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

RFR-A2097

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Introduction

No-till management results in little or no 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 early spring. In some soils, subsurface phosphorus (P) and potassium (K) banding can be more effective than broadcasting by limiting reactions with soil that may reduce their availability. Also, P and K move little through the soil profile (except in sandy soils) and broadcast fertilizer with no-till 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 Mahaska and Nira soils, consisted of separate P and K trials. Corn and soybean were planted using 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 other 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 in the High interpretation class (24 ppm, Bray-1), and initial soil-test K (STK) was in the Low category (128 ppm, ammonium-acetate). Although the field had been managed with tillage, samples from depths of 0-3 and 3-6 in. showed nutrient stratification for P and K (higher in the top layer), that was larger for P.

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 (11 ppm), maintained with the 28-lb P rate (27 ppm), and increased to high levels with the 56-lb rate. There was no clear or consistent STP difference between tillage systems or placement methods. The STP stratification for the broadcast fertilized plots was larger with no-till than with tillage.

Table 2 shows the 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 (although varying greatly over time) even with 25 years of cropping. This result was observed in other K trials and is the

reason for ongoing research looking at different soil K pools using different soil test methods. The 56-lb rate increased STK to a value borderline for Optimum and High categories. There was no consistent STK differences between tillage systems or placement methods. The STK stratification within the 6-in. depth was approximately similar for both tillage systems and was less than for STP. Previous studies also showed less stratification for STK.

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 9-10 bushels/acre higher with tillage for the 25-yr or last 4-yr periods. Soybean yield was not affected by tillage.

Phosphorus effects (Table 3). There was no yield response to P fertilization until 2003 because initial STP was in the High category. Since then, responses increased over time as STP of the control declined. Therefore, yield increases for both crops were smaller for 25-yr averages than for last 4-yr averages. Similar P rates broadcast or banded with the planter did not differ for any crop or tillage system. Average yield of both periods and tillage systems was highest with the 56-lb rate. For the last 4-yr period, the corn yield response was large and proportionally larger with no-till than with tillage (15 and 30 bu/acre higher than for the control with tillage and no-till, respectively). Proportionally smaller differences were observed for soybean (with increases 3 and 7 bu/acre with tillage and no-till, respectively). Yield with the 56-lb rate broadcast annually or twice the amount every other year before either crop did not differ.

Potassium effects (Table 4). Crop response to K was observed since the early years of the study because initial STK was Low, and yield increases became larger over time, although STK of the control plots remained in the Low category. Yield for broadcast or banded with the planter did not differ for any crop or tillage system, with occasional small differences for one or the other cancelling over time. Average yield of both periods and tillage systems was maximized by the 70-lb rate. For the last 4-yr period, the corn yield response was very large and proportionally larger with no-till than with tillage (21 and 38 bu/acre higher than for the control with tillage and no-till, respectively). Proportionally smaller differences were observed for soybean (with yield increases of 3 and 5 bu/acre with tillage and no-till, respectively). As was observed for P, yield with the 70-lb K rate broadcast annually or twice the amount broadcast every other year before either crop did not differ for either crop or tillage system.

Conclusions

Phosphorus fertilization began increasing crop yield only 10 years after the beginning of the study because initial STP was in the High category, whereas K fertilization always increased yield because initial STK was in the Low category. As other studies in Iowa have shown, yield for broadcast or planter-band P or K placement methods did not differ for any crop or tillage system. Although the P or K rate needed to maximize crop yield was similar for both tillage systems, a deficiency of either nutrient caused a larger corn yield reduction with no-till than with tillage.

Acknowledgements

We appreciate support by many organizations during different periods of this study. These include seed donation from Monsanto (Bayer); fertilizer donation by PCS (Nutrien); and funding by the Leopold Center for Sustainable Agriculture, the Iowa Soybean Association, the International Plant Nutrition Institute, PCS (Nutrien), and the Iowa State University College of Agriculture and Life Sciences.

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	13	38	89	25	40
	3-6	8	17	45	13	25
	0-6	11	27	67	19	33
No-Till	0-3	10	55	108	19	30
	3-6	6	12	20	10	12
	0-6	8	33	64	14	21

†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	174	178	182	180	178	181
	No-till	156	169	171	170	170	173
2015-2018	Tillage	214	224	231	229	221	230
	No-till	189	219	221	216	216	218
		---------- Soybean yield (bu/acre) ----------					
1994-2018	Tillage	54.4	56.0	56.7	56.9	55.4	56.1
	No-till	51.7	54.5	55.0	55.1	54.4	54.9
2015-2018	Tillage	59.5	63.6	63.6	63.0	63.2	60.7
	No-till	52.7	58.7	58.9	59.8	58.4	59.7

†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	172	180	182	182	182	183
	No-till	155	171	172	174	171	171
2015-2018	Tillage	209	226	231	233	226	228
	No-till	183	218	223	222	221	217
		---------- Soybean yield (bu/acre) ----------					
1994-2018	Tillage	52.5	54.5	55.3	54.8	54.4	54.7
	No-till	50.9	54.6	53.7	53.8	53.8	51.5
2015-2018	Tillage	54.1	57.5	58.3	56.1	59.0	57.8
	No-till	52.7	59.3	58.3	58.6	59.2	56.7

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