MAXIMIZING IRRIGATED CORN AND SOYBEAN YIELDS IN THE GREAT PLAINS

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ABSTRACT

The corn experiment was conducted in 2000 through 2002 on a producer's field in the Republican River Valley, on a Carr sandy loam soil, and in 2003-2004 on the North Central Kansas Experiment Field, on a Crete silt loam soil. Treatments consisted of two plant populations (28,000 and 42,000 plants/a) and nine fertility treatments consisting of three N rates (160, 230, and 300 lb/a) in combination with rates of P, K, and S. Results from the 3-year study on the Carr sandy loam soil show a clear interaction between plant density and fertility management. Increasing plant density had no effect on yield unless fertility was increased simultaneously and one-third of the fertility response was lost if plant density was not increased. Treatments added in 2001 and 2002 show that all three elements contributed to the yield response. The addition of P, K and S increased yield by 88 bu/a over the N alone treatment. Results from the two-year study on the Crete silt loam soil were similar. The low fertility level yields were decreased when population was increased. When additional fertility was added corn yield responded to higher plant populations. Addition of P, K and S all resulted in yield increases, although the magnitude of the sulfur response was not as great as it was on the sandy Carr soil. The soybean study was conducted in 2004-2205 on a Crete silt loam soil at the North Central Kansas Experiment Field. Treatments included row spacing (30 and 7.5 inch-rows) plant population (150,000 and 225,000 plants/acre) and fertility treatments. Fertility treatments consisted of a low P application (KSU soil test recommendations would consist of 30 lb P_2O_5/acre at this site), low P-low K, low P-high K, high P-high K, and an unfertilized check plot. In 2005 a treatment consisting of 5 lb/acre manganese (Mn) was added. Phosphorous application rates were 30 or 80 lb P_2O_5/acre, and K treatments were 80 or 120 lb K_2O/acre. The N-P-K treatment consisted of application of 20 lb N, 80 lb P_2O_5 and 120 lb K_2O/acre. Fertilizer was broadcast in mid-March each year. Soybeans were sprinkler irrigated. Neither increasing plant population nor decreasing row spacing resulted in any improvement in yield. In both years of the experiment, applying 80 lb P_2O_5 with 60 lb K_2O/acre increased yield by over 30 bu/acre as compared to the unfertilized check plot. Addition of Mn to the mix significantly increased yield. In high yield environments, soybean yields can be greatly improved by direct fertilization. Results of these experiments illustrate the importance of using a systems approach when attempting to increase yield levels.

INTRODUCTION

With advances in genetic improvement of corn, yields continue to rise. Modern hybrids suffer less yield reduction under conditions of water and temperature stress. Hybrids no longer suffer major yield loss due to insect, weed, and disease infestations. Newer hybrids have the ability to increase yields in response to higher plant populations. Since 1970, the national average corn yield has increase at a rate of 1.75 bushels/acre/year. Corn yields reached an all time high of 142 bushels/acre in 2003. However, yields obtained in university hybrid performance trials and in state corn grower contests have been much greater. The average corn yield increase during the period 1970-2003 in Republic County, Kansas was the same as the national average. However, yields in KSU's Irrigated Corn Hybrid Performance Test increased at the rate of 2.8 bu/acre/year. There is a large gap between attainable yields and present average yields. Soybean yield trends in performance tests have also been on an upward trend. However, average state-wide yields in Kansas have not increased. Typically in a corn-soybean rotation, fertilizer is only applied during the corn phase of the rotation. On a per bushel basis, soybean removes twice as much P and almost five times as much K as corn. One important aspect of yield advance is that it comes from synergistic interactions between plant breeding efforts and improved agronomic practices. Innovations in each field successively open up opportunities for the other. The overall objective of the research project is to find practical ways of narrowing the existing gap between average and obtainable yield. This study evaluates more intensive fertility management at standard and high plant populations.

METHODS

The corn experiment was conducted in 2000 through 2002 on a producer's field located in the Republican River Valley near the North Central Kansas Experiment Field, at Scandia, KS, on a Carr sandy loam soil. In 2003-2004 the experiment was conducted at the Experiment Field on a Crete silt loam soil. On the Carr sandy loam site, analysis by the Kansas State University Soil Testing laboratory showed that the initial soil pH was 6.8, organic matter was 2%, Bray-1 P was 20 ppm, exchangeable K was 240 ppm, and SO_4-S was 6 ppm. Soil test values for the Crete silt loam site were: pH, 6.5; organic matter, 2.6%; Bray-1 P, 25 ppm, exchangeable K 170 ppm, and SO_4-S, 15 ppm. Treatments included two plant populations (28,000 and 42,000 plants/acre) and nine fertility treatments. Fertility treatments consisted of three nitrogen (N) rates (160, 230, and 300 lb/acre) applied in two split applications (1/2 preplant and 1/2 at V4) in combination with 1) current soil test recommendations for P, K and S (this would consist of 30 lb/acre P_2O_5 at these two sites); 2) 100 lb P_2O_5 + 80 lb K_2O + 40 lb SO_4-S/acre applied preplant, and the three N rates applied in two split applications (1/2 preplant and 1/2 at V4 stage); and 3) 100 lb P_2O_5 + 80 lb K_2O + 40 lb/acre SO_4-S applied preplant with N applied in four split applications (preplant, V4, V8 and tassel). In 2001 treatments were included in order to determine which elements were providing yield increases. Additional treatments included an unfertilized check, 300 lb/a N alone, 300 lb N + 100 lb/a P_2O_5, 300 lb N + 100 lb/ P_2O_5 + 80 lb/a K_2O, and 300 lb N + 100 lb P_2O_5 + 80 lb K2O + 40 lb/a SO_4-S. Preplant applications were made 14-20 days before planting each year. Fertilizer sources were ammonium nitrate, monoammonium phosphate (MAP), ammonium sulfate, and potassium chloride (KCL). The experiment was fully irrigated. Irrigation was scheduled using neutron attenuation methods. Irrigation water was applied when 30% of the available water in the top 36 inches of soil was depleted.

The soybean experiment was conducted on a Crete silt loam soil at the North Central Kansas Experiment Field and included soybean planted at two row spacings (30 and 15 inches) and two plant populations (150,000 and 225,000 plants/acre). Fertility treatments consisted of a low P application (KSU soil test recommendations would consist of 30 lbs P_2O_5/acre at this site), low P-low K, low P-high K, high P-high K, N-P-K, N-P-K-Mn and an unfertilized check plot. Phosphorous application rates were 30 or 80 lb P_2O_5/acre, and K treatments were 80 or 120 lb K_2O/acre. The N-P-K treatment consisted of application of 20 lb N, 80 lb P_2O_5 and 120 lb/acre

K_2O. The N-P-K-Mn consisted of the same N-P-K treatment plus 5 lb/acre Mn. Soil test values were: pH, 6.9; Bray-1 P, 21 ppm, and exchangeable K, 210 ppm. Fertilizer was broadcast in mid-March. The soybean variety Asgrow 3305 was planted on May 8 in 2004 and on May 10, in 2005. Soybeans were sprinkler irrigated.

RESULTS

The results from the 3-year study on the Carr sandy loam soil clearly illustrate the interaction between plant density and fertility management (Table 1). Increasing plant density had no effect on yield unless fertility was increased simultaneously and one-third of the fertility response was lost if plant density was not increased. Fertility levels must be adequate in order to take advantage of the added yield potential of modern hybrids grown at high plant populations. Treatments added in 2001 and 2002 show that all three elements contributed to the yield response (Table 2). The addition of P, K, and S increased yield by 88 bu/acre over the N alone treatment.

Results from the two-year study on the Crete silt loam study were similar (Table 3). At the low fertility treatment yields were decreased when population was increased. When additional fertility was added corn yield responded to higher plant populations. As in the experiment on the Carr soil, one third of the fertility response was lost if plant population was not increased. Addition of P to the N increased yield by 56 bu/acre (Table 4). Addition of K further increased yield by 13 bu/acre, and adding sulfur to the mix further increased yield by 9 bu/acre. With both soils, yield increased with increasing N rate up to the 230 lb N/acre rate. Increasing the number of N applications from 2 to 4 did not increase yields on either soil in any year of the experiment.

Results of this experiment have shown a clear interaction between plant density and fertility management, thus illustrating the importance of using a systems approach when attempting to increase yield levels. This 5-year study also points out the need for soil test calibration and fertility management research that is conducted at high yield levels. Standard soil test recommendations on these two soils would not have produced maximum yield.

In neither year of the soybean experiment did increasing plant populations or reducing row spacing result in any increase in yield (Tables 5and 6). In 2004 increasing plant population in narrow rows actually reduced yield. Soybean yields did respond to fertilizer application. In 2004 applying 80 lb P_2O_5 with 60 lb/a K_2O increased yield by 32 bu/acre over the unfertilized check plot (Table 7). Applying additional K or adding N to the mix did not increase yields. In 2005 soybean yield was not affected by row spacing or plant population nor was yield affected by any interaction of factors. Fertility treatments did have a dramatic effect on soybean yield (Table 8). Applying 80 lb P_2O_5 with 60 lb/a K_2O increased yield by 33 bu/acre over the unfertilized check plot. Applying additional K or N did not result in any yield increase. However, addition of Mn to the mix did significantly increase yield.

Table 1. Maximizing Irrigated Corn Yields, Carr sandy loam soil, 2000-2002

Population, Plants/acre	$P_2O_5 + K_2O + S$ (lb/acre)* 30+ 0 +0	100 +80 + 40	Response
	Grain Yield, bu/acre		
28,000	162	205	43
42,000	159	223	64
Response	-3	18	

*Plus 230 lb N/acre (1/2 preplant; 1/2 at V4)

Table 2. Maximizing Irrigated Corn Yields, Carr sandy loam soil, 2001-2002

Fertility Treatment	Grain Yield, bu/acre
Unfertilized check	80
N	151
N + P	179
N + P + K	221
N + P + K + S	239
LSD (0.05)	10

Table 3. Maximizing Irrigated Corn Yields, Crete silt loam Soil, 2003-2004

Population	P2O5 + K2O + S (lb/acre)* 30 + 0 + 0	100 + 80 + 40	Response
	Grain Yield, bu/acre		
28,000	202	225	23
42000	196	262	66
Response	-6	37	

Table 4. Maximizing Irrigated Corn Yields, Crete silt loam soil, 2003-2004

Fertility Treatment	Grain Yield, bu/acre
Unfertilized check	137
N	187
N + P	243
N + P + K	256
N + P + K + S	265
LSD (0.05)	7

Table 5. Soybean yield as affected by row spacing and plant population (average over fertility treatments) 2004.

Row Space	150,000 plants/a	255,000 plants/a
	Yield, bu/a	
30 inch	76	77
7.5 inch	77	73
LSD (0.05) =3		

Table 6. Soybean yield as affected by row spacing and pant population (average over fertility treatments) 2005.

Row Space	150,000 plants/a	255,000 plants/a
	Yield, bu/a	
30 inch	78	80
7.5 inch	80	78
LSD (0.05) =NS*		

*Not Significant

Table 7. Plant population and fertility effects on soybean yield (average over row spacing) 2004.

Treatments	150,000 p/a	225,000 p/a
	Bu/a	Bu/a
Check	53	43
Low P	61	53
Low P-Low K	73	69
Low P-High K	77	77
High P-Low K	85	85
High P-High K	85	84
N-P-K	86	85
LSD (0.05)=2		

Table 8. Fertility effects on soybean yield, 2005 (average over row spacing and plant population).

Treatments	
	bu/a
Check	55
Low P	63
Low P-Low K	76
Low P-High K	81
High P-Low K	88
High P-High K	89
N-P-K	88
N-P-K-Mn	93
LSD (0.05)=3	