Corn Yield Response to Nitrogen 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. During the 2019 cropping season, an N rate experiment in corn was established in Scandia, KS, evaluating five N fertilizer rates as UAN (28-0-0) under both dryland and irrigated conditions. Average yields ranged from 138 to 236 bu/a under rainfed and from 153 to 249 bu/a for irrigated conditions. Under both dryland and irrigated conditions, maximum yields were achieved with an N rate of about 161 lb/a. Total N supply was calculated as N at planting plus fertilizer, which was approximately 300 lb N/a.

Introduction

In spite of decades of research efforts to develop N recommendations, given the nature of the N cycle and its complexity, addressing the uncertainty in the relationship between corn yield and fertilizer N rate remains a predominant concern (Morris et al., 2018; Raun et al., 2019). Thus, the aim of this study was to evaluate the response of corn (*Zea mays* L.) grain yield to N fertilizer.

Procedures

A first year of a long-term study under a corn-soybean rotation was established in the 2019 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 Argiudolls/Pachic Argiustoll). At planting time (May 3, 2019), six cores per soil sample were collected per plot at 0–6 inches soil depth in both rainfed and irrigated areas. A few soil features were tested such as 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.

The corn experiment consisted of a total of five fertilizer N rates in a randomized complete block design with five replications (Table 1) in plots 20-ft wide × 50-ft long. Soybeans served as a previous crop for corn plots. Plots were manually harvested on September 30, 2019, from the four central rows taking 4 subsamples of 1 m^{-2} each, then scaled to bu/a. Yields were corrected to 15.5% moisture content.

Data Analysis

The yield data analysis was executed by performing an analysis of variance (ANOVA) split by water condition. For each water condition, a mix 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 *P*-value adjustment. 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 acid pH, good SOM level, medium soil P, and high K. Initial soil N availability at 0–24 inches (NO_3-N plus NH_4-N) was high in both cases ranging from 80–120 lb/a and from 97–130 lb/a for dryland and irrigated areas, respectively. In both cases, at least two thirds of the N was as NO_3-N and the remaining one-third as NH_4-N.

Weather

The total precipitation during the planting-maturity period (May-September) was about 21 inches. The precipitation distribution pattern marked a humid period at the beginning of the season, with more than half of the seasonal rainfall (13 inches) during the first 60 days, and a relatively dry period during July with very good solar radiation and soil water levels around flowering (data not shown). The growing season ended with more regular and less intense precipitation events during the grain filling period. Thus, water stress risk was practically null until flowering (about July 20th) and low to very-low risk during the grain filling. Approximately 3 days before silking, four days in a row with more than 95°F were registered, with a negative impact on pollination that eventually reduced the attainable yield although levels remained high across all treatments.

Corn Grain Yield

In spite of the high initial soil N availability, the favorable weather conditions to the crop resulted in significant responses of grain yield to N fertilizer rate. Under both dryland and irrigated conditions, the lowest average yield resulted from the check plots (0 lb/a of N) (138 and 153 bu/a for dryland and irrigated, respectively) while the maximum yields were achieved with 161 and 214 lb/a of N, with no significant differences between these highest rates (233 bu/a and 236 bu/a for dryland; 242 bu/a and 249 bu/a for irrigated) (Figure 2A). Only slight differences between irrigated and rainfed in terms of N rate response curves were observed. When initial soil N availability was added to the N rate, the apparent N supply to achieve maximum yields was approximately 300 lb/a, and no significant differences between curves were observed (Figure 2B). Agronomic efficiencies were significantly affected by fertilizer N rate and results were quite similar between areas, ranging from 1.10 (214N) to 3.4 bu/lb of N (57N) at the dryland location, and from 1.2 (214 lb/a of N) to 3.5 bu/lb N (57 lb/a of N) at the irrigated area.

References

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Table 1. Soil fertility (0–6 inches) at planting of corn at irrigated and dryland areas in Scandia, KS, during the 2019 cropping season

0–6 inches	pH	SOM	Clay	Silt	Sand	P	K	NO_3-N	NH_4-N
		-------------------- % --------------------				------------------- *ppm* -------------------			
Irrigated	6.0	2.8	20.5	57.5	22.0	10	490	14.7	3.6
Dryland	5.9	3.0	17.2	59.2	23.6	12	531	16.4	4.8

SOM = soil organic matter
P = phosphorus
$N-NO_3$ = nitrate nitrogen
$N-NH_4$ = ammonium nitrogen
K = potassium

Table 2. Crop management practices for corn and soybean at Scandia, KS, during the 2019 cropping season

Practices	Corn	
Irrigation	Dryland	Irrigated
Tillage	No-till	
Hybrid	P1197AM	
Planting date	05/03/2019	
Seeding rate	29,000 seeds/a	36,000 seeds/a
Row spacing	30 inches	
Nitrogen (N) fertilization	Rates: 0, 53, 107, 161, and 214 lb/a of N	
	Time: V5	
	Source: urea-amonium-nitrate (UAN, 28-0-0)	
	Method: banded rows	
Phosphorus (P) fertilizer	Rate: 22 lb/a of P to all plots	
	Time: planting	
	Source: Triple Super-Phosphate (0-46-0)	
	Method: broadcast	

Weather data were gathered from the Kansas State University Mesonet system (Figure 1) from the North Central Kansas Research Station (Scandia, KS).
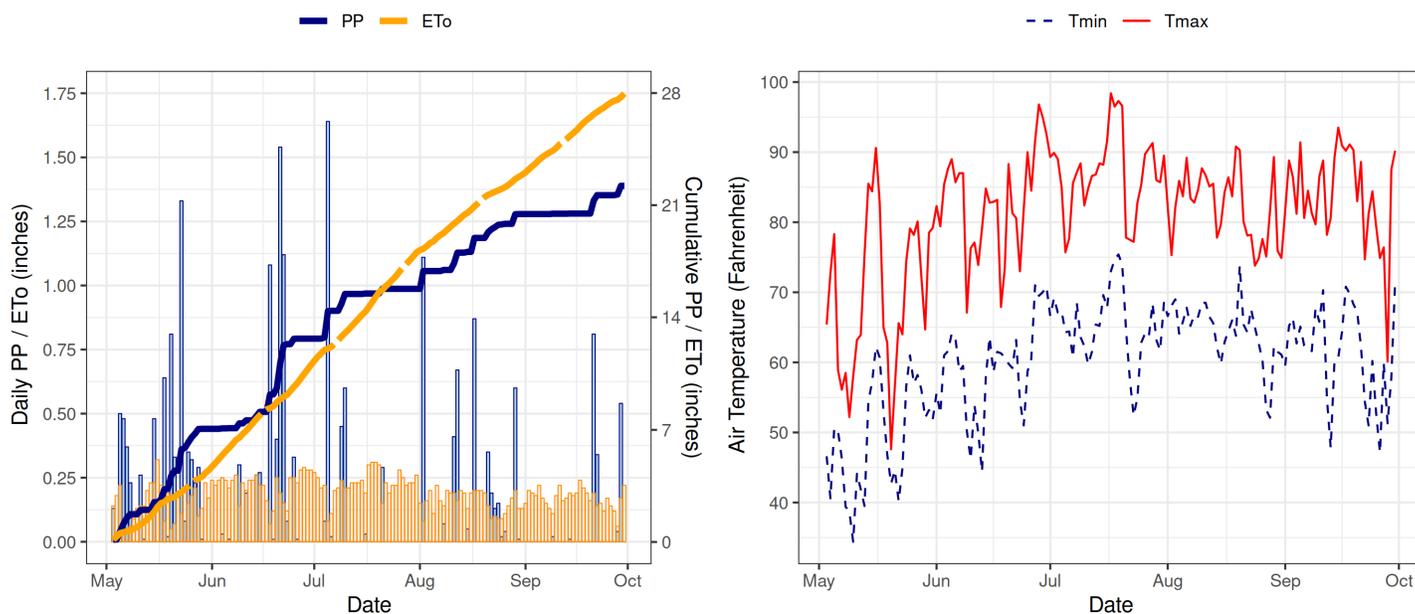

Figure 1. Daily and cumulative precipitation (PP) and reference evapotranspiration (ETo) on the left; and daily minimum and maximum air temperature, on the right for the 2019 cropping season at Scandia, KS.
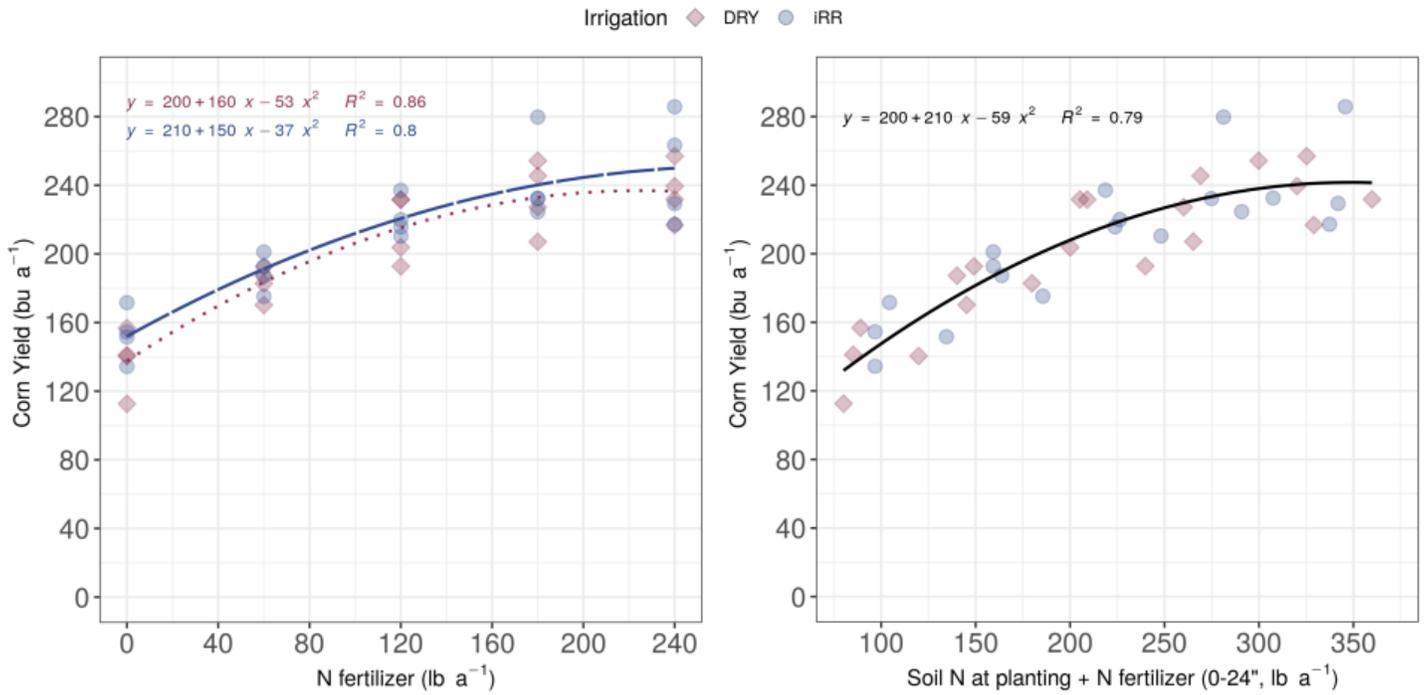
Figure 2. Corn grain yield (bu/a) vs. nitrogen (N) rate treatments (left) and vs. N availability as soil NO_3-N and NH_4-N (0–24 inches, lb/a) + N fertilizer (applied at V5). Different lowercase letters indicate significant differences across fertilizer N rates for rainfed. Different capital letters indicate statistical differences in N rates for irrigated conditions (Tukey LSD 5%, $P < 0.001$).