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Closing Soybean Yield Gaps via Improved Management: A Systems Approach

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Abstract

Three soybean research trials were conducted during the 2016 growing season. Two studies were conducted at Scandia, KS, (dryland and irrigated) and one at Topeka, KS (dryland). The objective of this study was to investigate the contribution of different farming systems for closing soybean yield gaps. Each experiment consisted of five treatments: common practices (CP), comprehensive fertilization (CF), production intensity (PI), ecological intensification (CF + PI), and advanced plus (AD). The EI and AD treatments presented the maximum yields at both locations. Under irrigation conditions, yield gap was larger at Scandia relative to Topeka site. Across all three soybean experiments, CP presented the lowest yield. EI yielded 79 bu/a at Topeka, and 83 and 86 bu/a at Scandia dryland and irrigated scenarios, respectively.

Keywords

soybean, yield gaps, cropping system

Cover Page Footnote

Thanks to the Kansas State University Crops Production Team for the valuable help in collecting and processing all the field data during 2016 growing season. This study was supported by the International Plant Nutrition Institute (IPNI, Project GBL 62), K-State Research and Extension and the Fulbright Program (partially covering G.R. Balboa's stipend).

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G.R. Balboa and I.A. Ciampitti

Summary

Three soybean research trials were conducted during the 2016 growing season. Two studies were conducted at Scandia, KS, (dryland and irrigated) and one at Topeka, KS (dryland). The objective of this study was to investigate the contribution of different farming systems for closing soybean yield gaps. Each experiment consisted of five treatments: common practices (CP), comprehensive fertilization (CF), production intensity (PI), ecological intensification (CF + PI), and advanced plus (AD). The EI and AD treatments presented the maximum yields at both locations. Under irrigation conditions, yield gap was larger at Scandia relative to Topeka site. Across all three soybean experiments, CP presented the lowest yield. EI yielded 79 bu/a at Topeka, and 83 and 86 bu/a at Scandia dryland and irrigated scenarios, respectively.

Introduction

Crop management practices (such as row spacing, planting date, and nutrient application) and their interactions with the environment (soil + weather) have a direct impact in closing yield gaps. By choosing different combinations of practices, farmers can modify the growing conditions. Thus, after considering the contribution from the genetics and the environment, on-farm yield is primarily influenced by farmers' decisions, the main components of which are agronomic practices. Crop management practices are often specific to the environment, hybrid/variety, and/or yield level. Each farmer needs to find the appropriate management practices that can help them to increase yields and profits. Increasing seeding rates and narrowing rows are two common intensification practices in high-yielding soybean systems.

Procedures

Three soybean research trials were conducted during the 2016 growing season. Two studies were located at the North Central Kansas (NCK) experiment fields (Scandia, KS), and one at the Kansas River Valley (KRV) experimental fields (Topeka, KS). At Scandia, one experiment was conducted under dryland and one under irrigated conditions. Soybean from maturity group 4 (MG 4) was planted on May 6 at Scandia and June 1 at Topeka. Each experiment consisted of 5 treatments with five replications in a completely randomized block design: 1) common practices (CP), (110,000 seeds/a + no-inoculation + no-nutrient application + 30-in. row spacing); 2) comprehensive fertilization (CF), (110,000 seeds/a + inoculation + nutrient application + 30-in. row spacing); 3) production intensity (PI), increasing productivity via narrowing rows and

increasing seeding rate (174,000 seeds/a + inoculation + no-nutrient application + 15-in. row spacing); 4) ecological intensification (CF + PI; 174,000 seeds/a + inoculation + nutrient application + 15-in. row spacing + micronutrients + fungicides); and 5) advanced plus (AD), or increasing input applications (174,000 seeds/a + inoculation + nutrient application + 15-in. row spacing + double application of micronutrients and fungicides). Mes SZ and Aspire (Mosaic company) product rates for an irrigated environment were 108 and 300 lb/a, with 77 and 215 lb/a for dryland scenario, respectively. The rates per nutrients in lb/a (N-P_2O_5-K_2O-S-Zn-B) were 13-43-180-11-1Zn-1.5B and 9-31-129-8-0.75Zn-1B for irrigated and dryland.

Results

Weather Conditions

Weather conditions for the growing season and historical information are shown in Figure 1 for NCK Scandia site and Figure 2 for KRV Topeka location (Mesonet, Kansas State University). The total amount of precipitation received during the growing season was 23 inches for the Scandia site and 24 inches for Topeka.

The total amount of water provided to the irrigated condition at NCK Scandia was 6.3 inches (6/23, 7/15, 7/21, 7/29, and 8/10). Temperatures ranged in normal values except for a few days that could present some heat stress for the soybeans.

Soil Test and Phenological Information

Soil samples were collected before planting to characterize each experimental site. Soil test results are shown in Table 1. The previous crop was corn at all locations. The soybean variety planted (MG 4), the date for phenological stages, and the harvest date are shown in Table 2.

North Central Kansas, Scandia Yields

At the NCK Scandia fields, average yield for the dryland condition was 75 bu/a, ranging from 63 to 85 bu/a (Figure 3). The irrigated condition yielded on average 73 bu/a. The total in-season precipitation can largely explain the lack of yield differential between dryland and irrigated conditions. Under dryland and irrigated conditions differences in yield were statistically significant ($P < 0.05$). For the dryland environment, the CF treatment yielded 7 bu/a more than the CP, but yields did not statistically differ. A balanced nutrition program and intensifying production (EI) in dryland allowed increasing yield 28% over the CP treatment (Figure 3). Treatments EI and AD showed the highest yields under both water environments. Maximum yield was recorded for the AD treatment under irrigation, averaging 90 bu/a. Yield gaps were 34 bu/a under irrigation and 22 bu/a under dryland (calculated as AD minus CP) (Figure 3). The PI treatment presented comparable soybean yields relative to the CF combination.

Kansas River Valley, Topeka Yields

At KRV Topeka site, average yield was 74 bu/a (Figure 4). Common practices (CP) and intensifying production without a balanced nutrition (PI) presented the lowest yield, averaging 72 bu/a. Soybean yields for CF, EI, and AD did not statistically differ, presenting an average of 76 bu/a. The yield gap in this environment was only 9 bu/a (calculated as the difference between EI—79 bu/a—minus PI—70 bu/a—maximum and minimum soybean yields for this site, respectively).

Acknowledgments

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Table 1. Soil characterization before planting time

Soybean studies	Organic matter	pH	Phosphorus
	%		ppm
NCK Scandia irrigated	2.2	6.2	11
NCK Scandia dryland	2.3	5.4	7.4
KRV Topeka dryland	2.3	5.8	11.3

NCK = North Central Kansas.
KRV = Kansas River Valley.

Table 2. Phenological data for the 2016 growing season for soybean

Phenological data	North Central Kansas, Scandia	Kansas River Valley, Topeka
Soybean variety	P39T67R (MG 4.0)	P39T67R (MG 4.0)
Planting date	05/06/2016	06/01/2016
Emergence date (VE)	05/12/2016	06/07/2016
Flowering (R1)	07/12/2016	07/20/2016
Maturity	09/26/2016	10/3/2016
Harvest date	10/18/2016	10/18/2016

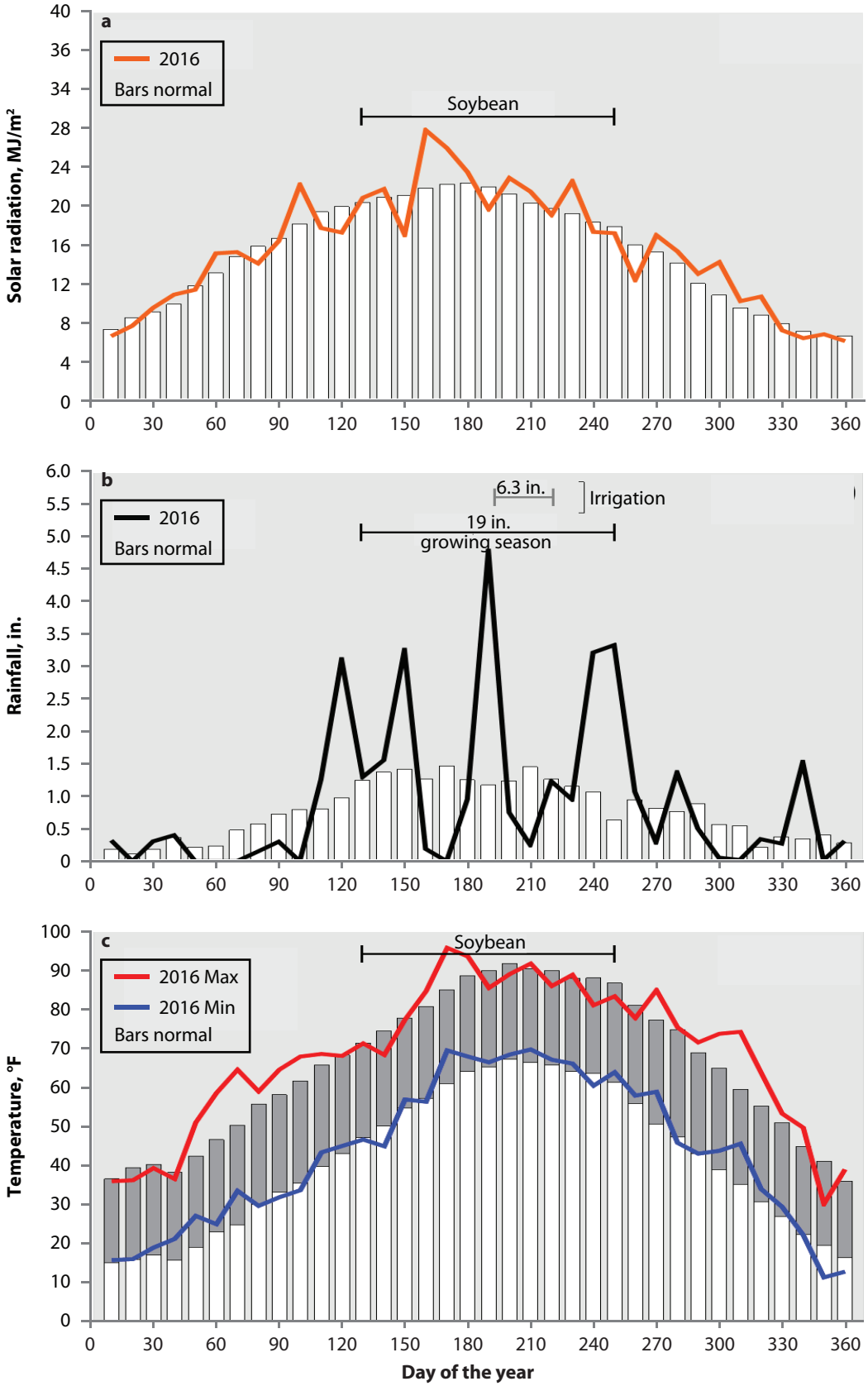

Figure 1. a) Daily solar radiation; b) Daily precipitation; and c) Daily maximum and minimum temperatures all for 2016 season and historical; North Central Kansas, Scandia.

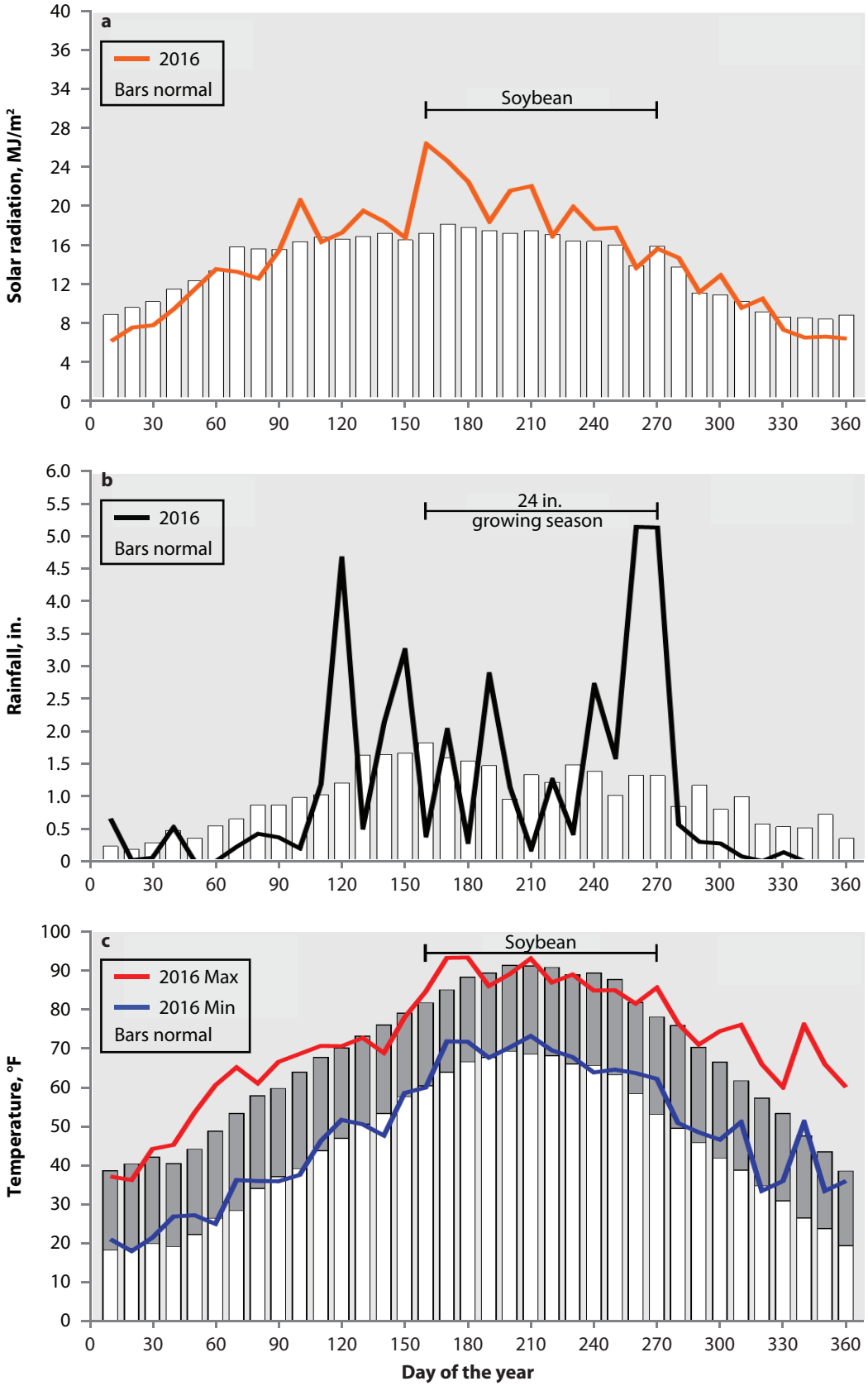

Figure 2. a) Daily solar radiation; b) Daily precipitation; and c) Daily maximum and minimum temperatures all for 2016 season and historical; Kansas River Valley, Topeka.

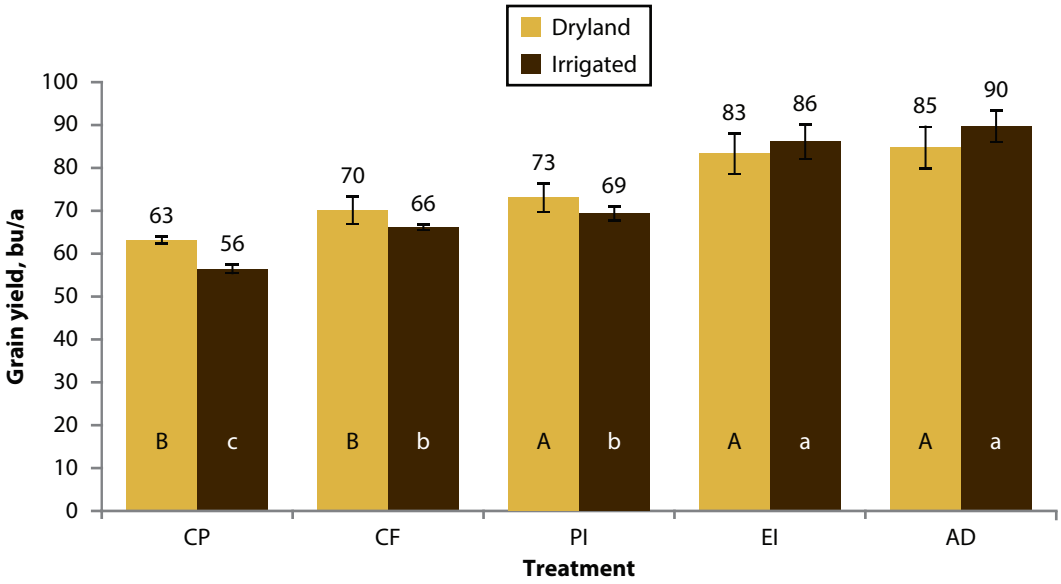

Figure 3. Soybean yield by treatment for dryland and irrigated conditions during the 2016 growing season, North Central Kansas, Scandia. Different letter shows statistical differences ($P < 0.05$). CP = Common practices, CF = comprehensive fertilization, PI = production intensification, EI = ecological intensification (CF+PI), AD = advanced plus. Lines in bars indicate standard deviation.

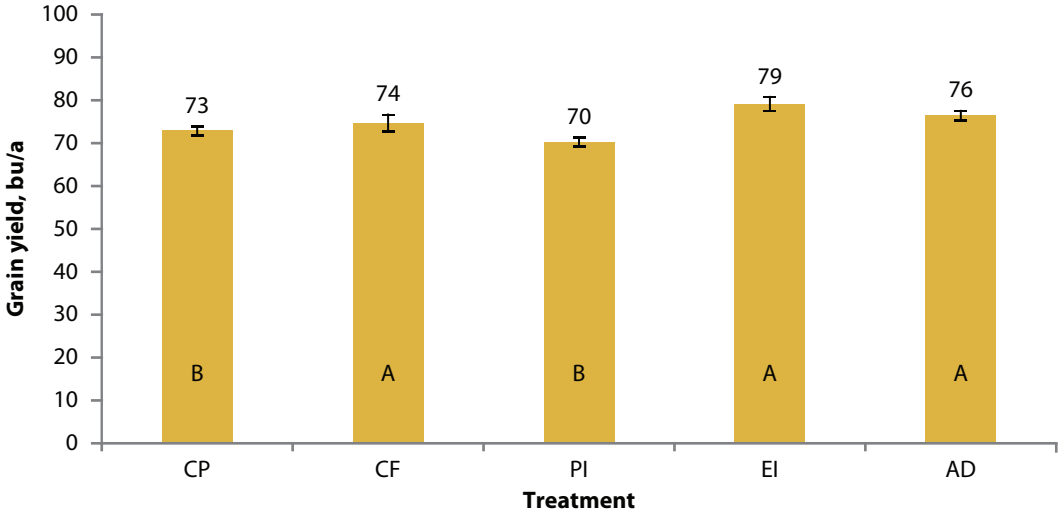

Figure 4. Soybean yield by treatment during the 2016 growing season, Kansas River Valley, Topeka. Different letter shows statistical differences ($P < 0.05$). CP = Common practices, CF = comprehensive fertilization, PI = production intensification, EI = ecological intensification (CF+PI), AD = advanced plus. Lines in bars indicate standard deviation.