FERTILIZER PLACEMENT AND TILLAGE INTERACTION IN CORN AND SOYBEAN PRODUCTION

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Abstract

Different tillage systems can affect the availability of phosphorus (P) in the soil. The objective of this study was to evaluate the effects and interaction of fertilizer placement, tillage, and varieties/hybrids for corn and soybean. The experiment was established at two locations in Kansas in 2014. The experimental design was a factorial in a randomized complete block with four replications. Three fertilizer treatments were combined with two tillage systems and two varieties/hybrids of soybean and corn selected based on contrasting root systems. Plant tissue samples were collected during the vegetative and reproductive stages to evaluate P concentration, P uptake and dry matter. Significant differences were found in the parameters by locations for corn and less consistent effects on soybean across locations. For corn, the interaction of no till/deep band/ for hybrid P1151AM showed the highest P uptake and dry matter at V-10 growth stage. All the parameters evaluated in this study were affected by the fertilizer placement, tillage system and variety/hybrid in both soybean and corn over the growing season.

Introduction

Phosphorus (P) is considered as a non-mobile nutrient in the soil compared to the other macronutrients. Different soil tillage systems can affect the availability of this nutrient in the soil. In Kansas, both no till and strip till are increasing in popularity especially because of the water storage capacity that these systems provide to the soil. No till system consists in leaving the soil surface covered with residue to minimize erosion, conserve moisture and improve nutrient cycling if associated with crop rotation. This entire residue which stays in the soil surface can also cause a reduction in yield in some regions because of wetter and cooler soils at planting time. This condition can reduce nutrient uptake and crop growth. No tillage can restrict root growth because of some level of compaction that can reduce root area to explore the soil and less contact with available P (Havlin et al, 2014). Even with sufficient P in the soil, some deficiency can occur under cool and wet soil conditions hindering the P diffusion. Strip tillage consists in disturbing only the portion of the soil that is to contain the seed row. Strip till helps to increase soil temperature and expand root growth and therefore contact with the fertilizer/phosphorus in the soil.

The effects of tillage on crop yield, early growth, and nutrients stratification can be greatly influenced by fertilizer placement. It improves the efficiency which plants uptake nutrients and consequently can increase crop yields by enhancing the contact of the fertilizer with the plant roots.

Modern corn hybrids and soybean varieties are being developed to support dry conditions. The main characteristic that may be considered about these corn hybrids and soybean varieties is that they may differ in root growth habits, and therefore ability to extract and use nutrients. Gordon et al. (1998) suggested that different root systems among corn hybrids may influence in nutrient uptake, including phosphorus early in the season, often resulting in different response to starter fertilizer application in corn. The objective of this study was to evaluate the effects of fertilizer placement, tillage and varieties/hybrids on phosphorus uptake, phosphorus concentration and dry matter accumulation in soybean and corn.

Material and Methods

The experiment was established at two locations in Kansas in 2014. The Scandia location is located west of Scandia, KS, on the North Central Agronomy Experiment Field. This location used supplemental irrigation to maintain adequate soil moisture limiting water stress throughout the growing season. The Ottawa location is located south of Ottawa, KS, on the East Central Agronomy Experiment Field. The Ottawa location was under rainfed conditions. Soil samples were collected in blocks, one composite sample of 20 cores was taken for each block, totalizing 4 samples per location. Samples were analyzed for P by the Mehlich-3 method (Frank et al., 1998) and K with the ammonium acetate method (Warncke and Brown, 1998). Soil pH was measured using a 1:1 soil:water ratio (Watson and Brown, 1998), and soil organic matter (OM) was determined by Walkley–Black method (Combs and Nathan, 1998). Soil test results are in Table 1.

Plot size was 10 ft wide and 40 ft long with four rows planted at 30 in spacing. The experimental design was a factorial in a randomized complete block in with four replications. The fertilizer treatments consisted of a control, deep band only and broadcast only. These three fertilizer treatments were combined with two tillage systems and two different varieties/hybrids of soybean and corn selected based on contrasting root systems. The two varieties of soybeans used were 94Y40 and P44T63R. The two hybrids of corn used were P1151 AM and P1105 AM. The two tillage operations were no-till and strip-till. Fertilizer was applied 2-3 weeks before planting. Deep band treatment rate was 40 lb ac^{-1} N as UAN (28-0-0, N-P2O5-K2O respectively) and 40 lb ac^{-1} P_2O_5 as ammonium polyphosphate (10-34-0, N-P_2O_5-K_2O respectively) for corn; 20 lb ac^{-1} N as UAN (28-0-0, N-P_2O_5-K_2O respectively) and 40 lb ac^{-1} P_2O_5 as ammonium polyphosphate (10-34-0, N-P_2O_5-K_2O respectively) for soybeans. Broadcast treatment rates were the same as deep band for both crops. Nitrogen for corn was applied at 120 lb ac^{-1} for the Ottawa location and 180 lb ac^{-1} for the Scandia location.

Plant tissue samples were taken during the vegetative and reproductive portion of the growing cycle of soybeans and corn. For soybeans, whole plant samples were collected at the grown stages V-3, and trifoliate at the R3 growth stage. For corn, whole plant samples were collected at the grown stages V-6, V-10 and VT. Plants were weighted and dried in a forced air oven at 155 °F for a minimum of 6 days and weighted for dry biomass calculation. Once dry and weighted, the plants were ground and sent to the Kansas State University Soil Testing Lab for P analysis. The biomass weight and P concentration were used to calculate P uptake. The data was analyzed by locations and across locations. The parameters were analyzed using PROC GLIMMIX (SAS

9.3). Separation of means at a significant level of P = 0.10 were completed using the LINES option in PROC GLIMMIX.

Results and Discussion

In soybean, both locations in the study showed a significant effect of tillage and fertilizer treatments for P tissue concentration, P uptake and biomass at theV3 growth stage (table 2). A significant interaction between these two factors were also found for some locations, the section of variety also show a significant effect for the Scandia location (table 2).

Ottawa and Scandia locations showed significant difference between hybrid and fertilizer for corn in all growing stages evaluated (tables 3 and 4). Tillage was only found to be different for dry matter in VT at Ottawa. The interaction tillage/hybrid was significant only at Scandia. For both locations, the interactions tillage x fertilizer and fertilizer x hybrid were statistically significant (table 5). At Scandia, there was a significant interaction tillage x fertilizer x hybrid at the V10 stage for P concentration, P uptake and dry matter (table 4).

Across locations, differences were found in fertilizer treatments for soybean (table 6). Deep band was superior in P concentration, P uptake and dry matter at the V-3 stage. Strip till provided higher dry matter but lower P concentration than no till. The variety P44T63R showed higher P concentration and P uptake than the variety 94Y40.

For corn, the no till x deep band x P1151AM hybrid showed the best results for P uptake and dry matter at the V-10 growing stage. At V-6, V-10 and VT stages, deep band and broadcast treatments were superior to the control in P concentration, P uptake and dry matter. The hybrid P1151 AM showed higher P uptake and dry matter than the hybrid P1105 AM at the V-6 and V-10. For VT, the hybrid P1105 AM had higher P concentration but less dry matter than the hybrid P1151 AM. No till had higher P concentration at the V-6 and dry matter in VT compared to strip till.

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Table 1: Average soil test values on each location of study. †

Location	Crop	Soil test values			
		STP	STK	pH	OM
		mg kg^{-1}			%
Ottawa	Soybean	25	175	6.5	3.1
	Corn	26	164	6.2	3.9
Scandia	Soybean	14	526	6.6	3.3
	Corn	13	527	6.5	3.0

† STP, soil test for phosphorus; STK, soil test for potassium; OM, organic matter.

Table 2: Levels of significance (p-values) for different variables by locations and across locations for soybean, samples collected at the V-3 growth stage.

Variables	Ottawa			Scandia			Across locations		
	P†	UPP	DM	P	UPP	DM	P	UPP	DM
	p > F								
Till (T)	0.128	0.011	0.008	0.166	0.961	0.601	0.002	0.380	0.016
Variety (V)	0.662	0.739	0.795	0.006	0.066	0.287	0.059	0.029	0.283
T x V	0.265	0.944	0.481	0.762	0.276	0.334	0.460	0.213	0.225
Fertilizer (F)	0.001	0.001	0.007	0.001	0.028	0.297	0.001	0.001	0.055
T x F	0.001	0.690	0.084	0.719	0.995	0.991	0.015	0.993	0.789
F x V	0.230	0.024	0.118	0.105	0.140	0.217	0.160	0.044	0.074
T x F x V	0.055	0.628	0.297	0.083	0.355	0.542	0.543	0.338	0.359

† P, phosphorus concentration; UPP, phosphorus uptake; DM, dry matter.

Table 3: Levels of significance (p-values) for different variables in Ottawa for corn.

Ottawa									
Variables	V-6 growth stage			V-10 growth stage			VT growth stage		
	P†	UPP	DM	P	UPP	DM	P	UPP	DM
	- p > F- -								
Till (T)	0.133	0.999	0.224	0.133	0.251	0.552	0.383	0.171	0.071
Hybrid (H)	0.140	0.003	0.004	0.831	0.284	0.284	0.068	0.338	0.006
T x H	0.300	0.338	0.210	0.501	0.174	0.217	0.681	0.861	0.299
Fertilizer (F)	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.001	0.001
T x F	0.039	0.332	0.894	0.787	0.054	0.038	0.001	0.078	0.002
F x H	0.326	0.607	0.880	0.120	0.088	0.223	0.367	0.935	0.805
T x F x H	0.427	0.243	0.173	0.759	0.800	0.774	0.662	0.538	0.289

† P, phosphorus concentration; UPP, phosphorus uptake; DM, dry matter; V-6, six leaf collar present; V-10, ten leaf collar present; VT, tasseling stage.

Table 4: Levels of significance (p-values) for different variables in Scandia for corn.

Scandia									
Variables	V-6 growth stage			V-10 growth stage			VT growth stage		
	P†	UPP	DM	P	UPP	DM	P	UPP	DM
	- p > F- -								
Till (T)	0.457	0.231	0.253	0.106	0.136	0.225	0.505	0.992	0.178
Hybrid (H)	0.507	0.079	0.010	0.053	0.048	0.159	0.389	0.504	0.881
T x H	0.932	0.474	0.266	0.922	0.226	0.084	0.063	0.158	0.624
Fertilizer (F)	0.001	0.001	0.001	0.066	0.097	0.245	0.293	0.058	0.011
T x F	0.009	0.896	0.269	0.257	0.511	0.969	0.327	0.382	0.402
F x H	0.784	0.393	0.341	0.994	0.623	0.308	0.098	0.577	0.315
T x F x H	0.331	0.983	0.648	0.051	0.024	0.047	0.934	0.886	0.508

† P, phosphorus concentration; UPP, phosphorus uptake; DM, dry matter; V-6, six leaf collar present; V-10, ten leaf collar present; VT, tasseling stage.

Table 5: Levels of significance (p-values) for different corn variables across locations.

Variables	V-6 growth stage			V-10 growth stage			VT growth stage		
	P†	UPP	DM	P	UPP	DM	P	UPP	DM
	- p > F- -								
Till (T)	0.061	0.273	0.396	0.433	0.407	0.483	0.150	0.345	0.003
Hybrid (H)	0.907	0.007	0.000	0.057	0.011	0.052	0.034	0.956	0.020
T x H	0.680	0.399	0.168	0.670	0.070	0.016	0.140	0.153	0.296
Fertilizer (F)	0.002	0.001	0.001	0.001	0.001	0.002	0.024	0.001	0.001
T x F	0.333	0.863	0.278	0.617	0.356	0.307	0.789	0.189	0.005
H x F	0.920	0.605	0.433	0.548	0.529	0.394	0.469	0.757	0.461
T x F x H	0.743	0.977	0.537	0.334	0.040	0.049	0.858	0.806	0.641

† P, phosphorus concentration; UPP, phosphorus uptake; DM, dry matter; V-6, six leaf collar present; V-10, ten leaf collar present; VT, tasseling stage.

Table 6: Mean values for the parameters evaluated during the soybean growing season across locations.

Variables				V-3		
				P†	UPP	DM
				%	mg plant^{-1}	g plant^{-1}
Tillage(T)	No till			0.31 a‡	6.42	1.93 b
	Strip till			0.30 b	6.66	2.12 a
Variety (V)	94Y40			0.30 b	6.24 b	1.99
	P44T63R			0.31 a	6.84 a	2.07
Fertilizer (F)	Check			0.28 c	5.87 c	1.96 b
	Broadcast			0.31 b	6.44 b	1.96 b
	Deep band			0.33 a	7.31 a	2.16 a
T x F x V	No till	94Y40	Check	0.29	5.62	1.84
	No till	94Y40	Broadcast	0.31	6.07	1.86
	No till	94Y40	Deep band	0.33	6.17	1.82
	No till	P44T63R	Check	0.28	5.91	1.93
	No till	P44T63R	Broadcast	0.31	6.53	1.90
	No till	P44T63R	Deep band	0.36	8.23	2.24
	Strip till	94Y40	Check	0.28	5.60	1.93
	Strip till	94Y40	Broadcast	0.30	7.01	2.23
	Strip till	94Y40	Deep band	0.30	6.97	2.24
	Strip till	P44T63R	Check	0.28	6.35	2.14
	Strip till	P44T63R	Broadcast	0.32	6.15	1.86
	Strip till	P44T63R	Deep band	0.32	7.87	2.36

† P, phosphorus concentration; UPP, phosphorus uptake; DM, dry matter; V-3, trifoliate leaves at three nodes

‡ Letters indicate a significant difference at $\alpha < 0.10$ using Proc GLIMMIX (SAS 9.3).

Table 7: Mean values for the parameters evaluated during the corn growing season across locations.

Variables				V-6			V-10			VT		
				P	UPP	DM	P	UPP	DM	P	UPP	DM
				%	mg plant^{-1}	g plant^{-1}	%	mg plant^{-1}	g plant^{-1}	%	mg plant^{-1}	g plant^{-1}
Tillage(T)	No till			0.42 a‡	45.61	12.57	0.34	283.13	85.53	0.22	338.11	150.42 a
	Strip till			0.41 b	43.21	12.21	0.35	295.30	87.67	0.23	326.6	140.14 b
Hybrid (H)	P1105 AM			0.41	41.38 b	11.47 b	0.33 b	270.24 b	83.61 b	0.24 a	332.02	141.35 b
	P1151 AM			0.41	47.45 a	13.31 a	0.35 a	308.19 a	89.59 a	0.22 b	332.69	149.21 a
Fertilizer (F)	Check			0.39 b	33.31 b	10.8 b	0.32 b	244.18 b	79 b	0.22 b	286.02 b	131.85 b
	Broadcast			0.43 a	49.05 a	12.84 a	0.35 a	317.97 a	91.6 a	0.24 a	356.65 a	151.90 a
	Deep band			0.42 a	50.88 a	13.53 a	0.36 a	305.49 a	89.22 a	0.23 a	354.39 a	152.10 a
T x F x V	No till	P1105 AM	Check	0.39	32.47	10.55	0.30	210.78 e	72.63 e	0.22	273.50	125.79
	No till	P1105 AM	Broadcast	0.43	48.81	12.74	0.34	290.52 bcd	88.03 bcd	0.23	345.70	150.41
	No till	P1105 AM	Deep band	0.44	49.23	12.56	0.35	250.93 de	75.78 ed	0.23	367.87	158.05
	No till	P1151 AM	Check	0.40	34.98	11.31	0.32	239.91 de	76.59 ed	0.21	283.26	135.68
	No till	P1151 AM	Broadcast	0.43	51.98	14.21	0.35	332.54 ab	96.06 ab	0.23	377.95	161.54
	No till	P1151 AM	Deep band	0.44	56.21	14.07	0.37	374.09 a	104.12 a	0.22	380.40	171.05
	Strip till	P1105 AM	Check	0.39	29.45	9.57	0.32	262.46 cde	85.02 bcd	0.24	310.66	132.16
	Strip till	P1105 AM	Broadcast	0.42	43.36	11.51	0.34	291.63 bcd	87.83 bcd	0.24	359.68	149.16
	Strip till	P1105 AM	Deep band	0.41	44.93	11.86	0.36	315.10 abc	92.40 abc	0.25	334.70	132.50
	Strip till	P1151 AM	Check	0.39	36.33	11.75	0.33	263.55 cde	81.72 cde	0.20	276.66	133.76
	Strip till	P1151 AM	Broadcast	0.42	50.46	12.91	0.38	357.17 a	94.48 ab	0.23	343.28	146.47
	Strip till	P1151 AM	Deep band	0.40	54.71	15.63	0.35	281.85 bcd	84.57 bcde	0.23	334.60	146.78

† P, phosphorus concentration; UPP, phosphorus uptake; DM, dry matter; V- six leaf collar present; V-10, ten leaf collar present; VT, tasseling stage.

‡ Letters indicate a significant difference at $\alpha < 0.10$ using Proc GLIMMIX (SAS 9.3).6,

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