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Pursuing the Best Management Strategies for Corn-Soybean Rotation Systems in North Central Kansas

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Abstract

The aim of this study was to evaluate different management strategies for improving yield productivity in corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.] rotation systems. During the 2018 season, a long-term corn-soybean experiment was continued in Scandia, KS, evaluating five management strategies under rainfed and irrigated conditions. For corn, average yields were 146 bu/a and 172 bu/a under rainfed and irrigated conditions, respectively. For soybean, rainfed and irrigated average seed yields were similar (47–50 bu/a), attributed to herbicide injury on the irrigated plots. For both crop and water scenarios, intensifying the crop management (by modifying seeding rate, row spacing, fertilization program, and pest control) significantly increased yields as compared to the farmer's strategies.

Keywords

yield gap, maize, rotation, productivity

Pursuing the Best Management Strategies for Corn-Soybean Rotation Systems in North Central Kansas

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Summary
The aim of this study was to evaluate different management strategies for improving yield productivity in corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.] rotation systems. During the 2018 season, a long-term corn-soybean experiment was continued in Scandia, KS, evaluating five management strategies under rainfed and irrigated conditions. For corn, average yields were 146 bu/a and 172 bu/a under rainfed and irrigated conditions, respectively. For soybean, rainfed and irrigated average seed yields were similar (47–50 bu/a), attributed to herbicide injury on the irrigated plots. For both crop and water scenarios, intensifying the crop management (by modifying seeding rate, row spacing, fertilization program, and pest control) significantly increased yields as compared to the farmer's strategies.

Introduction
The "Exploitable Yield Gap" could be defined as the difference between the actual yield (current farmer yield) and the attainable yield (improved yield achieved by adjusting management practices). Management practices such as row spacing, seeding rate, fertilization, pest, and disease control affect the size of the yield gap. A management system is a combination of production practices. The aim of this study was to evaluate the combination of production practices to identify the best management strategies for closing yield gaps in a corn-soybean system.

Procedures
A long-term study under a corn-soybean rotation, established in 2014, was continued during the 2018 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). Prior to planting and before tillage operations (April 2018), six cores per soil sample were collected per plot at 0–6 inches soil depth in both rainfed and irrigated areas. Samples were analyzed for pH, soil organic matter (SOM, %), and extractable (M-3) phosphorus (P), potassium (K), calcium (Ca), and magnesium (Table 1).

Similar to the previous seasons (2014–2017), the experiment consisted of five treatments in a randomized complete block design with five replications (Table 1) in plots 20-ft wide × 50-ft long. Corn served as previous crop for soybean, and soybean served as precedent crop for corn. Both corn (DKC64-69RIB) and soybean (P39T67R) were planted on May 4, 2018. Crops were mechanically harvested on November 1, 2018, (soybean) and November 6, 2018, (corn) from the two (farmer practice (FP) and comprehensive fertilization (CF)) or four central rows (production intensification (PI), ecological intensification (EI), and advanced plus (AD)). Yields were corrected to 15.5% moisture for corn, and 13% moisture for soybean.

Weather data were gathered from the Kansas Mesonet Weather Data Library, Kansas State University (Figure 1). Cumulative precipitations and mean temperatures for the 2018 growing season were compared to the historical data (1980–2017) from the North Central Kansas Research Station (Scandia, KS) (Figure 2).

Data Analysis

The yield data were executed by performing an analysis of variance (ANOVA) split by crop and water condition. For each crop × water condition, a mixed model was considered with treatment as the fixed factor and block as the random factor. When significant treatment effect was observed ($P \leq 0.05$) with ANOVA, mean comparisons were performed using the Tukey's *P*-value adjustment. Analyses were carried out using the '*nlme*' and '*emmeans*' packages of R software.

Results

Weather

The total rainfall during the planting-maturity period was approximately 19.6 inches for corn and 22.6 inches for soybean. Its distribution pattern marked a relatively dry period at the beginning of the season, followed by a peak by mid-June and another dry period until late-July, then the rainfall became more regular until early September, relatively accompanying the grain filling period for both crops. In early October (with the corn already mature), 3 inches of rainfall was registered while soybean was finishing seed filling. In terms of cumulative precipitations, the 2018 growing season was near the historical average mean for the April-October period; slightly below the average precipitation for corn (reaching maturity by late September), while slightly above the average for soybean (reaching maturity by early to mid-October). In terms of mean temperatures, the 2018 was one of the warmest seasons since 1980 (Figure 2).

Corn Grain Yield

The grain yields for the rainfed condition ranged from 104 bu/a (FP) to 185 bu/a (EI) while for the irrigated condition, yield ranged from 135 bu/a (PI) to 209 bu/a (EI) (Figure 3). Under rainfed conditions, the effect of treatment was significant ($p_R = 0.04$), but only differing for yield between the FP (lowest yield, 104 bu/a) and the EI (highest yield, 185 bu/a) treatments. Under irrigated conditions, treatment effect was also significant ($p_I = 0.009$). The EI (209 bu/a) and AD (195 bu/a) strategies showed the highest yields (not differing from each other), while FP (144 bu/a) and PI (135 bu/a) showed the lowest ones. The yield gap (%, over FP), expressed as the difference between the maximum yielding treatment and the FP, was estimated at 78% for rainfed corn and 45% when irrigated. Under both water conditions, adding fertilizer to corn (CF) reduced the yield gap, but an additional increase in plant density and reduction in row spacing (EI) were necessary to completely close the gap.

Soybean Seed Yield

The seed yields for the rainfed condition ranged from 31 bu/a (FP) to 65 bu/a (EI) while for the irrigated condition, yields ranged from 34 bu/a (PI) to 62 bu/a (AD) (Figure 4). The irrigated soybean crop suffered herbicide injury just before the beginning of the seed-filling period, so yield was negatively affected. Despite the latter, under both water conditions, the effect of treatment was significant ($p_R = 0.0022$; $p_I = 0.0048$). In both cases, the FP strategy always showed the lowest yields, while CF and PI reduced the yield gap, but not significantly, and the EI and AD strategies always resulted in significantly higher yields as compared to FP. Regarding the yield gap, it was estimated at 112% for the rainfed condition and at 82% when irrigated.

Overall, intensified management systems based on a high seeding rate, combined with a narrow row spacing and a balanced nutrition program, increased yields compared to the farmer practice scenario.

Table 1. Soil chemical analysis (0–6 inches) before planting corn and soybean at irrigated and rainfed areas in Scandia, KS, during the 2018 cropping season

Crop	pH	Soil organic matter	Phosphorus	Potassium	Calcium	Magnesium
		%	mg/kg			
Irrigated						
Corn	6.15	2.62	14	481	2014	359
Soybean	6.09	2.46	11	443	2075	381
Rainfed						
Corn	5.82	2.96	15	494	2632	507
Soybean	5.91	2.85	15	485	2104	360

Table 2. Treatments evaluated in corn-soybean systems at Scandia, KS, during the 2018 cropping season

Treatments:	Farmers' practices	Comprehensive fertilization	Production intensity	Ecological intensification	Advanced
Seeding rate:	Medium corn: 28,000 pl/a soybean: 110,000 pl/a		High corn: 40,000 pl/a soybean: 134,000 pl/a		
Row spacing:	Wide (30 in.)		Narrow (15 in.)		
Fertilization	No	*NPKS	No	NPKS+ 1x(Fe, Zn, B)	NPKS+ 2x(Fe, Zn, B)
Fungicide	No	No	No	1x	2x
Insecticide	No	No	No	1x	2x
Herbicide	Yes	Yes	Yes	Yes	Yes

*Nitrogen (N) was only applied to the corn plots.
P = phosphorus. K = potassium. S = sulfur. Fe = iron. Zn = zinc. B = boron.

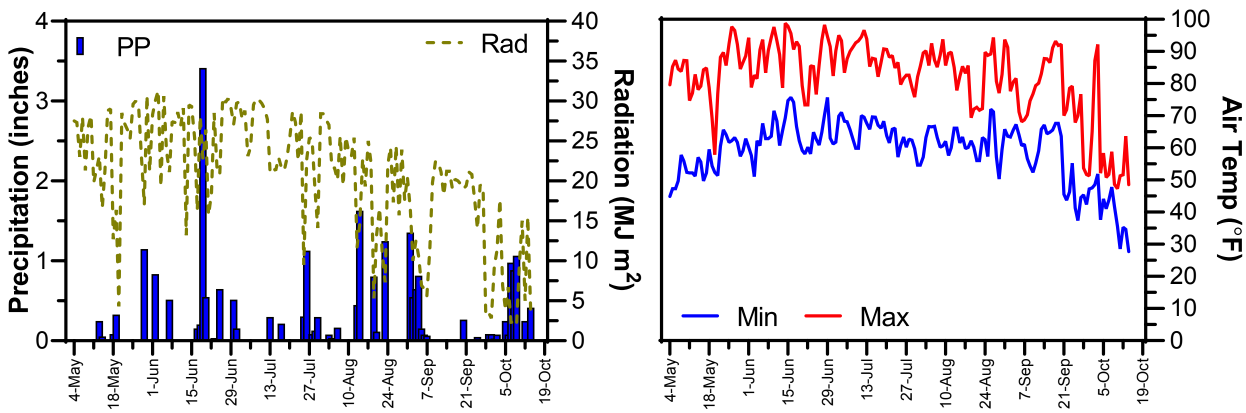

Figure 1. Daily precipitation (blue bars, inches), global radiation (dashed line, MJ/m²) on the left, and daily air temperature (minimum = blue line, and maximum = red line) on the right, for the 2018 corn-soybean season at Scandia, KS.

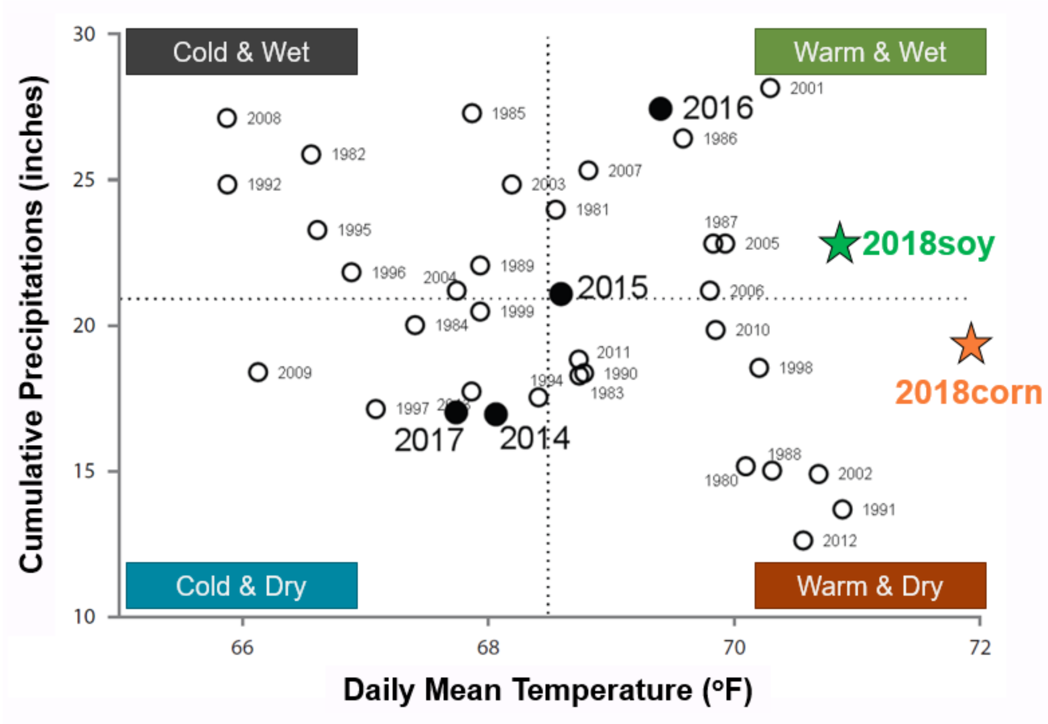

Figure 2. Yearly (1980–2016) mean temperature and precipitation for the period April-October. Filled symbols indicate seasons when the experiment was performed. Dotted vertical and horizontal lines indicate mean temperature (°F) and cumulative precipitation (in.) for the period.

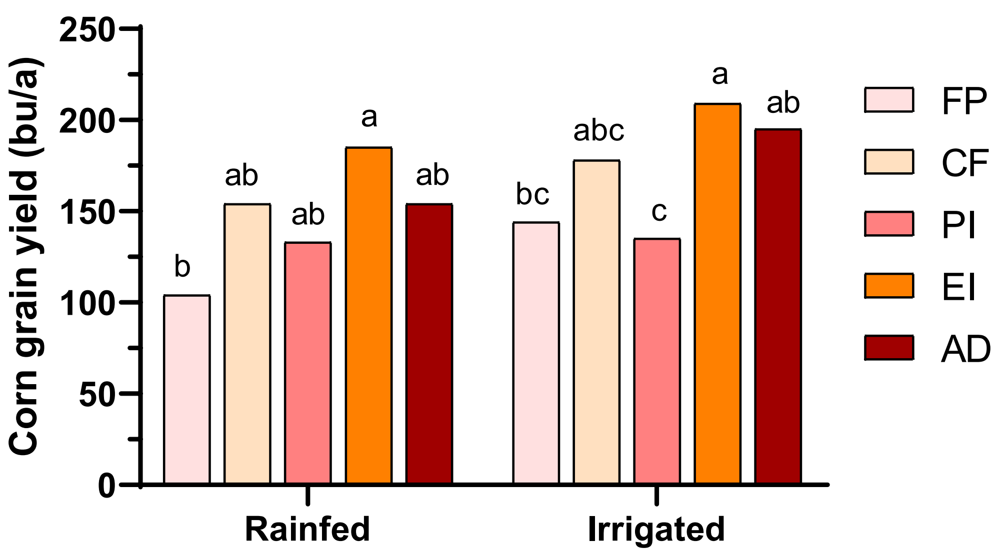

Figure 3. Corn grain yield by treatment for dryland and irrigated conditions in Scandia, KS, 2018. For each water condition, different letters indicate statistical differences ($P < 0.05$). FP = farmer practices, CF = comprehensive fertilization, PI = production intensification, EI = ecological intensification (CF+PI), AD = advanced plus.

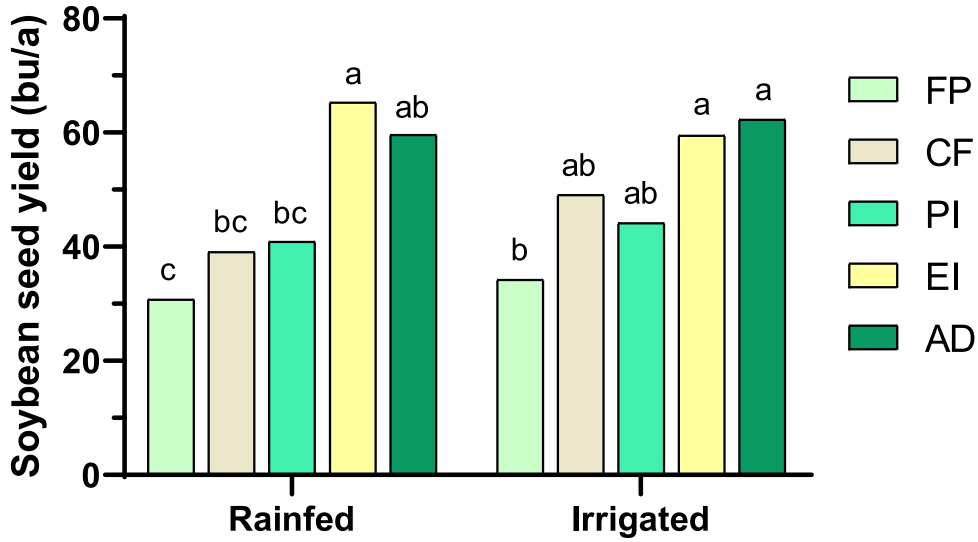

Figure 4. Soybean seed yield by treatment for dryland and irrigated conditions in Scandia, KS, 2018. For each water condition, different letters indicate statistical differences (*P* < 0.05). FP = farmer practices, CF = comprehensive fertilization, PI = production intensification, EI = ecological intensification (CF+PI), AD = advanced plus.