2006

Effects of Four Tillage Systems and Placement of Phosphorus and Potassium Mixtures on Grain Yield in Corn-Soybean Rotations and Continuous Corn

Antonio P. Mallarino
Iowa State University, apmallar@iastate.edu

Kenneth T. Pecinovsky
Iowa State University, kennethp@iastate.edu

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Abstract
Producers can use various tillage and fertilizer placement methods to optimize yield, nutrient use efficiency, soil conservation, water quality, and economic benefits in crop production. Different tillage systems may require different phosphorus (P) and potassium (K) application rates or placement methods because tillage changes many physical soil properties and root growth patterns. Broadcasting fertilizers may be less efficient than banding with conservation tillage because P, K, and crop residues accumulate at or near the soil surface.

Keywords
Agronomy

Disciplines
Agricultural Science | Agriculture | Agronomy and Crop Sciences

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Antonio P. Mallarino, professor
Department of Agronomy
Ken Pecinovsky, farm superintendent

Introduction

Producers can use various tillage and fertilizer placement methods to optimize yield, nutrient use efficiency, soil conservation, water quality, and economic benefits in crop production. Different tillage systems may require different phosphorus (P) and potassium (K) application rates or placement methods because tillage changes many physical soil properties and root growth patterns. Broadcasting fertilizers may be less efficient than banding with conservation tillage because P, K, and crop residues accumulate at or near the soil surface.

A study was conducted from 1997 to 2004 on an area with Floyd and Clyde soils to compare fertilizer placement methods for corn-soybean rotations and continuous corn managed with moldboard plow (MB), chisel plow (CH), no-till (NT), and ridge-till (RT) tillage. From 1978 until 1996, tillage treatments were applied to nonreplicated field blocks with uniform broadcasting of P and K fertilization. Plots managed with MB and CH were plowed in the fall and field cultivated in the spring. Crops were planted using 30-in. row spacing. Yields for this period are not shown. Tillage treatments were subdivided for the 1997 crop to apply twelve fertilizer treatments replicated three times (Table 1). Treatments were applied to all crops, and placement methods (broadcast or deep band, in the fall) and frequency of application (yearly or twice the rate applied in alternate years) for primary fertilization with or without P-K starter were evaluated. All fertilizer sources were commercial granulated products. The deep bands were placed using a 30-in. spacing and a 5–7 in. depth with coulters and knives that also strip-tilled the soil. The starter was applied 2 in. below and 2 in. besides the seeds.

Results and Discussion

Table 2 summarizes the effects of tillage and selected fertilizer treatments on soil-test values for the corn-soybean rotation. Similar effects were observed for continuous corn, even though initial soil-test values were higher. Iowa State University soil-test interpretations indicate that response to fertilization is unlikely when soil test values to a 6-in. depth are higher than optimum (higher than 20 ppm P and 170 ppm K for most Iowa soils). Calculations of average soil-test values to a 6-in. depth for these plots indicated that P was above optimum for all tillage systems during the evaluation period but initially high K levels in the check plots decreased to values in the optimum and low categories in recent years.

Soil P and K were not stratified with MB, were slightly stratified with CH, and were very stratified with NT and RT. The P accumulation near the soil surface for MB, CH, and NT or in the ridges for RT was relatively higher than for K, a result that agrees with slightly less mobility and recycling with crop residues for P than for K. Starter fertilization, which was slightly less than one-half the average P and K removed with harvest, did not maintain soil P and K values with MB and RT, but maintained values with CH and NT. We cannot fully explain this result, although CH and NT plots were mainly on

Floyd soil, while MB and RT were mainly on the slightly finer-textured Clyde soil. Broadcast or deep-band P and K maintained or increased soil-test values. Deep banding reduced soil-test stratification with CH and NT, although the effect was more significant for P. Other experiments also have showed that deep banding is more effective at reducing stratification of P than K, probably due to less P mobility and recycling with residues. Deep banding did not significantly change lateral stratification with RT.

Table 3 summarizes treatment effects on crop yield. The design did not allow for statistical tests of tillage effects; however, data indicate that NT and RT resulted in lower corn yield than MB and CH but about similar soybean yield. No fertilizer treatment influenced yield in early years when soil-test levels were high. Crops started to respond over time because soil-test K of check plots decreased into low values. Yield for broadcast or deep-band treatments applying twice the annual rate every other year (not shown) did not differ from the annual applications.

Fertilization effects usually did not differ clearly across crops and tillage systems, but there were a few exceptions. Yield response to fertilization was relatively greater and more frequent for corn than for soybean, especially with MB. Application of starter alone did not affect or decreased yield with RT. We cannot fully explain this result, but perhaps the depth control of the planter attachments was poorer in the ridges. Deep bands or a combination of broadcast and starter were the most effective treatments for no-till corn, especially for corn after soybean. Other studies with separate treatments for strip tillage and deep-band P or K at this farm showed a response to deep K banding beyond any strip tillage effect.

Conclusions

Crops responded to fertilization only in the last years of the study when soil K of the check plots had decreased into the optimum or low categories. Responses were small and differences among fertilized treatments were small and inconsistent. However, the results showed that starter alone was as effective as higher broadcast or deep-band rates for MB and CH but not for NT and RT. Deep banding and a combination of broadcast plus starter fertilization were more effective that broadcast fertilization alone for NT and RT, which was probably explained by deep K placement.

Table 1. Phosphorus and potassium treatments.*

Treat	Place	Starter	Broad	Deep
		-- lb P_2O_5 and K_2O/acre --		
1	Check	0	0	0
2	S	18/23	0	0
3	B	0	50/60	0
4	SB	18/23	50/60	0
5	D	0	0	50/60
6	SD	18/23	0	50/60
7	Balt	0	100/120	0
8	SBalt	18/23	100/120	0
9	Dalt	0	0	100/120
10	SDalt	18/23	0	100/120
11	BDalt	0	100/120	100/120
12	SBDalt	18/23	100/120	100/120

*Treat=treatment; Broad or B=broadcast; Deep or D=deep band; S=starter; alt=B or D applied in alternate years. For BD, broadcast and deep band applied alternating every two years.

Table 2. Initial soil-test values and final values for selected soil sampling depths and treatments.*

		Soil-Test P (Bray-1 Test)					Soil-Test K (Ammonium Acetate Test)				
Tillage	Depth	Initial	Check	Starter	Broad	DB	Initial	Check	Starter	Broad	DB
	in.	---------- ppm ----------					---------- ppm ----------				
CH	0-3	62	40	69	72	55	215	184	246	259	236
	3-6	45	31	50	63	55	129	109	141	153	148
MB	0-3	34	20	24	33	40	139	92	92	112	146
	3-6	29	18	21	33	38	99	88	86	103	121
NT	0-3	66	44	65	96	67	196	154	222	234	214
	3-6	17	23	30	36	55	84	84	101	94	119
RT	0-6r	52	25	27	57	62	163	102	99	151	170
	0-6v	18	18	14	42	43	91	94	85	139	163

*CH=chisel; MB=moldboard plow; NT=no-till; RT=ridge-till; Broad=broadcast; DB=deep band; 0–6r=samples taken from the ridges and 0–6v=samples taken from the valleys.

Table 3. Crop grain yield as affected by tillage and P-K fertilization during the last four years of the study.*

Crop	Tillage	Check	Starter	Broad	B + S	Deep	D + S	Fert Avg
		---------- bu/acre ----------						
CC	CH	177	184	180	185	181	181	182
	MB	183	186	187	191	181	187	186
	NT	164	165	167	167	169	171	168
	RT	177	172	183	178	181	181	179
Cs	CH	198	203	209	211	203	207	207
	MB	191	199	206	202	200	206	203
	NT	189	200	200	206	205	205	203
	RT	189	181	195	202	201	198	195
cS	CH	52.7	54.5	54.4	54.9	54.6	54.9	54.7
	MB	53.2	52.2	51.4	53.6	52.4	53.2	52.6
	NT	51.7	52.2	53.5	53.7	53.7	54.0	53.4
	RT	48.8	48.8	51.6	50.8	51.3	51.0	50.7

*Four crops for continuous corn (CC) and two crops for corn after soybean (Cs) and soybean after corn (cS). AQ1.Corn yield severely affected by excess moisture in 1999 and yields of both crops affected by draught in 1999 were not included. Broad=broadcast; B + S=broadcast plus starter; deep = deep band; D + S=deep band plus starter.