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Long-term Phosphorus and Potassium Placement Methods and Tillage Effects on Yield of Corn and Soybean

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Abstract
No-till management can change many soil properties and crop yield compared with tillage. Because broadcast phosphorus (P) and potassium (K) fertilization with no-till results in significant accumulation of both nutrients at or near the soil surface, subsurface band application could be more effective. A study was initiated in 1994 to compare no-till and chisel-plow tillage and fertilizer placement methods for a corn-soybean rotation. The soil at the experimental area is Floyd loam, and initially tested Very High in P (33 ppm, Bray- 1) and Optimum in K (140 ppm). The study includes four trials: P for corn, P for soybean, K for corn, and K for soybean. Both crops are grown each year by alternating adjacent areas, and treatments are applied for both crops. The crops are planted using a 30-in. row spacing. Cornstalks of plots managed with tillage are chisel-plowed in the fall and field cultivated in spring, whereas soybean residues only are field cultivated in spring.

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Introduction

No-till management can change many soil properties and crop yield compared with tillage. Because broadcast phosphorus (P) and potassium (K) fertilization with no-till results in significant accumulation of both nutrients at or near the soil surface, subsurface band application could be more effective. A study was initiated in 1994 to compare no-till and chisel-plow tillage and fertilizer placement methods for a corn-soybean rotation. The soil at the experimental area is Floyd loam, and initially tested Very High in P (33 ppm, Bray-1) and Optimum in K (140 ppm). The study includes four trials: P for corn, P for soybean, K for corn, and K for soybean. Both crops are grown each year by alternating adjacent areas, and treatments are applied for both crops. The crops are planted using a 30-in. row spacing. Cornstalks of plots managed with tillage are chisel-plowed in the fall and field cultivated in spring, whereas soybean residues only are field cultivated in spring.

Materials and Methods

Until the 2009 crop year, fertilizer placement methods have been broadcast, deep band (both in the fall), and planter band (spring). Deep bands were applied at a 30-in. spacing and 5 to 6 in. deep with a toolbar equipped with coulters and knives that strip till the soil. Planter bands were applied 2 in. below and beside the seeds with dry fertilizer attachments. Fertilizer rates are a control, rates slightly higher than one-half the estimated average maintenance needs for the rotation (28 lb P_2O_5/acre or 35 lb K_2O/acre), and double these rates (56 lb P_2O_5/acre or 70 lb K_2O/acre). Additional treatments applied once every two years were the high annual rate before corn or soybean. A strip-tillage check was included for the no-till treatments.

Results and Discussion

We summarized grain yield results for the three placement methods until 2009, because the deep-band treatment was discontinued in fall 2009. Data in Tables 1 and 2 show average grain yields for the 16-yr period and for the last two years. Data for treatments that were applied every two years at twice the high annual P or K rate before each crop are averaged with the equivalent annual rates because yields were similar.

Crop yields, mainly of corn, have increased significantly over time. Soybean yield across fertilized treatments has been about the same for both tillage systems. However, fertilized corn yield has been higher for chisel-plow tillage (7 bu/acre for the 16-yr average and also the last 2-yr average). This difference has varied greatly over time, however, ranging from no difference up to 21 bushels/acre. Rainfall, spring temperature, and green snapping (worse for chisel-plowed corn one year) have explained the differences over time.

No crop has shown a consistent yield response to P (Table 1) even after 16 years cropping because initially the soil tested Very High in P. In the last two years there was a very small responsive trend for no-till corn. By fall 2006 soil P of the non-fertilized plots had decreased to the Optimum soil-test class. The 56-lb annual rate treatment increased the soil test to higher levels. In agreement with little or no

response to P, no differences have been observed between the P placement methods. In contrast to these grain yield results, measurements done until early 2000 showed that deep-band and planter-band P significantly increased crop early growth and P uptake compared with the broadcast treatment.

Potassium fertilization effects on crop yield are shown in Table 2. The crops began to respond to K fertilization 1997 for both tillage systems. Responses have increased over time because soil-test K of the control plots has been decreasing and began testing Low in 2003. The K fertilizer treatments (application rates or placement methods) were statistically similar in both time periods for soybean managed with either tillage system and also for corn managed with chisel-plow tillage. The K treatments sometimes differed for no-till corn, however. In both time periods, the high K rate applied broadcast or banded with the planter increased yield more than the low rate. For the deep-band treatment, however, both the low and high K rates resulted in yields as high as with the highest rates applied broadcast or with the planter. This result suggests a higher efficiency for low K rates applied deep banded. This was also observed in trials conducted until 2001 at other research farms and farmers' fields managed with no-till, strip-till, or ridge tillage. This is the reason ISU recommendations in publication PM 1688 suggested deep-band K for corn managed with these tillage systems.

The results in Tables 1 and 2 show that yield of no-till soybean was not affected by strip tillage alone. For no-till corn, however, results show a small response (4 bu/acre) only in the P trial (Table 1), for which high broadcast K rates have been applied across all plots (including the P controls) in the past, but not in the K trials. Results from trials at other fields sometimes also have shown that a strip tillage effect is smaller when high broadcast P rates have been applied. This can be explained by P enhancing early corn growth.

Conclusions

The tillage method seldom influenced soybean yield but corn yield has been lower for no-till. Strip-tillage has not improved no-till grain yield consistently. Grain yield has not been increased by P fertilization because soil-test P of control plots has been Optimum or higher, although banded P has increased early growth more than broadcast P. Large yield response to K has been observed recently because soil-test K of control plots has decreased into the Low category. Deep-band K fertilization has slightly increased no-till corn yield over the broadcast and planter-band methods only for the lowest K rate applied.

Table 1. Tillage and phosphorus fertilizer placement methods and rates effects on corn and soybean yields.

		Phosphorus placement and rate (lb P_2O_5/acre/year)							
		No P fertilizer		Broadcast		Deep bands		Planter bands	
Tillage	Years	Check	Strip till	28 lb	56 lb	28 lb	56 lb	28 lb	56 lb
		Corn grain yield (bu/acre)							
Chisel	1994-2009	179	180	179	180	179	181	179	179
	2008-2009	209	211	212	216	212	217	208	209
No-till	1994-2009	170	170	173	172	173	174	170	173
	2008-2009	200	204	209	210	206	213	205	211
		Soybean grain yield (bu/acre)							
Chisel	1994-2009	57.9	57.2	58.6	58.7	58.9	58.4	58.9	58.9
	2008-2009	62.2	61.1	64.8	64.5	64.4	62.8	63.9	65.6
No-till	1994-2009	57.4	55.5	57.4	56.8	56.3	56.9	56.8	57.0
	2008-2009	60.2	60.2	61.9	62.0	61.4	61.1	60.4	62.5

Table 2. Tillage and potassium fertilizer placement methods and rates effects on corn and soybean yields.

		Potassium placement and rate (lb K_2O/acre/year)							
		No K fertilizer		Broadcast		Deep bands		Planter bands	
Tillage	Years	Check	Strip till	35 lb	70 lb	35 lb	70 lb	35 lb	70 lb
		Corn grain yield (bu/acre)							
Chisel	1994-2009	172	173	182	184	182	185	186	181
	2008-2009	204	203	223	222	221	221	227	214
No-till	1994-2009	160	162	170	178	179	177	173	176
	2008-2009	185	185	207	219	212	214	205	210
		Soybean grain yield (bu/acre)							
Chisel	1994-2009	52.1	50.5	55.7	56.8	56.4	57.7	56.4	56.8
	2008-2009	52.1	50.3	56.0	59.4	59.4	59.8	58.6	57.8
No-till	1994-2009	50.7	49.9	55.7	56.5	56.8	56.8	55.2	56.5
	2008-2009	49.0	50.2	58.4	60.0	60.3	60.2	56.6	60.2