Phosphorus and Potassium Fertilizers Placement Methods and Tillage Systems for Corn and Soybean During 25 Years in Southwest Iowa Soil

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Introduction

No-till management results in little incorporation of crop residues and fertilizer into the soil, which may increase soil moisture and nutrient uptake in summer, but may result in colder soil and reduced uptake in spring. Subsurface phosphorus (P) and potassium (K) banding has proven to be better than broadcasting in some soils by limiting reactions that may reduce the availability. Also, P and K move little through the soil profile (except in sandy soils) and in no-till, broadcast fertilizer causes accumulation in the top few inches of soil that may increase or decrease uptake. Therefore, a study was conducted from 1994 through 2018 to evaluate 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 2001 when deep banding was dropped. Previous reports showed deep-band results. This report summarizes results for broadcast and planter-band methods for the 25-yr study.

Materials and Methods

The study, on Marshall soil, consisted of separate P and K trials. Corn and soybean were planted using a 30-in. row spacing on adjacent areas with identical design, with crops rotated each year. The tillage consisted of chisel-plowed cornstalks in fall and field cultivated for both crops in the spring. Fertilizers used were granulated triple superphosphate and potassium chloride (potash). The broadcast fertilizer was spread in the 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. Two additional broadcast treatments were twice the high rates of P or K every two years before either crop.

Results and Discussion

Soil-test values. Initial soil-test P (STP) in 1994 for a 6-in. depth was borderline between the Optimum and High categories (20 ppm, Bray-1) and soil-test K (STK) was Very High (260 ppm, ammonium-acetate). Although the fields had been managed with tillage, samples from depths of 0-3 and 3-6 in. showed little nutrient stratification for P and K (higher in the top layer).

Table 1 shows STP at the end of the study in fall 2018. At a 6-in. depth, STP for control plots slowly declined over time to a value borderline of Low and Optimum categories (15 ppm), maintained by the 28-lb P rate (25 ppm), and increased to high levels with the 56-lb rate. There was no clear STP difference between tillage systems or placement methods. Table 2 shows the STK values in fall 2018. At a 6-in. depth, STK for control plots declined to the lower portion of Optimum category (although varying greatly over time), declined to a value borderline of the Optimum and High categories with the 35-lb rate, and slightly increased with the 70-lb rate. In contrast to results of similar studies at four other research farms, the STP and STK stratification in the top 6 in. of soil was small and approximately similar for both tillage

systems. In the other trials the STP stratification was large with both tillage systems, but larger for no-till and less for STK stratification than for STP.

Tillage effects. Tables 3 and 4 show corn and soybean yields as affected by tillage systems and the P or K fertilization treatments for averages across the entire 25-yr period and the last 4 years. Note: corn yields for 2018 were excluded because strong summer wind lodged most plants and introduced very large yield variability. Corn and soybean yields were not affected by tillage system. Corn yield sometimes was higher with tillage in normal or wet years but higher with no-till in drought years. Similar trials at other locations/soils showed corn yields were higher with tillage.

Phosphorus effects (Table 3). There was no crop yield response to P fertilization until 2002, when STP decreased to the Low category. Since then, responses have increased over time as STP of the control continued declining. Therefore, yield increases for both crops were smaller for the 25-yr averages than the last 4-yr averages. Similar P rates broadcast or banded with the planter did not show statistically significant differences for any crop or tillage system. The 28-lb rate maximized yield of both crops for the 25-yr period. For the last 4 years the 28-lb rate also maximized soybean yield, but the 56-lb rate maximized corn yield. This result agrees with guidelines in extension publication, because although both crops have the same optimum STP level, higher P rates are recommended for corn. For the last 4-yr period, the corn yield response to P was approximately similar for both tillage systems (21 to 23 bu/acre over the control). Crop yield for the 56-lb rate broadcast annually or twice the amount every other year before either crop did not differ.

Potassium effects (Table 4). Initial soil-test K was in the Very High category and, therefore, there was no crop response to K by any crop during the first 16 years of the study. Small responses began in 2010, and increased over time. There was no statistically significant placement method difference for any period, crop, or tillage system. Occasional small differences for one or the other method were observed over time, but overall the banded 70-lb rate decreased yield slightly compared with the broadcast 70-lb rate. The 35-lb rate maximized yield for both the 25-yr and the last 4-yr periods. For the last 4-yr period, the corn yield increase was 14 and 5 bushels/acre with tillage and no-till, respectively. Proportionally smaller differences were observed for soybean, with yield increases of 2 and 4 bushels/acre with tillage and no-till, respectively. As was observed for P, yield with the 70-lb K rate broadcasted annually or twice the amount broadcasted every other year before either crop did not differ for either crop or tillage system.

Conclusions

Phosphorus fertilization began increasing crop yield eight years after the beginning of the study because initial STP was borderline between the Optimum and High category. Potassium fertilization began increasing yield after 16 years because initial STK was Very High. As the other similar studies in Iowa have shown, yield for 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 25-yr period (fall 2018).†

		Annual 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	23	40	95	35	63
	3-6	8	9	21	12	36
	0-6	15	25	58	24	45
No-Till	0-3	24	47	108	41	57
	3-6	9	12	27	13	20
	0-6	17	30	67	27	39

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

Table 2. Soil-test K at the end of the 25-yr 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	188	232	327	208	221
	3-6	154	174	200	157	165
	0-6	171	203	263	183	193
No-Till	0-3	175	239	371	184	240
	3-6	156	171	204	149	159
	0-6	165	205	288	167	200

†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)*					
1994-2017	Tillage	177	184	186	187	182	184
	No-till	175	182	183	184	179	182
2015-2017	Tillage	231	247	253	251	242	250
	No-till	230	241	253	253	236	253
		Soybean yield (bu/acre)					
1994-2018	Tillage	56.7	59.2	59.1	59.1	58.5	58.9
	No-till	57.1	59.7	60.8	60.4	58.8	60.0
2015-2018	Tillage	67.0	70.1	71.7	71.1	70.4	69.4
	No-till	66.8	69.3	71.1	70.7	68.3	69.9

*2018 corn yields not included due to late-season windstorm causing yield variability.
†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)*					
1994-2017	Tillage	179	182	184	185	182	181
	No-till	179	184	184	185	185	182
2015-2017	Tillage	230	244	244	244	239	232
	No-till	235	242	240	240	237	244
		Soybean yield (bu/acre)					
1994-2018	Tillage	56.5	56.1	56.3	56.3	57.0	56.5
	No-till	58.1	58.6	58.1	57.8	59.1	58.7
2015-2018	Tillage	64.9	66.9	67.0	66.1	66.9	65.4
	No-till	65.4	69.3	68.5	66.8	69.0	69.7

*2018 corn yields not included due to late-season windstorm causing yield variability.
†70x2, twice the 70-lb rate applied once for the 2-yr rotation before corn or soybean.