Evaluation of Phosphorus and Potassium Fertilizer Placement Methods and Tillage Systems for Corn and Soybean During 25 Years in Northeast Iowa Soil

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Introduction

No-till management results in little or no incorporation of crop residues and fertilizer into the soil. The residue cover increases soil moisture and root efficiency in the summer, but results in colder soil in early spring. Because both phosphorus (P) and potassium (K) have little mobility in soils, no-tillage causes P and K accumulation in the top few inches of soil. In these conditions, subsurface banding could be more effective than broadcast fertilization in some soil types and climates. Therefore, a long-term study was conducted from 1994 through 2018 to evaluate the effects of P and K fertilizer rates and placement methods on grain yield of corn and soybean managed with no-till or tillage. Broadcast, planter-bands, and deep bands were evaluated until 2009, when the deep banding was discontinued. Previous reports summarized deep-band results. This report summarizes results for broadcast and planter-band methods for the entire 25-year study.

Materials and Methods

The study, on Floyd loam soil, included a P trial for corn and soybean and a K trial for corn and soybean. Both crops were planted each year on adjacent areas with identical treatments and were rotated over time using 30-in. row spacing. Cornstalks of tilled plots were chisel-plowed in fall and field cultivated in spring. Soybean residue was only field cultivated in spring. Fertilizers used were granulated triple superphosphate and potassium chloride (potash). The broadcast fertilizer was spread in fall and bands were placed 2 in. below and 2 in. beside the seeds with planter attachments. Annual rates for both placement methods were a control, 28 lb P_2O_5/acre or 35 lb K_2O/acre, and 56 lb P_2O_5/acre or 70 lb K_2O/acre. Other broadcast treatments were twice the high rates applied every two years before corn or soybean.

Results and Discussion

Soil-test values. Initial soil-test values in 1994 for a 6-in. depth according to ISU current interpretations were borderline between High and Very High for P (33 ppm, Bray-1 test) and Low for K (140 ppm, ammonium acetate test on dried samples). Samples from depths of 0-3 and 3-6 in. showed greater stratification for P than for K (top layer levels were 67 and 26 percent greater for P and K, respectively).

Table 1 shows final soil-test P (STP) at end of study fall 2018. STP at 6-in. depth for control plots declined to Low category, maintained with 28-lb P rate and increased with 56-lb rate. There were no clear or consistent STP differences between tillage systems or placement methods. The STP stratification (higher in the top 3 in.) was large for all treatments, but was larger in fertilized plots than in control plots and was larger with no-till than with tillage for the lowest 28-lb broadcast rate.

Table 2 shows the final soil-test K (STK) values in fall 2018. At a 6-in. depth, STK for nonfertilized plots declined over time to the Very Low category, declined only slightly with the 28-lb K rate, and increased with higher rates. There were no large or consistent

STK differences between tillage systems or placement methods. The STK stratification was much less than for STP with small and inconsistent differences between tillage systems and placement methods. Previous studies also showed less stratification for soil K than soil P for all tillage systems.

Tillage effects. Tables 3 and 4 show corn and soybean yields as affected by tillage systems, fertilization rates, and placement methods. Corn yield was higher with tillage than with no-till for most years. Calculations from data in the tables indicate that across P and K fertilized plots, corn yield with tillage was 8 and 6 bushels/acre higher than with no-till for averages across the 25 years or the last 4 years, respectively. Soybean yield was not affected by tillage (small differences in some years canceled out over time).

Phosphorus effects (Table 3). In the early years, there was no crop response to P because STP was high. Occasional small increases were observed in the late 1990s that became larger over time as STP of the control continued declining. Therefore, there were very small yield increases for the 25-yr averages but larger increases for the last 4-yr averages, mainly for corn. Average corn yield for the last four years for both tillage systems was the highest with the annual 56-lb rate broadcast or banded and with twice this rate broadcast every two years. However, a corn P deficiency reduced yield more with no-till than with tillage, which also was observed by other Iowa research. Soybean yield response to P was much less than corn yield in both periods, and there were no placement method differences. The 28-lb rate broadcast or banded maximized soybean yield for both average periods. Although placement method did not affect yield, early results from this study showed banded P increased early growth more than broadcast P, mainly with no-till.

Potassium effects (Table 4). There was a crop response to K from the beginning of the study because STK was in the Low category and yield increases became larger over time. In the last four years, yield increases were much larger for corn than for soybean and also larger with no-till than with tillage. There was no statistically significant K placement effect. On average, for the last four years the additional yield increases by the 70-lb rate over the 35-lb rate were only 3 to 4 bushels/acre for both crops. As was observed for P, applying K annually, or twice the amount every other year before either crop, did not differ. In contrast to results for P, a K deficiency reduced soybean yield much more with no-till than with tillage, but the difference was less for corn.

Conclusions

Potassium fertilization increased yield of both crops from the beginning of the study because STK was low and P began increasing yield once initially high STP of the non-fertilized plots declined over time. The broadcast or planter-band P or K placement methods did not differ for any crop or tillage system and the P or K rate needed to maximize crop yield were similar with no-till or tillage. However, a P or K deficiency reduced yield more with no-till than with tillage, especially P deficiency for corn and K deficiency for soybean.

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Table 1. Soil-test P at the end of the 25-year period (fall 2018).†

		Annual P placement method and rate (P_2O_5/acre)				
			Broadcast		Planter-band	
Tillage	Depth	0	28	56	28	56
	inches	Soil test P (ppm)				
Tilled	0-3	13	33	76	25	49
	3-6	8	15	33	13	25
	0-6	10	24	54	19	37
No-till	0-3	7	49	94	27	65
	3-6	5	12	31	12	34
	0-6	6	30	63	20	49

† Mean of Bray-1 and Mehlich-3 tests (colorimetric measurement of extracted P).

Table 2. Soil-test K at the end of the 25-year period (fall 2018).†

		Annual K placement method and rate (K_2O/acre)				
			Broadcast		Planter-band	
Tillage	Depth	0	35	70	35	70
	inches	Soil-test K (ppm)				
Tilled	0-3	118	137	217	165	165
	3-6	93	110	129	116	128
	0-6	105	124	173	141	147
No-till	0-3	106	138	227	134	208
	3-6	89	94	125	99	135
	0-6	98	116	176	116	171

† Mean of ammonium-acetate and Mehlich-3 tests with dry soil sample handling.

Table 3. Phosphorus placement method and application rate effects on crop yield.

		P placement method and rate (lb P_2O_5/acre)					
Period	Tillage	0	Broad 28	Broad 56	Broad 56x2†	Band 28	Band 56
		Corn yield (bu/acre)					
1994-2018	Tillage	189	191	194	194	191	192
	No-till	177	184	185	185	183	185
2015-2018	Tillage	222	232	237	235	226	234
	No-till	203	222	230	230	226	232
		Soybean yield (bu/acre)					
1994-2018	Tillage	58.6	60.5	60.6	60.5	60.2	60.7
	No-till	58.3	59.6	59.6	59.7	59.8	59.5
2015-2018	Tillage	60.1	63.6	64.2	64.0	61.7	64.5
	No-till	61.8	64.2	67.0	64.8	67.1	64.3

†56x2, twice the 56-lb rate applied once for the 2-yr rotation before corn or soybean.

Table 4. Potassium placement method and application rate effects on crop yield.

		K placement method and rate (lb K_2O/acre)					
Period	Tillage	0	Broad 35	Broad 70	Broad 70x2†	Band 35	Band 70
		Corn yield (bu/acre)					
1994-2018	Tillage	178	193	195	196	196	193
	No-till	165	183	190	190	183	188
2015-2018	Tillage	197	228	233	232	232	228
	No-till	183	221	225	226	216	226
		Soybean yield (bu/acre)					
1994-2018	Tillage	50.2	55.7	57.5	57.2	56.7	56.9
	No-till	48.0	56.3	57.8	57.5	55.9	57.9
2015-2018	Tillage	46.6	54.9	57.9	59.2	56.4	57.0
	No-till	43.3	58.2	61.5	61.7	57.5	60.5

†70x2, twice the 70-lb rate applied once for the 2-yr rotation before corn or soybean.