Long-Term Phosphorus and Potassium Placement Methods and Application Rates for Corn and Soybean Managed with No-Tillage and Tillage

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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 of P and K fertilizers could be more effective than broadcast fertilization in some soil types and climates. Therefore, a long-term study was conducted from 1994 to 2018 at the ISU Northwest Research Farm, Sutherland, Iowa, to evaluate P and K fertilizer placement methods for corn-soybean rotations managed with no-till or chisel-plow/disk tillage.

Materials and Methods

Separate P and K trials were established in 1994 on an area with Galva and Primghar silty clay loam soils. Corn and soybean were grown each year on adjacent areas and were rotated each year. Treatments replicated three times were combinations of P or K placement methods and application rates and frequency for no-till or chisel-plow/disk management. Placement methods evaluated were broadcast, deep-band, and planter-band until 2001, when the deep banding was discontinued due to insufficient funds and equipment. Previous reports have shown results for the early period. This report summarizes results from 2002 until 2018 for the broadcast and planter-band placement methods.

Tillage for the tillage treatment was chisel-plowing in the fall and field cultivating in the spring for plots with cornstalks, and only field cultivation in the spring for plots with soybean residue. Since fall 2001, the P or K placement methods were broadcast in the fall or banding with the planter in the spring. The fertilizers used were granulated triple superphosphate (0-46-0) and potassium chloride (0-0-62). Broadcast fertilization was done in the fall for both tillage systems and before chisel-plowing for plots managed with tillage. The planter had row cleaners and attachments for banding granular fertilizer 2 in. below and 2 in. beside the seeds. Crops were planted using a 30-in. row spacing.

Fertilizer rates for each placement method were a nonfertilized control, annual rates of 28 and 56 lb P_2O_5/acre or 35 and 70 lb K_2O/acre for P and K trials, respectively, application of the low rates both broadcast in the fall and banded in the spring (total 56 lb P_2O_5/acre or 70 lb K_2O/acre), and broadcasting 112 lb P_2O_5/acre or 140 lb K_2O/acre once for the 2-yr rotation either before corn or soybean. Since fall 2001, annual broadcast rates of 112 lb P_2O_5/acre or 140 lb K_2O/acre were applied to plots of P or K trials that had received the low rates both broadcast and deep-banded.

Results and Discussion

Soil-test values. Initial soil-test values in 1994 for a 6-in. depth for P were borderline between Very Low and Low according to ISU current interpretations (8 ppm, Bray-1 test) and for K were in the lower portion of the High category (211 ppm, ammonium acetate test on dried samples). Samples taken from depths of 0-3 and 3-6 in. showed greater stratification of P than of K (levels of the top 3-in. layer were 67 and 26 percent greater, respectively).

Table 1 shows the final soil-test P values in fall 2018 for selected treatments sampled. Soil P of the nonfertilized controls at 6-in. depth declined slightly to a Very Low level over time. Also, all P fertilizer rates increased soil P values. Soil P for the 6-in. depth did not differ clearly between tillage systems or placement methods. The soil P levels were in the upper range of the Low category for the annual 28-lb rate, and tested Very High for higher rates. The soil P stratification within a 6-in. depth was greater in fertilized plots (higher P in the top 3 in. of soil), and greater with the broadcast placement and no-till treatments.

Table 2 shows the final soil-test K values in fall 2018. Soil K of the nonfertilized plots for the 6-in. depth declined to the lower portion of the Optimum category. Also, all K fertilizer rates increased soil K values. Soil K for the 6-in. depth did not differ consistently between the tillage systems or placement methods. The soil K levels were in the upper range of the Optimum category for the annual 35-lb rate, and tested Very High for higher rates. The soil K stratification was much less than for P, and was only slightly greater with the broadcast placement and no-till treatments. Previous studies also have shown soil K stratification is less than for soil P for all tillage systems.

Grain yield. Tables 3 (for P) and 4 (for K) 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 all P and K fertilized plots (excluding the zero controls) corn yield with tillage was 14 and 7 bushels/acre higher than with no-till for averages across the 17 years or the last 4 years, respectively. Soybean yield was not affected by tillage during both periods (small differences in some years canceled out over time).

Potassium placement and rates. Phosphorus (Table 3) greatly increased grain yield of corn and soybean because initial soil-test P was low and declined over time. In the early years, there was no yield difference between P rates, but since the late 1990s the 56-lb rate increased yield more than the 28-lb rate. The 112-lb rate did not increase yield further. Crop yield response to the annual 56-lb rate and the 112-lb rate applied every other year did not differ. It is noteworthy that a P deficiency in corn impacted yield much more for no-till than for tillage (greater difference with no-till) but not in soybean. There were no statistically significant yield differences between broadcast and band P placement methods for any crop or tillage system, although banded P increased early corn growth more than broadcast P with no-till (not shown).

Potassium (Table 4) began increasing corn yield in the late 1990s when soil K of control plots declined into the Optimum category (for which removal-based fertilization is suggested), but not soybean yield until the early 2000s. In the last four years, yield increases from K fertilization were large for corn and moderate for soybean, although the lowest K rate attained statistically similar yield than higher rates. As was observed for P, applying K annually or twice the amount

every other year before either crop did not differ. Corn yield relative increases from K were greater for no-till than with tillage, and soybean was greater than for P. There were no yield differences between broadcast and planter-band K application.

Conclusions

Soybean grain yield did not differ between tillage systems. Corn yield was consistently higher with tillage than with no-till, although the difference decreased in recent years. Phosphorus fertilization greatly increased yield of both crops in this initially low-testing soil. Potassium fertilization began increasing yield more recently once K level of nonfertilized soil decreased into the Optimum category. The broadcast or planter-band P or K placement methods did not differ consistently for any crop or tillage system.

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Table 1. Soil-test P at the end of the 24-yr period for selected treatments.

		Phosphorus placement method and rate (lb P_2O_5/acre per year)					
			Broadcast rate			Planter-band rate	
Tillage	Depth	0	28	56†	112†	28	56
	in.	Soil-test P (ppm)‡					
Tilled	0-3	7	21	74	131	22	46
	3-6	4	7	16	51	9	23
	0-6	5	14	45	91	15	35
No-till	0-3	7	21	82	181	12	53
	3-6	5	6	13	39	7	16
	0-6	6	13	47	110	10	34

†Received 56 lb from 1994 until 2001 and 112 lb from 2002 until 2018.
‡Average of Bray-1 and Mehlich-3 tests with colorimetric measurement of extracted P.

Table 2. Soil-test K values at the end of the 24-yr period for selected treatments.

		Potassium placement method and rate (lb K_2O/acre per year)					
			Broadcast rate			Planter-band rate	
Tillage	Depth	0	35	70	140	35	70
	in.	Soil-test K (ppm)‡					
Tilled	0-3	177	223	327	469	207	282
	3-6	161	175	205	258	171	196
	0-6	169	199	266	363	189	239
No-till	0-3	187	201	374	561	195	313
	3-6	165	159	204	267	170	212
	0-6	176	180	289	414	183	262

†Received 70 lb from 1994 until 2001 and 140 lb from 2002 until 2018.
‡Average of ammonium-acetate and Mehlich-3 tests on dried soil samples.

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

Period	Tillage	Phosphorus placement method and rate (lb P_2O_5/acre)							
		0	Broad 28	Broad 56	Broad 56 x 2†	Broad+Band 56	Broad 112‡	Band 28	Band 56
		---------- Corn yield (bu/acre) ----------							
2002-2018	Tillage	149	194	206	205	206	208	199	206
	No-till	120	180	194	191	193	195	183	193
2015-2018	Tillage	175	227	230	232	237	238	240	241
	No-till	148	214	215	236	227	231	230	237
		---------- Soybean yield (bu/acre) ----------							
2002-2018	Tillage	46.5	58.3	60.9	60.9	61.0	61.6	59.8	61.4
	No-till	43.0	56.5	59.3	59.8	59.8	60.0	57.6	59.1
2015-2018	Tillage	53.3	67.4	69.4	71.3	71.7	71.2	71.3	73.3
	No-till	52.4	67.8	68.0	70.3	71.0	70.9	70.9	72.3

†56 x 2, twice the annual 56 lb-rate applied once for the 2-yr rotation before corn or soybean.
‡56 lb/year1994-2001 and 112 lb/year 2002-2018.

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

Period	Tillage	Potassium placement method and rate (lb K_2O/acre)							
		0	Broad 35	Broad 70	Broad 70 x 2†	Broad+Band 70	Broad 140‡	Band 35	Band 70
		---------- Corn yield (bu/acre) ----------							
2002-2018	Tillage	183	191	195	192	193	194	194	193
	No-till	162	178	179	180	182	180	176	181
2015-2018	Tillage	213	229	230	236	232	231	229	230
	No-till	198	224	221	223	227	228	226	224
		---------- Soybean yield (bu/acre) ----------							
2002-2018	Tillage	55.9	57.5	57.7	57.5	56.8	57.7	57.5	56.9
	No-till	53.4	56.5	56.5	56.8	56.8	56.4	55.7	55.4
2015-2018	Tillage	66.4	70.1	70.8	71.3	71.4	70.7	70.4	69.6
	No-till	63.1	69.6	69.4	70.8	69.7	67.5	71.4	70.8

†70 x 2, twice the annual 70 lb-rate applied once for the 2-yr rotation before corn or soybean.
‡70 lb/year 1994-2001 and 140 lb/year 2002-2018.