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

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Introduction

In some soils, subsurface phosphorus (P) and potassium (K) banding can be more effective than broadcast fertilization by limiting reactions with soil that may reduce their availability. 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 in spring. Also, P and K move little through the soil profile (except sandy soils), and no-till with broadcast P and K 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 placements 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

There were separate P and K trials on predominantly Webster soil. Corn and soybean were planted using a 30-in. row spacing on adjacent areas with identical design, with crops switching sides each year to complete a rotation over time. The tillage consisted of chisel-plowed cornstalks in the fall and field cultivated for both crops in the spring. The 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. Other broadcast treatments were twice the high P or K rates every two years before corn or soybean.

Results and Discussion

Soil-test values. Initial soil-test P (STP) in 1994 for a 6-in. depth was in the upper Low interpretation category (12 ppm, Bray-1), and initial soil-test K (STK) was in the upper range of the Low category (124 ppm, ammonium-acetate). Although the field had been managed with tillage, samples from depths of 0-3 and 3-6 in. showed nutrient accumulation in the top layer that was greater for P than for K.

Table 1 shows STP at the end of the study in fall 2018. At a 6-in. depth, STP for control plots declined over time to the Very Low category, maintained with the 28-lb P rate, and increased to very high levels with the 56-lb rate. There was no clear or consistent STP difference between tillage systems or placement methods. The STP stratification was larger for the fertilized plots than for control plots and larger with no-till than with tillage for the lowest 28-lb broadcast rate.

Table 2 shows STK values in fall 2018. In contrast to results for STP, at a 6-in. depth, STK of control plots remained in the Low category even after 25 years of cropping. This result was observed in other K trials at this farm (Nicollet, Webster, and Canisteo soils) and is the reason for ongoing research for

these soils looking at different soil K pools using different soil test methods. At a 6-in. depth, the 56-lb rate increased STK to a value borderline with the Optimum and High categories. There was no large or consistent STK difference between tillage systems or placement methods. The STK stratification was similar for both tillage systems and was smaller than STP. Previous studies also showed less stratification for K than P.

Tillage effects. Tables 3 and 4 show corn and soybean yields as affected by tillage systems and the P or K fertilization treatments. Corn yield was higher with tillage than with no-till. Calculations from data in the tables indicate that on average for plots receiving P and K, corn yield was 10 to 12 bushels/acre higher with tillage for the 25-yr or last 4-yr periods. Soybean yield with tillage was only 2 bushels/acre higher for the 25-yr period and there was no difference for the last 4-yr period.

Phosphorus effects (Table 3). Yield responses to P increased over time as STP of the control declined. Therefore, average yield increases for the 25-yr period were smaller than for the last 4-yr period. There were no differences between P placement methods for any crop or tillage system. The 56-lb rate maximized yield of both crops with tillage or no-till. For the last 4-yr period, the corn yield increase over the control was 49 and 51 bushels/acre with tillage and no-till, respectively, and soybean yield increase was 14 and 16 bushels/acre with tillage and no-till, respectively. The broadcast 56-lb rate applied annually or twice the amount every other year before corn or soybean did not differ for both crops.

Although the same P rate attained maximum yield with both tillage systems, a P deficiency caused a larger yield reduction with no-till than with tillage, which was also observed by other Iowa research.

Potassium effects (Table 4). Crop response to K also was observed since the early years of the study, and yield increases became larger over time, although STK of the control plots remained in the Low category. Therefore, average yield increases for the 25-yr period were smaller than for the last 4-yr period. As was observed for P, the K placement methods did not differ for any crop or tillage system. The 70-lb rate broadcast or banded maximized yield of both crops. The 70-lb rate maximized corn yield, and a similar K rate broadcast annually or twice the amount broadcast every other year before corn or soybean resulted in similar yield increases for both crops. Although the same K rate attained maximum yield with tillage or no-till, a K deficiency caused a larger yield reduction of both crops with no-till than with tillage, and was a larger difference than observed for P.

Conclusions

Fertilization with P and K increased yield of corn and soybean because both STP and STK was low since the beginning of the study, and the increases became larger in recent years. As other studies in Iowa have shown, yield for 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. Although the same P or K rates attained maximum crop yield with tillage or no-till, a deficiency reduced yield of both crops more with no-till than with tillage.

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Table 1. Soil-test P at the end of the 25-yr 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	5	18	61	14	27
	3-6	5	8	21	6	17
	0-6	5	13	41	10	22
No-till	0-3	6	22	65	9	24
	3-6	4	7	22	5	12
	0-6	5	14	44	7	18

†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	148	174	219	159	186
	3-6	125	148	149	143	156
	0-6	137	161	184	151	171
No-till	0-3	138	168	249	151	179
	3-6	128	142	154	141	151
	0-6	133	155	202	146	165

†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	138	167	171	169	166	172
	No-till	126	154	160	161	154	161
2015-2018	Tillage	141	184	190	189	185	191
	No-till	130	171	182	179	169	180
		Soybean yield (bu/acre)					
1994-2018	Tillage	39.1	49.2	49.9	49.5	48.8	50.3
	No-till	36.6	46.3	49.1	47.9	46.2	47.9
2015-2018	Tillage	39.7	51.9	53.6	53.0	53.6	54.2
	No-till	38.4	52.1	54.3	52.9	53.0	55.7

†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	142	171	173	172	169	172
	No-till	121	158	163	167	159	164
2015-2018	Tillage	146	188	191	192	192	192
	No-till	104	174	185	186	175	178
		Soybean yield (bu/acre)					
1994-2018	Tillage	41.2	46.9	49.5	48.0	46.8	47.2
	No-till	36.5	44.1	45.9	48.8	45.0	47.2
2015-2018	Tillage	43.8	50.5	51.2	51.3	49.7	51.2
	No-till	38.2	49.1	51.5	53.5	50.0	52.4

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