Compaction - K Fertility Interactions in Corn Production[1]

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Soil compaction is recognized as a significant factor affecting yield in crop production today. The pressure to produce crops profitably has often led growers to farm greater acreages, with larger equipment under soil conditions which favor compaction. Effects of compaction are not limited to the surface layers of a soil but often may be apparent throughout much of the root zone.

With the interest in soil compaction and its effects on crop growth, a research project was initiated to accomplish the following objectives.

1. To determine the method and rate of application of K fertilizer needed to maximize corn field on compacted soils.

   To evaluate the effects of compaction and K fertilizer application on plant growth and K uptake.

Materials and Methods

Field plots were established in 1986 near Oshkosh, Wis. on a Kewaunee silty clay loam soil. Initial soil tests at the site were: pH, 7.1; organic matter content, 37 t/a; and P and K levels of 12 and 200 lb/a, respectively. A split-split-plot design with four replications was used.

Three main plot compaction treatments were established in April, 1985 on fall plowed, spring disked ground using vehicles with axle loads of <5 (none), 9 (IH 5288 2-WD tractor), or 19 t (IH 8 row combine). The 9 and 19 t plots were tracked with a single pass perpendicular to the direction the corn was to be planted. Tracks were made to slightly overlap each other such that the entire plot area was compacted. Compaction treatments were imposed in both 1985 and 1986 at soil moisture levels near field capacity. Following compaction, all plots were field cultivated to prepare the seedbed.

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Sub-plot corrective applications of K were made in April, 1985 to establish soil test K levels of 200, 250, and 500 lb/a. Available soil K levels average 204, 262, and 469 lb/a K, respectively, when measured in August, 1985. The sub-sub-plot placement treatemnt consisted of none or 45 lb/a K_2O applied with the planter in a 2 x 2 placement. Phosphorus fertilizer was applied to adjust soil test P to 60 lb/a. All plots received 225 lb/a N preplant incorporated.

Corn was planted in the first week of May using 'Pioneer Brand 3906' and was thinned to a final population of 27,000 plants/a. Bi-weekly plant samples from selected treatments were analyzed for dry matter accumulation and nutrient concentration. Grain yields are reported at 15.5% moisture.

Results and Discussion

Relative differences in resistance to penetration as measured by a constant rate penetrometer were consistent with the levels of compaction used (Figure 1). In the 15 to 20 cm depth, nearly a two-fold difference in penetration resistance was observed between the non-compacted and 19 t treatment. Soil moisture levels ranged from 25 to 30% by weight throughout the depth measure by the penetrometer.

For the purpose of this paper, three treatments were selected to compare crop response to K fertilization at various compaction levels. Specifically, these were the control (no K added), the initial soil test K level plus 45 lb/a K_2O in the row, and the 500 soil test K without row applied K_2O. Analysis of variance was done using compaction as the main plot and K treatment as the sub-plot.

Tables 1 and 2 show the effect of the K fertilization treatment over three compaction levels on the dry matter accumulation, K ooncentration, and K content for 1985 and 1986. In general, the main effect of increasing compaction level was to reduce corn dry matter accumulation, especially in the 19 t treatment. Very little effect of compaction on K concentration was seen in either year, although at several sampling dates a significant interaction was observed between compaction and K treatments. The K content, which is the product of the previous two parameters with a conversion factor, basically reflected the effects on dry matter accumulation. Potassium treatment had a consistently significant effect on each parameter. In 1985 the high soil test level depressed early growth somewhat as a result of high salt concentration from the 1360 lb/a K_2O applied seven weeks progressed. This treatment consistently increased Plant K concentration throughout each season. The row treatment increased the K concentration over the control until approximately 75 days after which little increase was observed.

Several interactions between compaction and K treatment were significant (Tables 1 and 2). With increasing levels of soil compaction, plant K content decreased in the high soil test level, but usually remained constant or increased slightly in the control and row treatments. Presumably the increase in compaction restricted root growth sufficiently to diminish the response to high K in the soil.

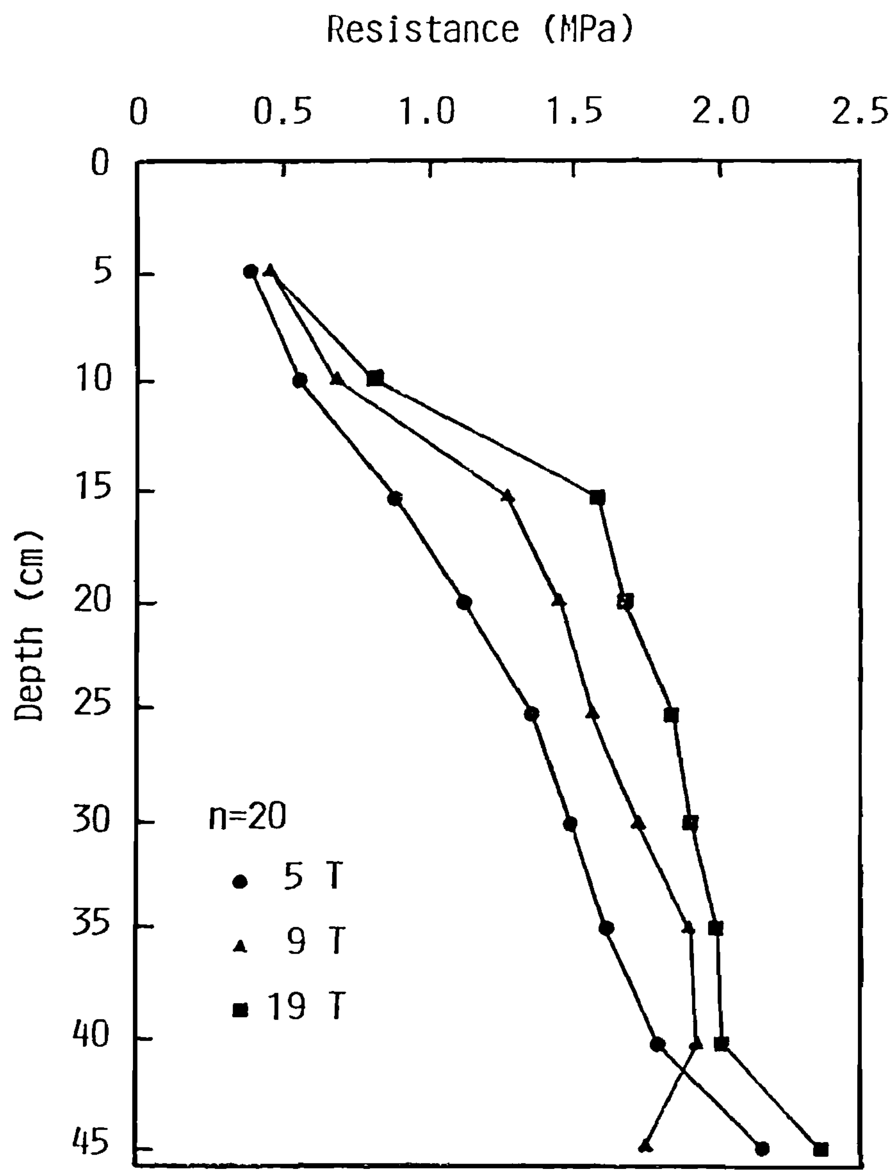

Figure 1. Average penetrometer resistance in three compaction levels measured 29 Aug. 1985, Oshkosh, Wis.

Table 1. Effect of soil compaction and K fertilization on corn dry matter accumulation, K concentration, and K content at several times following planting, Oshkosh, Wis., 1985.

Compaction Level	K Treatment*	Dry Matter 48+	Dry Matter 75	Dry Matter 97	Dry Matter 132	K Concentration 48	K Concentration 75	K Concentration 97	K Concentration 132	K Content 48	K Content 75	K Content 97	K Content 132
t		g plant^{-1}				%				g plant^{-1}			
<5	0	4.0	48.9	75.2	212.8	1.11	1.16	0.84	0.68	0.05	0.55	0.64	1.45
	45 Row	5.6	69.2	100.2	201.0	1.58	1.38	0.88	0.72	0.09	0.95	0.88	1.45
	500 Soil	4.8	55.6	116.8	251.5	3.15	3.43	1.45	1.09	0.14	1.91	1.68	2.77
9	0	3.8	48.4	101.8	206.3	1.01	1.21	0.74	0.64	0.04	0.58	0.75	1.33
	45 Row	5.0	70.4	109.0	195.9	1.46	1.19	0.86	0.69	0.07	0.84	0.94	1.34
	500 Soil	2.7	47.7	88.2	211.8	2.42	3.08	1.34	1.18	0.07	1.46	1.17	2.52
19	0	4.2	49.2	77.4	206.2	1.00	1.18	0.84	0.74	0.04	0.58	0.65	1.31
	45 Row	4.2	43.9	116.1	205.3	1.67	1.39	0.89	1.08	0.07	0.60	1.04	1.53
	500 Soil	2.3	46.2	115.9	215.8	2.79	2.79	1.30	1.45	0.06	1.28	1.50	2.31
Significance (Pr>F)**													
Compaction (c)		0.42	0.01	0.74	0.50	0.46	0.48	0.35	0.93	0.13	0.06	0.47	0.52
K Treatment (T)		0.01	0.05	0.02	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C x T		0.15	0.14	0.08	0.60	0.86	0.01	0.01	0.28	0.05	0.02	0.01	0.86

* K Treatment = initial soil test K of 200 lb/a, the same plus 45 lb/a K_2O in starter, and fertilized with a goal of 500 lb/a soil test K.

\+ Values indicate days after planting.

** Probability that tabular F ratio exceeds calculated F ratio by analysis of variance.

Table 2. Effect of soil compaction and K fertilization on corn dry matter accumulation, K concentration, and K content at several times following planting, Oshkosh, Wis., 1986.

Compaction Level	K Treatment*	Dry Matter				K Concentration				K Content			
		38†	71	86	142	38	71	86	142	38	71	86	142
t		g plant^{-1}				%				g plant^{-1}			
<5	0	1.3	46.9	183.5	284.2	1.67	1.71	0.88	0.72	0.02	0.80	1.62	2.06
	45 Row	1.5	44.3	187.9	308.2	3.20	1.92	1.13	0.69	0.05	0.84	2.10	2.17
	500 Soil	2.2	57.5	179.1	291.3	5.40	2.81	1.75	1.01	0.12	1.61	3.14	2.93
9	0	1.7	45.4	197.6	276.5	1.88	1.93	1.07	0.74	0.03	0.83	2.11	2.08
	45 Row	1.9	51.6	190.8	288.0	3.32	1.78	1.01	0.71	0.06	0.92	1.93	2.04
	500 Soil	2.3	53.2	195.7	255.6	5.44	2.75	1.57	0.97	0.13	1.47	3.07	2.48
19	0	1.4	37.5	158.1	245.0	2.51	1.89	1.08	0.84	0.04	0.71	1.70	2.11
	45 Row	1.7	52.2	167.8	266.2	3.17	2.07	1.11	0.67	0.05	1.07	1.86	1.79
	500 Soil	1.7	49.7	188.4	256.0	4.36	2.87	1.53	1.03	0.07	1.42	2.89	2.64
Significance (Pr>F)**													
Compaction (c)		0.01	0.60	0.05	0.02	0.77	0.80	0.78	0.22	0.05	0.83	0.60	0.02
K Treatment (T)		0.01	0.01	0.60	0.23	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C x T		0.10	0.06	0.40	0.91	0.03	0.71	0.10	0.22	0.01	0.10	0.64	0.88

* K Treatment = initial soil test K of 200 lb/a, the same plus 45 lb/a K_2O in starter, and fertilized with a goal of 500 lb/a soil test K.

† Values indicate days after planting.

** Probability that tabular F ratio exceeds calculated F ratio by analysis of variance.

Regardless, the K content was higher within all treatments when compared to the control and row treatment. When grain yield was evaluated for the same three treatments over all compaction levels the row treatment produced as well as the high soil tcst treatment (Table 3).

The importance of K fertility for maximizing grain yield on compacted soils in this study is shown in Table 3. This table gives results for the entire study analyzed across the levels of compaction, soil test K, and placement. As expected, the response to row K decreased as the soil test K level was increased. In the compacted treatments the yield response to row applied K was considerably larger than in the non-compacted treatments. Additionally, the response to row applied K was more consistently observed at higher soil test K levels in the compacted treatments. Thus, to maximize yield in the compacted situation, row applied K was essential.

Summary

This experiment evaluated the effects of soil compaction on a responsive soil under worst case conditions. Factors such as soil texture, organic matter content, and traffic management would have a significant impact on the detrimental effects of compaction in production situations. Regardless, the importance of overlooked. Increasing soil test K helped compensate for some of the effects of compaction; however, the best yields were obtained when K was row applied. It should be recognized that K fertilization did not totally offset the negative effects of compaction.

Table 3. Effect of compaction, soil K, and row K_2O on corn grain yield, Oshkosh, Wis., 1985-1986.

		Compaction Level (T)					
	Row	<5		9		19	
Soil K	K_2O	1985	1986	1985	1986	1985	1986
lb/a	lb/a	bu/a					
204	0	132	169	114	168	111	147
	45	162	175	152	176	159	169
262	0	175	179	137	169	149	165
	45	171	174	168	167	157	168
469	0	165	172	160	163	146	151
	45	161	176	160	173	143	159

PR>F	1985	1986
Compaction (C)	0.23	0.08
Soil K (S)	0.01	0.15
C x S	0.75	0.92
Row K (R)	0.01	0.09
C x R	0.51	0.40
S x R	0.01	0.02
C x S x R	0.13	0.38

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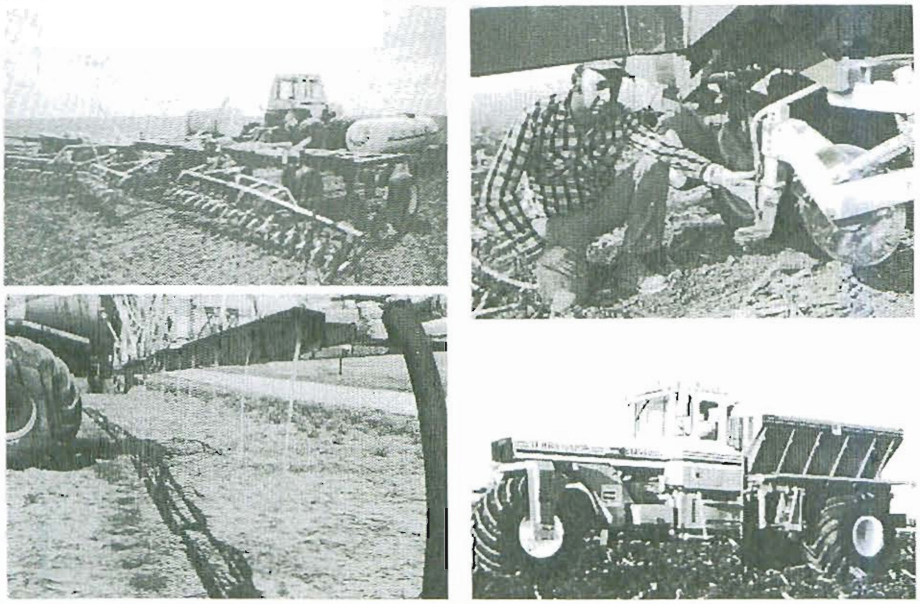

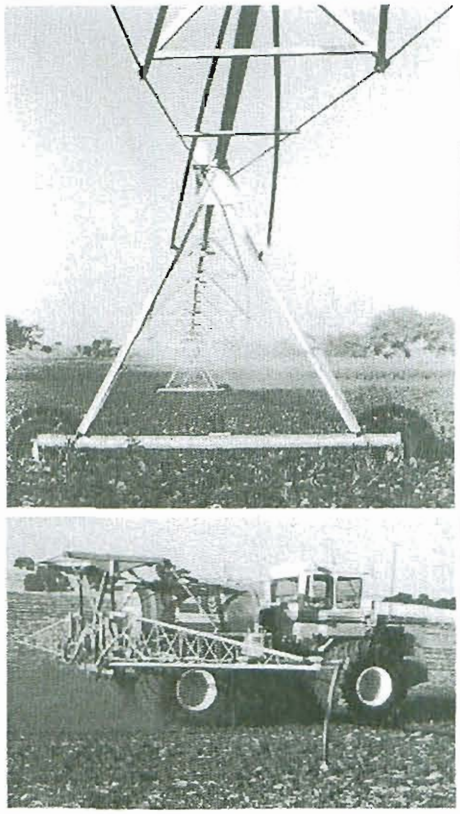

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