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## **Breaking Soybean Yield Barriers: A Cropping Systems Approach**

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### **Summary**

During 2015, four soybean research trials were conducted in dryland and irrigated environments. Two trials were at Scandia, KS, and two were in Topeka, KS. The objective of these trials was to study the contribution of different farming systems to developing efficient and high-yielding soybean production systems. Each experiment had five treatments: common practices (CP), comprehensive fertilization (CF), production intensity (PI), ecological intensification (CF + PI), and advanced plus (AD). Under dryland and irrigation EI and AD treatments had the maximum yield in both locations. Under irrigation, yield gap was the largest as compared to the dryland environment in both locations. In all four experiments common practices had the lowest yield.

### **Introduction**

Crop management practices (such as row spacing, planting date, nutrient application, and disease control) and their interactions with the environment (weather) have a direct impact in yield gaps. By choosing different combinations of practices, farmers can modify the growing conditions. Thus, after considering 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. All farmers, depending on the characteristics of their farms, need to find the appropriate management practices that can help them to increase yields and close yield gaps. Increasing plant populations and narrowing rows are two common intensification practices in high-yielding soybean systems.

### **Procedures**

Four soybean research trials were conducted; at each of their respective locations one of the experiments was conducted in dryland condition and the other under irrigation. Two trials were conducted at the Scandia Unit of the North Central Kansas (NCK) Experiment Field, and two at Kansas River Valley (KRV) Experimental Field. Soybean from maturity group 4.0 was planted on May 28 (NCK Scandia) and June 8 (KRV Topeka). Each experiment had 5 treatments with 5 replications in a completely randomized block design: (1) common practices (CP), common farming practices (110,000 seeds/a + no inoculation + no nutrient application + 30-in. row spacing); (2) comprehensive fertilization (CF), or balancing nutrients (110,000 seeds/a + inoculation + nutrient application + 30-in. row spacing); (3) production intensity (PI), increasing productivity via narrowing rows, and increasing plant population (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); and (5) advanced plus (AD) or increasing input applications (174,000 seeds/a + inoculation + nutrient application + 15-in. row spacing). Each treatment was replicated five times.

## Results

### *Weather Conditions*

Weather conditions for the growing season and historical values are shown in Figures 1 and 2 for NCK Scandia, KS; and KRV Topeka, KS; respectively. The total amount of rain received during the growing season was 15 in. for Scandia and 16.3 in. for Topeka. The total amount of water provided to the irrigated condition at NCK Scandia was 7.5 inches (7/7, 7/15, 7/23, 8/5, 8/20, and 9/10). At KRV the total amount of water provided by irrigation was 5.24 inches (06/23, 07/02, 08/01, 08/16, 08/17, 08/24 and 09/03). Temperatures ranged in normal values for the crop, registering only a few days of heat stress for the soybeans.

### *Soil Test and Phenological Information*

Soil samples were taken before planting to characterize each site. Results of soil tests are shown in Table 1. Scandia had more organic matter but low values of P compared to Topeka. The variety planted, the date for phenological stages of interest, and the harvest date are showed in Table 2. Total number of days from emergence to physiological maturity was 116 and 114 for Scandia and Topeka, respectively.

### *Stand Counts*

At emergence, stand count for all the treatments were measured. Table 3 shows the plants per acre for each of the treatments for both locations in dryland and irrigated conditions. In all the cases, statistical differences were detected between treatments CP-CF and PI, EI and AD.

### *NCK Scandia, KS, Yields*

In NCK, Scandia, KS the average yield for the dryland condition was 34 bu/a ranging from 27 to 38 bu/a. (Figure 3). The irrigated condition yielded an average 73 bu/a. The irrigated condition yielded 114% more than the dryland condition. The minimum yield registered for irrigated was 62 bu/a for CP and the maximum 82 bu/a for AD treatment. There were statistical differences in yield between treatments. In both conditions (dryland and irrigated), treatments EI and AD showed the highest yields without presenting statistical differences. The PI treatment documented comparable yields relative to EI and AD for the dryland site, while an average yield gap of 7 bu/a was recorded under irrigation when PI was compared against the EI-AD treatments. At both water supply environments, CP and CF recorded the lowest yield relative to the rest of the treatments evaluated (Figure 3).

In summary for NCK Scandia, in relative terms, dryland presented a larger yield gap from minimum to maximum yielding treatments (36%, CP-CF vs. PI-EI-AD) relative to the irrigated environment (24%, CP-CF vs. EI-AD). In absolute terms, dryland presented a measurable yield gap of 11 bu/a; while at the irrigated site the gap was close to two-fold greater, 20 bu/a (Figure 3).

***KRV Topeka, KS, Yields***

At KRV Topeka, the dryland environment yielded 73 bu/a on average and in the irrigated condition the average yield for all the treatments was 65 bu/a. The soil characteristics of both sites could explain the difference in yield. The irrigated site had a sandy soil with low water retention capacity. The soil test result shows that dryland site has more fertility related to higher values of OM and P (Table 1). Better fertility and more water retention because of the texture could explain the better performance compared to the irrigated site.

In both conditions, yields were statistically different for the treatments evaluated ( $p < 0.05$ ). For dryland condition PI, EI, and AD yielded on average 8 bu/a (12%) more than CP and CF but without differences with PI. The maximum yield was registered in AD treatment (77 bu/a). The lowest yield was reported in CP (66 bu/a).

For the irrigated conditions, there was a similar trend for the one observed for dryland. EI and AD showed the high yield with an average of 70 bu/a. EI and AD yielded 15% more compared with CP, CF, and PI.

In summary, for KRV Topeka in dryland and irrigated conditions EI and AD were the treatments that registered the highest yields. Following the same trend as NCK Scandia, the yield gap in the irrigated was bigger than for dryland condition. A smaller yield gap was identified between dryland and irrigated conditions for Topeka, this can be attributed to the different quality of the environments explained before.

**Table 1. Soil characterization before planting time**

Soybean studies	OM%	pH	P (ppm)
NCK, Scandia irrigated	2.77	6.2	13.7
NCK, Scandia dryland	2.83	6.1	13.1
KRV, Topeka irrigated	1.62	7.3	23.8
KRV, Topeka dryland	2.04	6.8	40.1

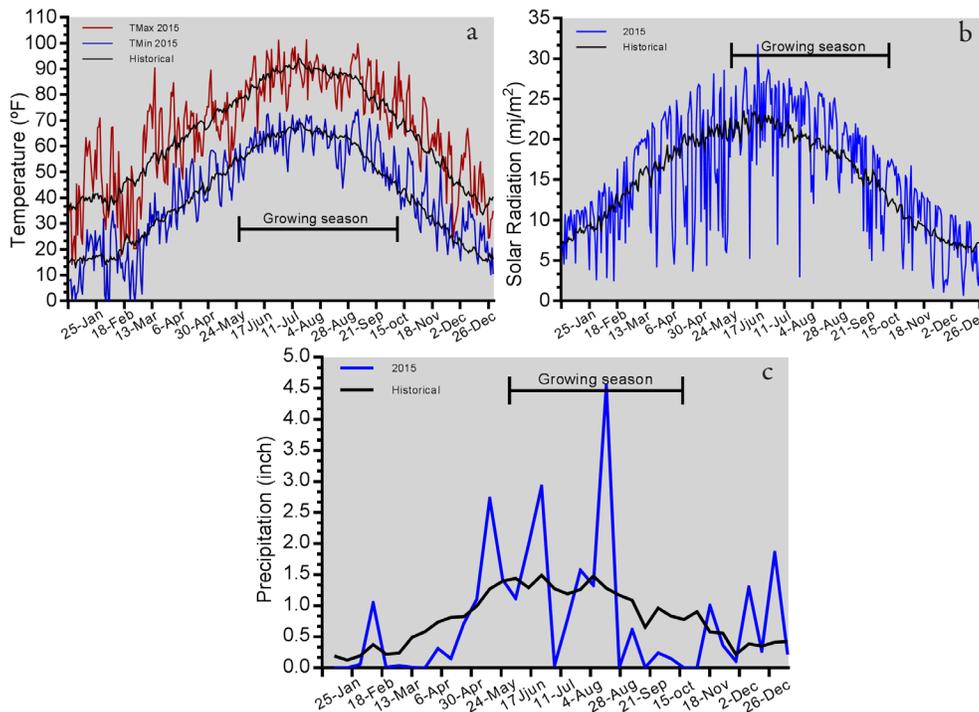
**Table 2. Phenological data for the 2015 growing season for soybean**

Phenological data	NCK, Scandia	KRV, Topeka
Soybean variety	P39T67R (MG 4.0)	P39T67R (MG 4.0)
Planting date	05/28/15	06/08/2015
Emergence date (VE)	06/04/15	06/13/2015
Flowering (R1)	07/29/15	07/23/2015
Maturity	09/28/15	10/05/2015
Harvest time	10/14/15	10/15/2015

**Table 3. Stand count at emergence for all the sites and locations**

Treatment	Stand Count (plants per acre)			
	NCK, Scandia		KRV, Topeka	
	Dryland	Irrigated	Dryland	Irrigated
CP	70,741 b	93,741 b	106,286 b	108,377 b
CF	71,090 b	97,051 b	102,453 b	96,877 b
PI	116,392 a	148,801 a	145,316 a	136,429 a
EI	111,862 a	150,892 a	144,967 a	143,748 a
AD	121,619 a	151,240 a	144,096 a	137,126 a
P value	0.0001	0.0001	0.0001	0.0001

CP = Common practices, CF = comprehensive fertilization, PI = production intensification, EI = ecological intensification (CF+PI), and AD = advanced plus. Different letter in columns indicates statistical difference between the treatments ( $p < 0.05$ ).



**Figure 1. (a) Daily maximum and minimum temperatures for the 2015 growing season and historical. (b) Daily solar radiation for 2015 and historical. (c) Daily precipitation for 2015 and historical. NCK, Scandia, KS.**

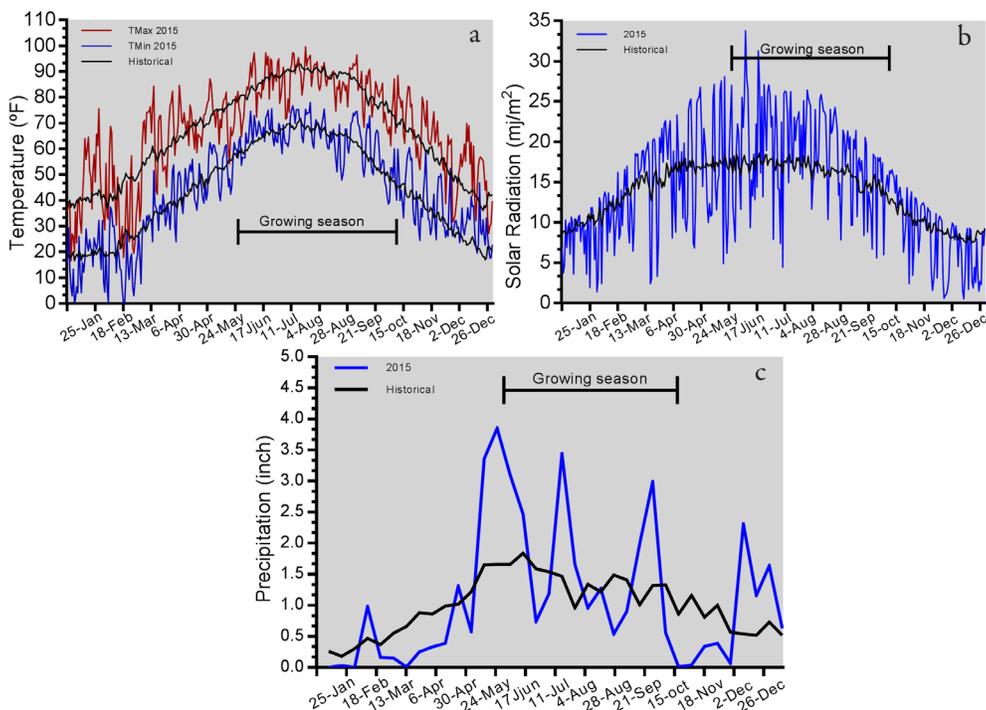


Figure 2. (a) Daily maximum and minimum temperatures for the 2015 growing season and historical. (b) Daily solar radiation for 2015 and historical. (c) Daily precipitation for 2015 and historical. KRV, Topeka, KS.

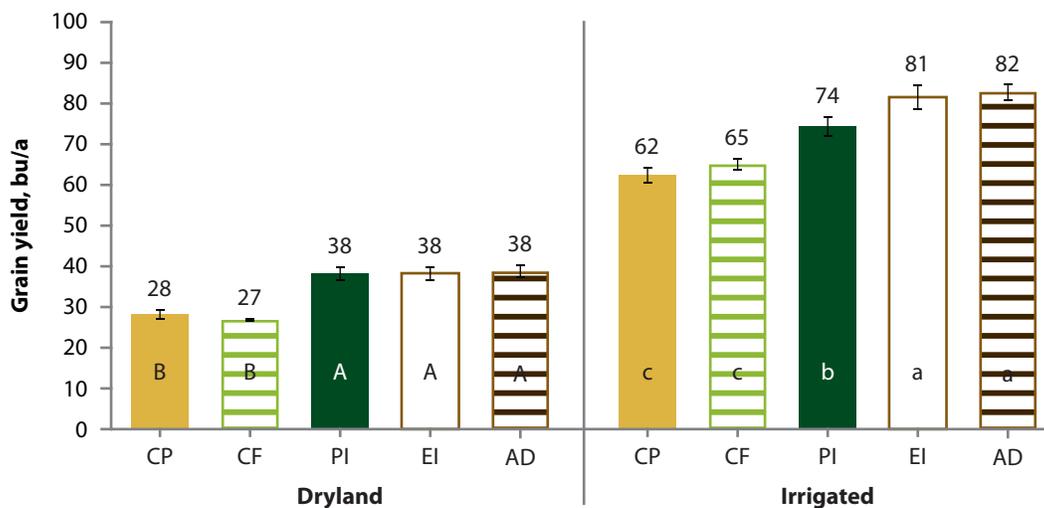


Figure 3. Soybean grain yield by treatment for dryland and irrigated conditions during the 2015 growing season, NCK, Scandia, KS. Different letter shows statistical differences ( $p < 0.05$ ). CP = Common practices, CF = comprehensive fertilization, PI = production intensification, EI = ecological intensification (CF+PI), and AD = advanced plus.

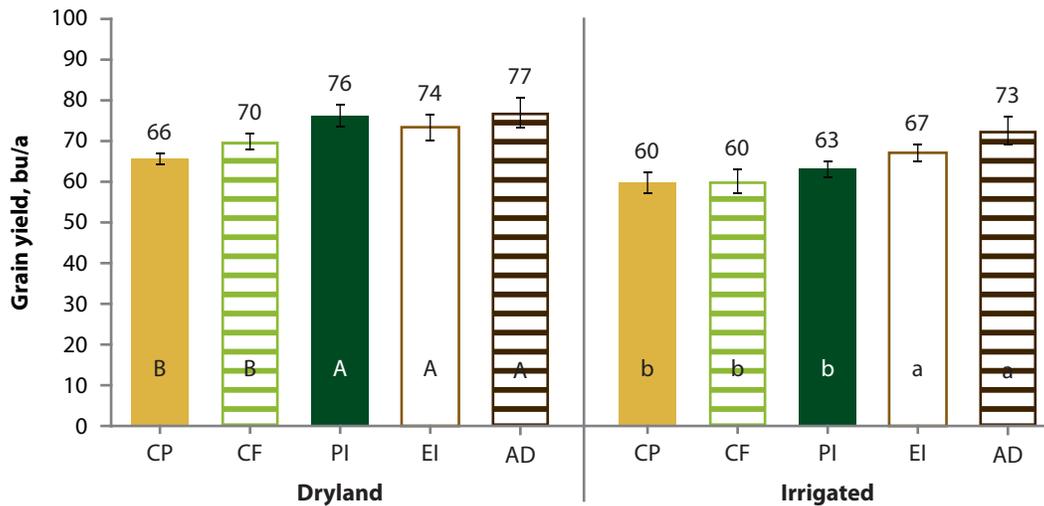


Figure 4. Soybean grain yields by treatment for dryland and irrigated conditions during the 2015 growing season, KRV, Topeka, KS. Different letter shows statistical differences ( $p < 0.05$ ). CP = Common practices, CF = comprehensive fertilization, PI = production intensification, EI = ecological intensification (CF+PI), and AD = advanced plus.