/a for dryland and from 76 to 86 bu/a for irrigated conditions. A significant effect of previous corn fertilizer N rate was observed under dryland conditions. Also, a significant positive soybean seed yield effect with corn maximum N rate (214 lb N/a) with respect to rates of 53 and 107 lb N/a. No residual effects of previous corn N rate were observed on soybean yields under irrigation.

Keywords

yield response, maize, soybean, productivity, dryland, irrigation, corn

Authors

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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 2021 growing season, a corn-soybean rotation study was continued at Scandia, KS (USA), evaluating the effect of five N fertilizer rates (0, 53, 107, 161, and 214 lb N/a) applied in corn under both dryland and irrigated conditions. Average corn grain yields ranged from 124 to 147 bu/a for dryland, and from 159 to 203 bu/a for irrigated conditions. However, no significant grain yield response to fertilizer N rate was observed in either dryland or irrigated plots. Average soybean seed yields varied from 46 to 59 bu/a for dryland and from 76 to 86 bu/a for irrigated conditions. A significant effect of previous corn fertilizer N rate was observed under dryland conditions. Also observed was a significant positive soybean seed yield effect with corn maximum N rate (214 lb N/a) with respect to rates of 53 and 107 lb N/a. No residual effects of previous corn N rate were observed on soybean yields under irrigation.

Introduction

The aim of this study was to continue with the assessment, under both rainfed and irrigated conditions, of the response of corn grain yield to N fertilizer and the residual effects of the N fertilization practice on corn on the following soybean crop in north central Kansas.

Procedures

A third year of a long-term study under a corn-soybean rotation (started in 2019) was continued in the 2021 cropping 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 Argiustolls). Before planting, 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 on those samples by testing for pH, soil organic matter (SOM, %), soil texture (%), extractable (M-3) phosphorus (P, mg/kg), potassium (K, mg/kg), 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 (NO_3-N + NH_4-N). Seasonal weather data were gathered from Kansas Mesonet (Kansas State University (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 was the previous crop for corn plots. Under the same design, the N rate management on the previous corn crop (2020) was used as treatment for the 2021 soybean crop. Corn plots were planted on May 4, and soybean plots on May 12. Corn plots were mechanically harvested using a combine on October 17, 2021, from the two central rows, then corrected to 15.5% moisture content and scaled to bu/a. Soybean plots were mechanically harvested using a combine on October 5 (dryland) and October 12 (irrigated) from the two central rows then corrected to 13% of moisture and scaled to bu/a.

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 and block as the random factor. When a 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 (approximately 3%), medium soil P, and high K. Initial soil N availability for corn at 0–24 inches (NO_3-N plus NH_4-N) averaged 106 lb N/a for the dryland and 122 lb N/a for irrigated areas, respectively. In both cases, between 59% to 89% of N was with the NO_3-N form.

Weather

The total precipitation during the planting-maturity period (May-September) was low, approximately 12 inches. The precipitation distribution pattern denoted low precipitation at the beginning of the season (< 5 in. during the first month) and a dry month of June. More regular and abundant precipitation events were registered during late July and August. Only 4 days with heat stress risks (T_{max}>95°F) were registered from June to August.

Corn Grain Yield

Although a positive yield trend was observed, corn grain yield did not significantly respond to N fertilization ($P > 0.05$) either under dryland or irrigated conditions (Figure 2), presumably due to the high initial soil N availability (>100 lb N/a). As expected for a dry season, greater yields were observed for irrigated (159 to 203 bu/a) as compared to dryland (124 to 147 bu/a), where yield was limited due to water stress. When initial soil N availability was added to the N rate (not shown), a regression model did not show any improvements detecting response to soil N availability (which was presumably a not limiting factor).

Soybean Seed Yield

Average soybean yields varied from 46 to 59 bu/a for dryland and from 76 to 86 bu/a under irrigation (Figure 3). Negligible effects of the corn N management from the previous season were significant ($P > 0.05$) under irrigated conditions for soybean seed yield. However, under dryland management, yields were significantly higher ($P < 0.01$) on plots where the previous corn received the maximum N rate (214 lb N/a) compared to rates of 53 and 107 lb N/a. Nonetheless, dryland soybean yields for previous N rates of 0 and 163 lb N/a were not statistically different from any other previous N rate.

References

R Core Team. 2019. 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 2021 cropping season

Crop	0- to 6-in. depth	pH	SOM	Clay	Silt	Sand	P	K	$N\text{-}NO_3$	$N\text{-}NH_4$
		-	%				ppm			
Corn	Dryland	5.9	3.1	23	60	17	13	501	8.9	6.9
	Irrigated	6.0	2.9	22	59	19	17	498	14	5.8
Soybean	Dryland	5.7	3.0	24	60	16	15	520	4.3	6.1
	Irrigated	6.2	2.9	25	57	18	18	495	8.1	4.7

Table 2. Crop management practices for corn and soybean crops at Scandia, KS, for the 2021 cropping season

Practices	Corn		Soybean	
Irrigation	Dryland	Irrigated	Dryland	Irrigated
Tillage	No-till			
Planting date	05/04/2021		05/12/2021	
Genotype	P1366AML		P39A45X (RR2-Xtend)	
Seeding rate	28,500 seeds/a	30,000 seeds/a	110,000 seeds/a	140,000 seeds/a
Row spacing	30 inches			
P fertilization	23 lb P/a			
N fertilization	0, 53, 107, 161, 214 lb N/a		zero N fertilization	

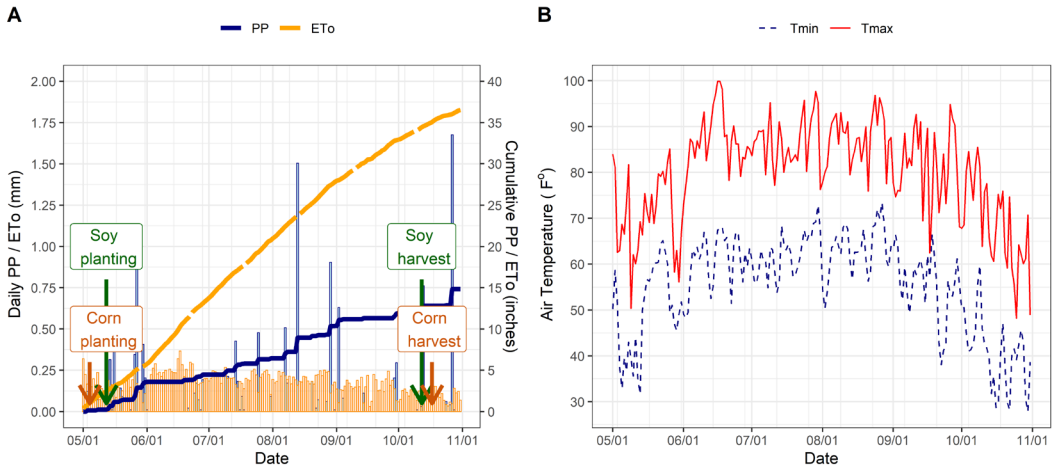

Figure 1. A) Daily and cumulative precipitation (PP) and reference evapotranspiration (ETo); and B) daily minimum and maximum air temperature for the 2021 cropping season at Scandia, KS.

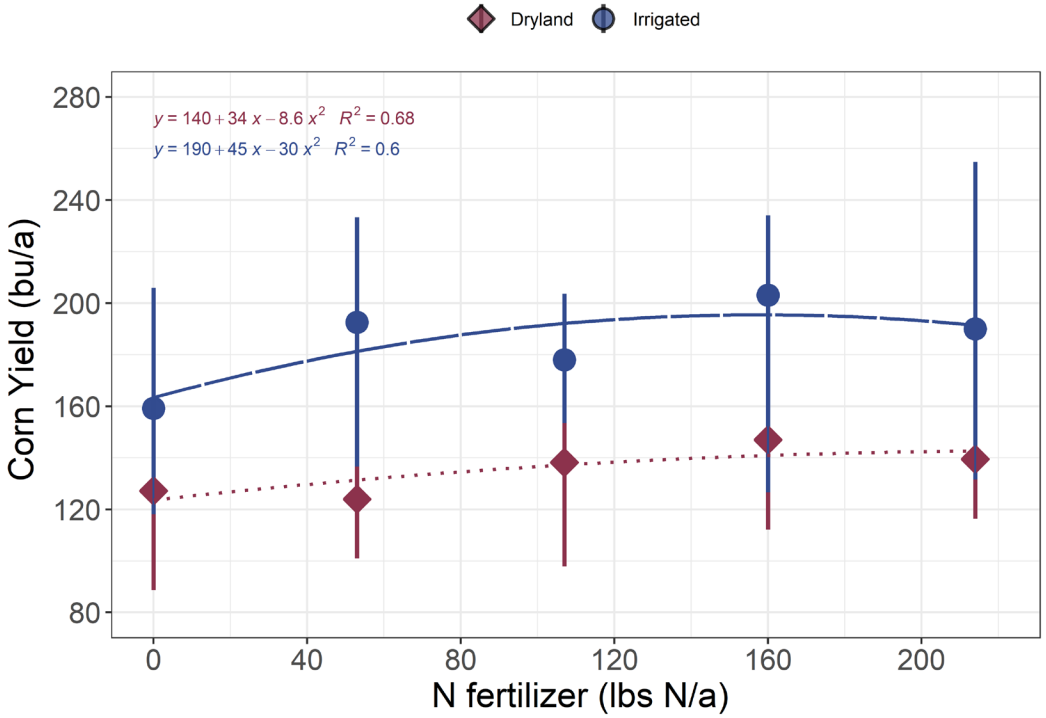

Figure 2. Corn grain yield (bu/a) versus N fertilizer rate treatments (applied as urea at V5 stage).

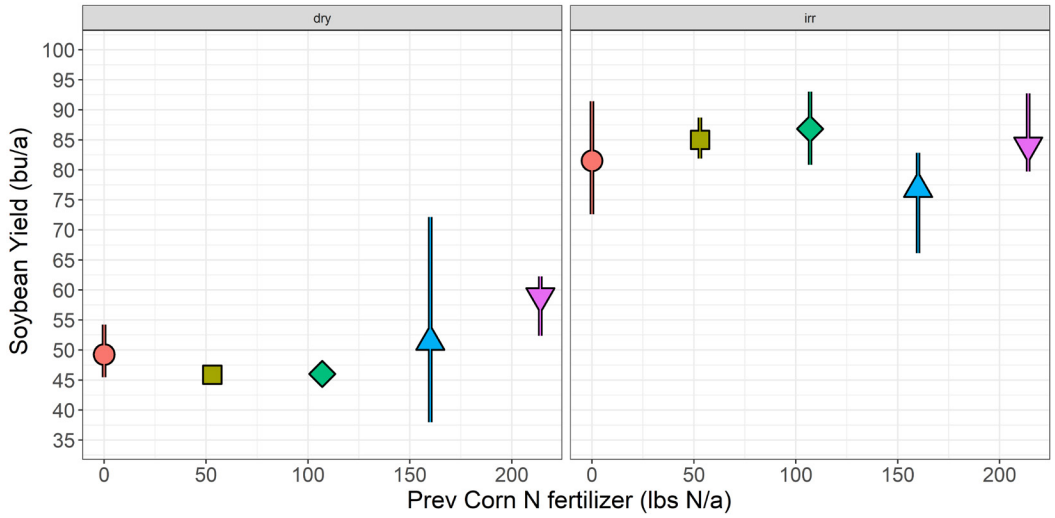

Figure 3. Soybean seed yield (bu/a) versus previous corn N fertilizer rate treatments (lb N/a). Overlapping error bars indicate the absence of statistical differences (Tukey LSD 5%).