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Wheel-traffic effects on corn as influenced by tillage system

D.W. Reeves, H.H. Rogers, J.A. Droppers, S.A. Prior and J.B. Powell
USDA–ARS National Soil Dynamics Laboratory, and Alabama Agricultural Experiment Station, Auburn, AL 36849, USA

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ABSTRACT

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Surface and subsoil compaction limit crop productivity on many soils of the southeastern Coastal Plain of the United States. Deep tillage, and to a lesser extent, controlled traffic have been utilized to manage soil compaction on these soils, but there is a need to develop tillage systems that integrate conservation tillage practices with deep tillage and controlled traffic. In 1988, a study was initiated with a wide-frame (6.3 m) vehicle to determine the interactive effects of traffic, deep tillage, and surface residues on corn (*Zea mays* L.) grown on a Norfolk loamy sand (fine-loamy, siliceous, thermic, Typic Kandiudults). Corn was planted into a winter cover crop of 'Cahaba White' vetch (*Vicia sativa* L.) Treatments included: traffic (conventional equipment or no traffic); deep tillage (no deep tillage, in-row subsoiling, or complete disruption); surface tillage (no surface tillage or disk and field cultivate). Complete disruption was accomplished by subsoiling at a depth of 43 cm on 25-cm centers. Although tillage × traffic interactions significantly affected soil strength and soil water, the only grain yield response both years was due to a surface tillage × deep tillage interaction. In a drought year (1988), with surface tillage, yields averaged 3.54, 2.75, and 1.41 t ha^{-1} with complete disruption, in-row subsoiling, and no deep tillage, respectively. Without surface tillage, respective yields averaged 3.77, 3.14, and 1.12 t ha^{-1}. In 1989 when rainfall amount and distribution were excellent, yields with complete disruption, in-row subsoiling, and no deep tillage averaged 7.79 t ha^{-1}, 7.08 t ha^{-1}, and 6.44 t ha^{-1}, respectively, with surface tillage; and 7.40 t ha^{-1}, 6.91 t ha^{-1}, and 4.70 t ha^{-1} respectively, without surface tillage. Soil strength and soil water measurements confirmed the detrimental effect of traffic after disking and field cultivation; however, soil water measurements and the lack of any yield response to applied traffic suggest that corn compensated for reduced rooting capacity in wheeled interrows by increased rooting in non-wheeled interrows.

INTRODUCTION

The coarse-textured soils of the US Southeastern Coastal Plain limit crop production potential because of surface and subsoil compaction (Kashirad et al.,1967; Campbell et al., 1974; Touchton et al., 1989). Deep tillage, especially subsoiling, often results in yield increases for crops grown on these soils (Kamprath et al., 1979; Chancy and Kamprath, 1982; Box and Langdale, 1984; Reeves and Touchton, 1986). Restricting equipment operations to certain areas in the field, i.e. controlled traffic, has also been shown to increase crop yield on these highly compactible soils (Dumas et al., 1973; Nelson et al., 1975; Williford, 1982). Previous research, however, has generally been with conventional tillage systems and has focused on single components of the compaction problem, i.e. tillage or traffic. The interactive roles that tillage systems, especially conservation tillage systems, and traffic have on soil compaction and resultant crop responses have not been clarified.

The objective of this on-going study is to evaluate the roles and interactions of residue management practices, deep tillage, and traffic on soil compaction and crop response on a highly compactible coastal plain soil. This comprehensive study, using corn as the test crop, will facilitate the development of economically and environmentally sustainable soil management systems for these problem soils. Results from the first two growing seasons, which included a drought year and a year of excellent rainfall amount and distribution, are presented here.

MATERIALS AND METHODS

This field study was conducted for 2 years (1988–1989) on a Norfolk loamy sand (fine, loamy, siliceous, thermic Typic Kandiudults) at the E. V. Smith Research Center of the Alabama Agricultural Experiment Station in east-central Alabama, USA. The soil is highly compactible and has a well-developed hardpan at the 18–30 cm depth. Physical properties of the soil at the initiation of the experiment are summarized in Tables 1(A)–1(C). Initial soil levels of phosphorus and potassium were in the 'high' range (157 kg ha^{-1} and 120 kg ha^{-1}, respectively). Cation exchange capacity averaged 2.02 cmol$_c$ kg^{-1}, and organic matter averaged 10.0 g kg^{-1}. Soil pH averaged 6.4.

A winter cover crop of 'Cahaba White' vetch (*Vicia sativa* L.) was planted in the autumn of 1987 and 1988. The cover crop was killed with an application of paraquat (1,1′-dimethyl-4,4′bipyridinium ion) 4–7 days prior to planting corn each spring. Pioneer brand 3165 hybrid corn was planted on 4 May 1988 and 15 April 1989 in 75-cm rows at a seeding rate of 59 000 seeds ha^{-1}. Three weeks after planting, stands were thinned to a uniform 49 400 plants ha^{-1}. The eight-row plots were 21.3 m long. The test site was originally divided into two separate but adjacent halves and the treatments were established on separate halves of the area in 1988 and in 1989 to avoid confounding from residual tillage effects. At planting, 34 kg N ha^{-1} and 49 kg P ha^{-1} were applied over the row in a 10 cm band. Four weeks after planting, 134 kg N ha^{-1} and 29 kg S ha^{-1} were applied in a narrow stream 25 cm from the row. Weeds were effectively controlled with an early post-emergence spray of atrazine (6-chloro-*N*-ethyl-N′-[1-methylethyl]-1,3,5-triazine-2,4-diamine)

TABLE 1

Soil physical properties from four depths within the profile of a Norfolk loamy sand at initiation of the field experiment

	Depth (cm)			
	2–8	20–26	33–39	50–56
(A) *Soil water retention* ($m^3 m^{-3}$)				
Matric head (−MPa)				
0	0.440	0.300	0.380	0.345
0.010	0.135	0.180	0.200	0.190
0.033	0.110	0.145	0.175	0.170
0.080	0.100	0.130	0.160	0.155
0.140	0.085	0.115	0.150	0.140
(B) *Textural characterization*				
Soil separate[1]				
Sand (%)	77.0	72.9	71.5	71.7
Silt (%)	17.3	18.4	17.5	15.2
Clay (%)	5.7	8.7	11.0	13.1
(C) *Bulk density and porosity*				
Bulk density ($Mg m^{-3}$)	1.51	1.76	1.62	1.62
Total porosity (% v/v)	43.9	30.1	38.0	34.6

[1] USDA particle size distribution.

(0.9 kg ai ha^{-1}) plus alachlor (2-chloro-*N*-[2,6-diethylphenyl]-*N*-[methoxymethyl]acetamide) (1.7 kg active ingredient (ai) ha^{-1}) and a shielded sprayer application of glyphosate (*N*-[phosphonomethyl]glycine) (0.34 kg ai ha^{-1}) 8 weeks after planting.

The experimental design was a strip-split plot design of four replications (Gomez and Gomez, 1984). Vertical factors were deep tillage: (i) no deep tillage; (ii) in-row subsoiling; (iii) complete disruption. Subsoiling depth was 40–44 cm. Complete disruption was accomplished by subsoiling on 25-cm centers. Horizontal factors were traffic: (i) no traffic; (ii) trafficked. Intersection or subplot treatments were surface tillage: (i) no surface tillage; (ii) disk-field cultivate.

All operations were done with an experimental wide-frame tractive vehicle (WFTV) (Fig. 1; Monroe and Burt, 1989). The WFTV allows for untrafficked research plots 6.1 m wide. In the trafficked plots, a 4.6 t tractor with 470 mm × 970 mm tires inflated to an average pressure of 125 kPa was driven through the plots to simulate traffic that would have been applied by an operation. Random traffic patterns were applied in the fall simulating land preparation/planting operations for planting the cover crop; uniform traffic patterns were established in corn to simulate operations done by a farmer with four-row equipment. With the four-row traffic pattern, every corn row

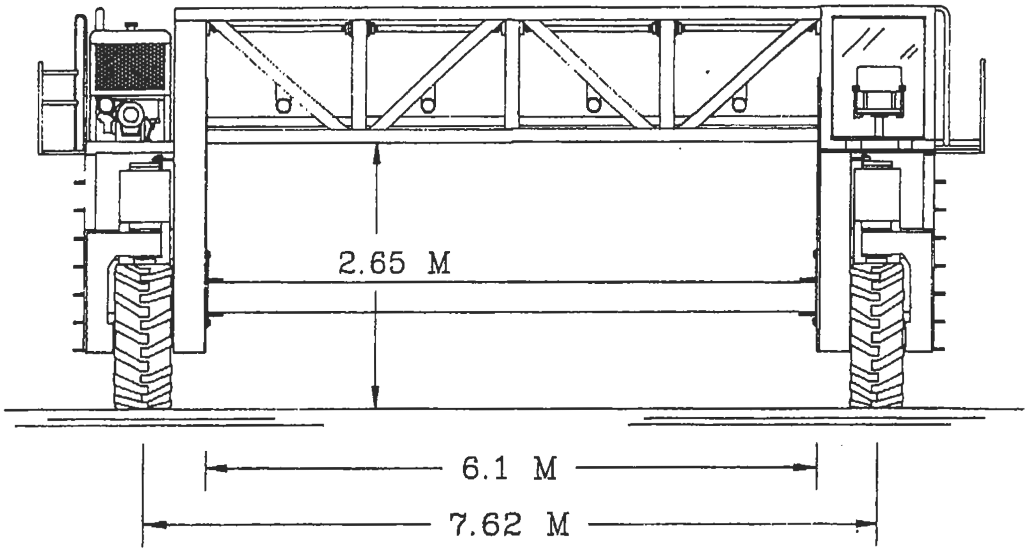

Fig. 1. Wide-frame tractive vehicle (WFTV) used in soil compaction research at USDA-ARS National Soil Dynamics Laboratory.

in trafficked plots had a trafficked (hereafter referred to as tire position) and a non-trafficked (hereafter referred to as no tire position) interrow.

Whole plant samples were collected 5 weeks after planting from a 4.8 m section of a row for determination of dry weight. Grain yield and stover dry matter were determined from a 30.5 m section of a row from the middle four rows of each plot at maturity. Grain yields were adjusted to 155 g kg^{-1} moisture.

In 1988, 96 soil cores were obtained at physiological maturity to assess root growth. Two cores, one from each of the two middle rows, were pulled from each of the 48 plots. Sampling position was at center-row, midway between adjacent corn plants. A custom-made coring tube with a high-relief bit was used to obtain soil cores 3.2 cm in diameter to a depth of 80 cm. The steel coring tube was fitted with a split polyvinylchloride plastic (PVC) sleeve into which the soil core fed as the tube was pushed into the ground by a hydraulic cylinder mounted on the WFTV. The sleeve containing the soil core was removed and capped at each end for transport and cold storage prior to processing. Cores were cut into three depth segments: 0–20, 20–40, and 40–80 cm. Roots were washed from individual segments with a commercially available hydropneumatic elutriation system (Smucker et al., 1982) (Gillison's Variety Fabrication Inc., Benzonia, MI[a]). After separation from the soil, samples were placed in 70% ethanol and refrigerated. Debris was removed man-

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ually using tweezers and spring-loaded suction syringes. Root sample lengths were then measured with a Comair Root Length Scanner[a] (Hawker de Havilland, Ltd., Salisbury, SA).

In 1989, prior to tasseling, parallel paired stainless steel rods 6 mm in diameter were installed at three depths (20, 40, and 80 cm) 38 cm from the row in both tire and no-tire interrows. A Tektronix 1502B TDR[a] (Tektronix, Beaverton, OR) cable tester was used to measure soil water using the time–domain reflectrometry (TDR) method as developed by Topp (Topp et al., 1980; Topp and Davis, 1985). Measurements were taken 11 times over a 47 day period from tasseling through black layer formation (physiological maturity).

Penetrometer recordings were also made on 22 June 1989, when corn was tasseling. Readings were made after a period of heavy rainfall, when the soil was nearly saturated. Two penetrations were made at three positions within each plot; in-row, and in the interrows on either side of the row. In trafficked plots, the two interrow positions corresponded to tire and no-tire positions.

In addition to field measurements of cone resistance, four replicate core samples from depths of 2–8 cm, 20–26 cm, 33–39 cm, and 50–56 cm were taken from the site and were exposed to matric heads (-MPa) of 0, 0.010, 0.033, 0.080, and 0.140. Volumetric water contents at these matric heads are shown in Table 1. After equilibration to the respective matric heads, cone resistance was determined using a mini-probe on an Instron Testing System Model 1122[a] (Instron, Canton, MA) static type penetrometer. Although sampling was not extensive, the data derived from this procedure give an estimate of cone resistance changes as affected by soil water content. Data were subjected to analysis of variance and Fisher's protected least significant difference ($P \leq 0.10$) was used for mean separation of preplanned comparisons. Unless otherwise specifically noted in the text, only significant treatment effects are discussed, and in cases where interactions were significant, main effects of independent variables which composed the interaction are not discussed separately.

RESULTS AND DISCUSSION

Plant response

Traffic had no effect on early season plant growth in 1988 or in 1989. Surface tillage increased plant dry matter, measured 5 weeks after planting, by

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18% in 1988 and 51% in 1989 (Table 2). In the drought year of 1988, deep tillage, either in-row subsoiling or complete disruption, increased dry matter by an average of 28%. In 1989, deep tillage had no effect on early season dry matter production; presumably because high rainfall minimized soil compaction effects.

In 1988, grain yields were limited by an extreme drought. Rainfall for the 35 day period following tasseling averaged only 23% of the 30 year average (Fig.2). Traffic had no effect on grain yields. However, there was a deep tillage × surface tillage interaction effect on yields (Table 3). Maximum yields were obtained with the complete disruption of the plowpan, followed by in-row subsoiling, in both the surface-tilled and no-surface-tilled plots. With both complete disruption and in-row subsoiling, yields were greatest when vetch residue was not incorporated by surface tillage. Without the benefit of deep tillage, however, surface tillage increased yields.

In 1989, rainfall amount and distribution were excellent (Fig. 2). With the favorable rainfall, there was no beneficial effect of surface residues as in the drought year of 1988 (Table 3). However, yields again increased with the intensity of deep tillage. Also, as in 1988, surface tillage increased yields when no deep tillage was performed.

Although there were no traffic effects or interactions with tillage treatments on grain yield, there were significant traffic × surface tillage interactions on stover dry matter in both 1988 and 1989 (Table 4). In the drought year of 1988 not incorporating surface residues increased stover production in no-traffic plots. The benefits of not incorporating residues are generally greater when rainfall is inadequate such as in 1988 (Campbell et al., 1984; Eckert, 1984, 1988; Fox and Piekielek, 1987). When traffic was applied, however, surface tillage had no effect on stover production. In the year of abundant

TABLE 2

Effect of surface and deep tillage on early season plant growth ($t\ ha^{-1}$; dry matter 5 weeks after planting)

	1988	1989
Surface tillage		
Disk-field cultivate	0.326	0.206
None	0.276	0.136
$LSD_{0.10}$	0.027	0.022
Deep tillage		
In-row subsoil	0.327	0.160
Complete disruption	0.337	0.186
None	0.239	0.168
$LSD_{0.10}$	0.033	NS

NS, not significant.

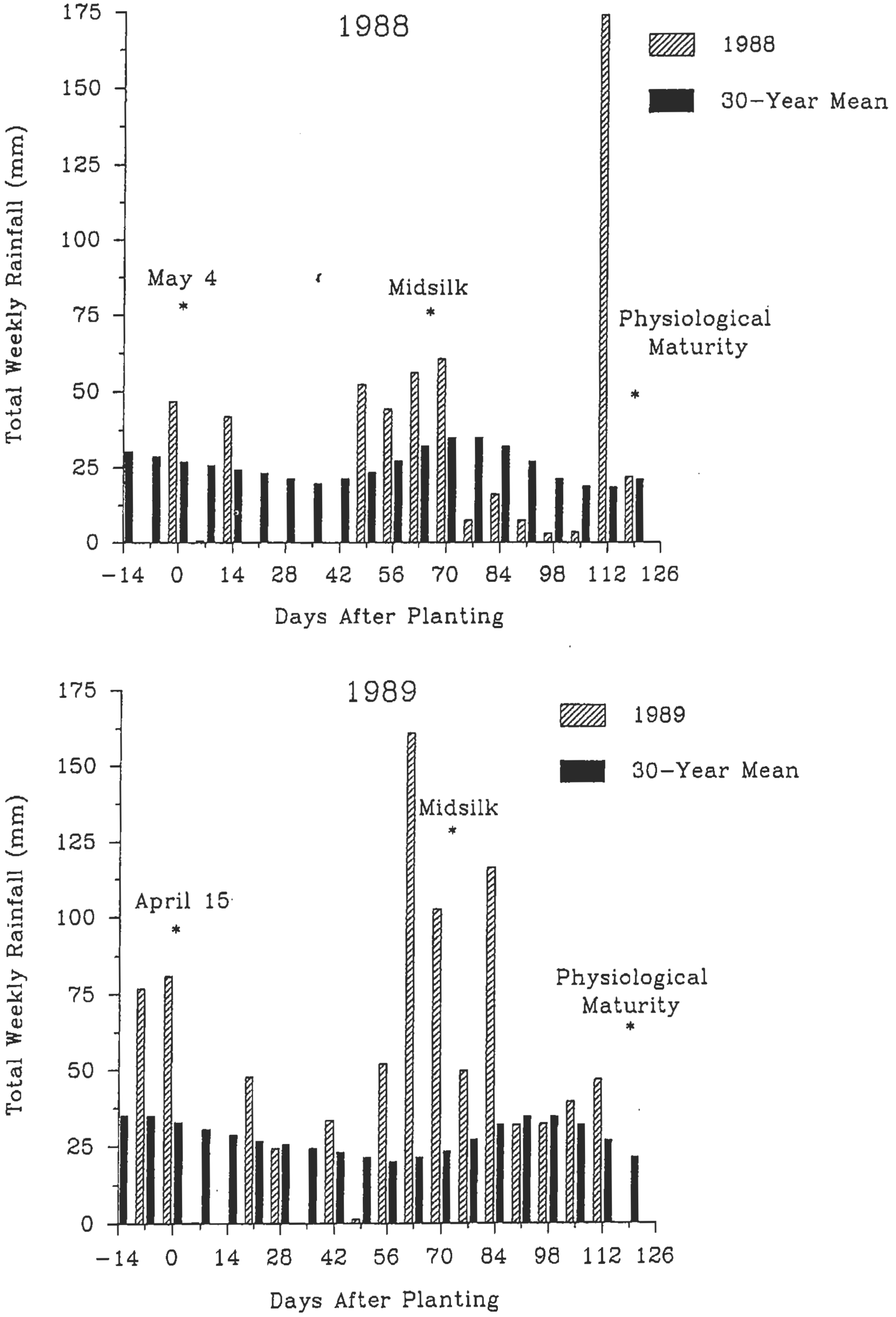

Fig. 2. Total weekly rainfall during 1988 and 1989 growing seasons in relation to 30 year mean rainfall.

TABLE 3

Influence of deep tillage and surface tillage on corn grain yield (t ha^{-1}) in 1988 and 1989

Deep tillage	1988		1989	
	Surface tillage	No surface tillage	Surface tillage	No surface tillage
In-row subsoil	2.75	3.14	7.08	6.91
Complete disruption[1]	3.54	3.77	7.79	7.40
None	1.41	1.12	6.44	4.70
LSD$_{0.10}$ (surface tillage within deep tillage)	0.27		0.59	

[1] Subsoiled 40–44 cm deep on 25-cm centers.

TABLE 4

Influence of traffic and surface tillage on corn stover dry matter (t ha^{-1}) in 1988 and 1989

	1988		1989	
	Surface tillage	No surface tillage	Surface tillage	No surface tillage
Traffic	4.66	4.28	7.36	7.57
No traffic	3.85	5.07	7.78	7.01
LSD$_{0.10}$ (surface tillage within traffic)	0.61		0.61	

rainfall (1989), surface tillage did not affect stover production in trafficked plots, but increased stover production when traffic was not applied. In both years, traffic apparently negated the effects of surface tillage on stover yield. Deep tillage, either in-row subsoiling or complete disruption, increased stover dry matter by an average of 26% in 1989. Stover dry matter averaged 7.97 t ha^{-1}, 7.98 t ha^{-1}, and 6.33 t ha^{-1} for in-row subsoiling, complete disruption, and no deep tillage, respectively ($\text{LSD}_{0.10}=0.77$ t ha^{-1}).

Limited root sampling in 1988 indicated that both surface tillage and deep tillage altered root length densities, but traffic did not. Mean values for surface tillage were numerically higher at all three depth increments ($P\leq0.26$, $P\leq0.10$, and $P\leq0.12$ for 0–20 cm, 20–40 cm, and 40–80 cm depths, respectively; Fig. 3). Deep tillage significantly affected root length densities at the two upper increments, 0–20 and 20–40 cm, but not at the lowest one, 40–80 cm (Fig. 3). The somewhat lower values for complete disruption as compared with annual in-row subsoiling are probably due to greater lateral spread of the root system with complete disruption, and consequent reduced com-

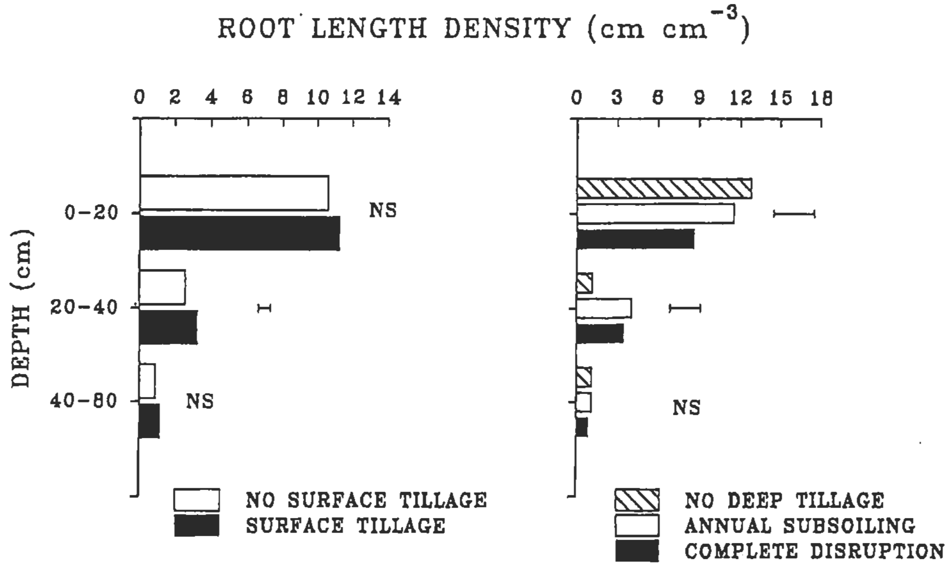

Fig. 3. Root length density of corn at three depth increments measured under the row in 1988 as affected by surface and deep tillage. Horizontal lines, $LSD_{0.10}$; NS, not significant.

pensatory root growth in the zone of subsoiling under the row. Chaudhary and Prihar (1974) reported that interrow compaction checked corn root growth and diverted it downward. Garcia et al. (1988), in a well-designed greenhouse experiment, demonstrated that lateral compaction would not cause a reduction in total roots of corn, but would effectively cause compensatory root growth directly under the plant. Root growth within the no deep tillage treatment was severely restricted below the surface tillage depth.

Cone resistances

Both in-row subsoiling and complete disruption eliminated compaction above the 40–43 cm depth in the row (Fig. 4). Subsoiling on 25 cm centers did completely disrupt the tillage pan, as was shown by reduced cone resistances to the 40 cm depth in all measured positions (in-row, wheeled or tire interrow, and no-tire interrow). The effect of recompaction from equipment traffic is shown by the increased cone resistances to the 40 cm depth with complete disruption in wheeled (tire) interrows as compared with non-wheeled (no-tire) interrows.

The detrimental effect of traffic following surface tillage as opposed to traffic on plots without surface tillage is seen in Fig. 5. When traffic was applied, the increased bearing capacity of no-till (no surface tillage) plots resulted in reductions in cone resistances in the upper 20 cm of the profile of up to one-half that found following disking and field cultivation.

Recompaction by traffic following surface tillage was not confined to the interrow. Cone resistances in surface tilled plots increased in the 20–28cm depth under the row following traffic (Fig. 5). Although this increase gener-

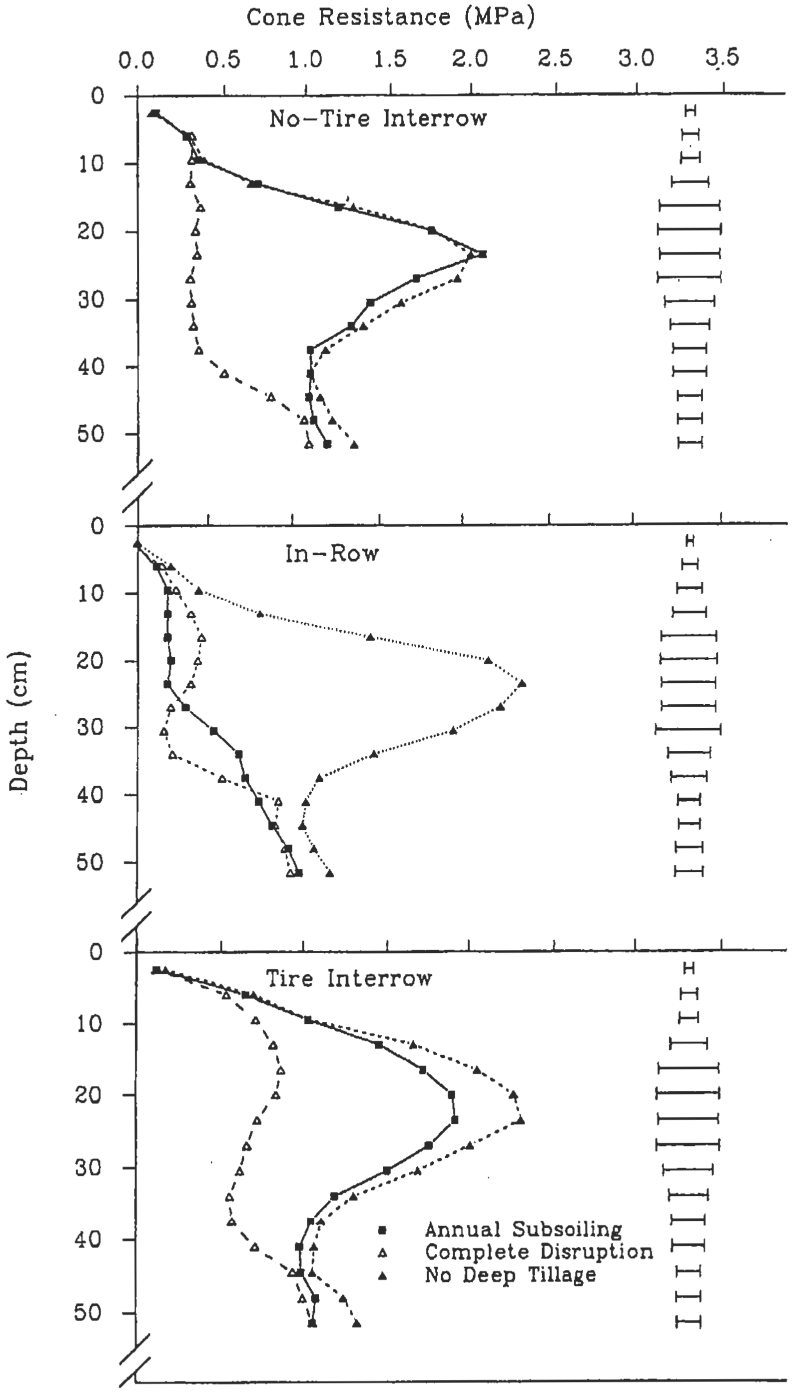

Fig. 4. Cone resistance relative to row position as influenced by deep tillage. Means averaged over traffic and surface tillage treatments. Horizontal lines, $LSD_{0.10}$.

ally averaged only around 0.25–0.40 MPa, these penetrometer measurements were taken when the soil was saturated. At lower soil water contents, cone resistances within this profile depth dramatically increase (Fig. 6). For example, at the 25 cm depth, the 1.25 MPa cone resistance measured in surface-tilled plots following traffic shown in Fig. 5 (in-row position) could be expected to increase to approximately 2.0 MPa at a soil water content of 0.213 $m^3\ m^{-3}$. This was the average soil water content for this treatment maintained from tasseling to black layer at this depth. Thus, these increases in cone

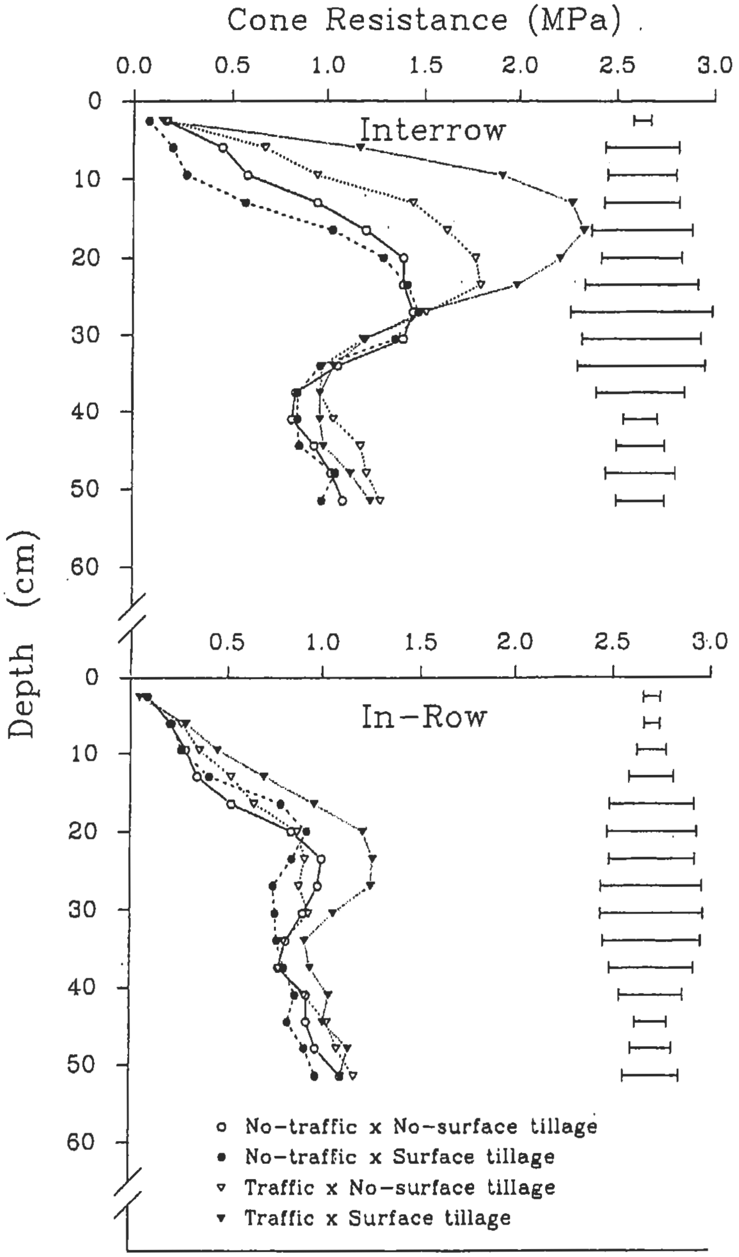

Fig. 5. Influence of traffic and surface tillage on cone resistance in the tire interrow (top) and in-row position (bottom). Means averaged over deep tillage treatments. Horizontal lines, $LSD_{0.10}$.

resistance with traffic and surface tillage, although small, could have some effect on root growth under the row. To a lesser degree, traffic following complete disruption also increased soil strength under the row (data not shown).

Soil water

The detrimental effect of wheel traffic on root growth and water infiltration in 1989 can be inferred from the average soil water content maintained from

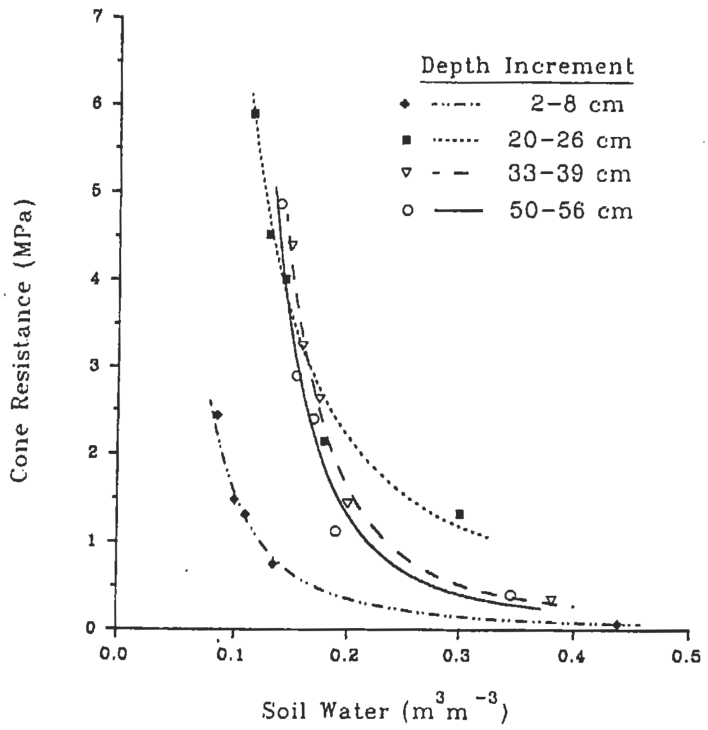

Fig. 6. Cone resistance from four depth increments within the profile of a Norfolk loamy sand as affected by soil water content.

TABLE 5

Volumetric soil water content ($m^3 m^{-3}$) maintained in tire and no-tire interrows of corn during the 47-day period from tasseling to black layer in 1989. Means are from trafficked plots and are the average of 11 measurements

Depth (cm)	Tire interrow		No-tire interrow		$LSD_{0.10}$
	Surface tillage	No surface tillage	Surface tillage	No surface tillage	
0–20	0.150	0.140	0.102	0.125	0.008
20–40	0.213	0.230	0.190	0.182	0.010
40–80	0.231	0.226	0.225	0.226	0.008

tasseling to black layer in trafficked plots (Table 5). In the no-tire interrows, at the 0–20 cm depth, the lower soil water content with surface tillage can most likely be explained by increased root growth and consequent extraction of water. Soil water was highest in the wheeled or tire interrows, especially with surface tillage. This suggests that soil compaction in the wheel tracks resulted in reduced root growth and water extraction. Differences in soil water among and between tillage and traffic treatments could also have been influenced by variations in soil water retention characteristics as affected by variations in bulk density caused by treatments. Hydraulic properties, as affected by bulk density, were not measured during the course of the experiment owing to time and labor constraints. Although we did not measure interrow root density in this experiment, the hypothesis that soil compaction in the wheel tracks resulted in reduced root growth and water extraction is supported by other researchers. Voorhees (1989) reported that interrow traffic decreased corn root length density in the top 30 cm of a clay loam by up to 90%. Tardieu (1988) reported that the rate of water extraction by corn in a tracked interrow was about one-half that of the non-tracked interrow and in-row position, owing to reduced root density. In our study, wheel compaction to the 20 cm depth was especially severe with surface tillage as compared with no surface tillage, as evidenced by the increase in soil water (Table 5) and increases in cone resistances discussed previously (Fig. 5). These results agree with those of Hilfiker and Lowery (1988) who reported that reductions in root density in the top 30 cm of three soils were more severe with moldboard plowing than with no tillage.

The decrease in soil water with surface tillage, as compared with no surface tillage, at the 20–40 cm depth in tire interrows (Table 5) could be due to reduced infiltration caused by greater compaction from wheel traffic in surface-tilled plots compared with no surface tillage (Fig. 5). This decrease in soil water in tire interrows might also be explained by greater inhibition of rooting in the compacted 0–20 cm depth with surface tillage and greater diversion of roots to the lower depth (20–40 cm) with a consequent greater extraction of water from the 20–40 cm depth. Chaudhary and Prihar (1974) reported downward diversion of root growth in corn caused by interrow compaction.

The interactions of traffic, deep tillage, and surface tillage on volumetric soil water content are best illustrated by measurements taken within the tire interrow position (Table 6). The deep tillage×traffic×surface tillage interaction significance level was $P \leq 0.04$, $P \leq 0.10$, and $P \leq 0.16$ for the 0–20 cm, 20–40 cm and 40–80 cm depths, respectively. At the 0–20 cm depth, volumetric soil water content during the measurement period was generally greater in traffic plots than in non-trafficked plots, regardless of tillage. Within plots with no deep tillage; at the 0–20 cm depth, surface tillage had no effect on soil water when traffic was applied. However, in the absence of traffic, water content remained higher with no surface tillage. This is probably because of less water extraction by fewer plant roots as a result of surface compaction in no-tillage plots (Fig. 5). The lowest water content, regardless of surface tillage, was maintained in the complete disruption treatment with no traffic. This treatment would be expected to minimize compaction and maximize root growth and water extraction. With in-row subsoiling, surface tillage reduced soil water content, compared with no surface tillage, in no-traffic plots but increased soil water content when traffic was applied. The decreased soil water

TABLE 6

Influence of deep tillage, traffic, and surface tillage on volumetric soil water ($m^3\ m^{-3}$) maintained in corn plots during the 47 day period from tasseling to black layer in 1989. Means are the average of 11 measurements taken in the tracked (tire) interrow position

Depth (cm)	Traffic	Deep tillage					
		In-row subsoil		Complete disruption		None	
		Surface tillage	No surface tillage	Surface tillage	No surface tillage	Surface tillage	No surface tillage
0–20	Yes	0.159	0.136	0.145	0.136	0.147	0.148
	No	0.120	0.133	0.105	0.103	0.103	0.123
$LSD_{0.10}=0.010$							
20–40	Yes	0.227	0.233	0.205	0.238	0.208	0.219
	No	0.225	0.212	0.125	0.169	0.213	0.213
$LSD_{0.10}=0.013$							
40–80	Yes	0.226	0.211	0.240	0.236	0.227	0.230
	No	0.235	0.225	0.201	0.225	0.241	0.236
NS							

Deep tillage × traffic × surface tillage interaction significant at $P\leq0.04$, $P\leq0.10$, and $P\leq0.16$ for 0–20 cm, 20–40 cm, and 40–80 cm depths, respectively. LSD is for surface tillage within any deep tillage × traffic combination.
NS, not significant.

owing to surface tillage with in-row subsoiling in no-traffic plots is probably explained by increased rooting and water extraction as a result of reducing soil compaction in this soil depth zone. In contrast, traffic applied after surface tillage recompacted the soil to a greater extent than when applied without surface tillage, resulting in a zone more restrictive to root growth compared with no surface tillage. Soil strength data discussed previously (Figs. 4 and 5) confirm this and explain the increased soil water maintained in surface-tilled plots compared with plots with no surface tillage with in-row subsoiling and traffic applied.

At the 20–40 cm depth, with in-row subsoiling and no traffic, soil water was less without surface tillage (Table 6). Chaudhary and Prihar (1974) reported that interrow surface compaction (0–20 cm depth) inhibited lateral root growth of corn and caused downward growth of roots. Within no-traffic plots, increased surface compaction without surface tillage compared with surface tillage (Fig. 5) probably inhibited lateral root growth in the 0–20 cm depth and increased rooting within the 20–40 cm depth resulting in more water extraction in this zone.

The most notable differences in soil water occurred at the 20–40 cm depth with complete disruption (Table 6). Within this deep tillage treatment and depth, traffic resulted in increased water content, regardless of surface tillage, probably because of less root extraction of soil water. No-surface tillage resulted in greater soil water content than surface tillage, regardless of traffic, probably because of less soil water extraction from decreased root growth, as well as increased infiltration with no surface tillage. Variations in hydraulic properties as a result of changes in bulk density cannot, however, be ruled out as a reason for variation among treatments. Maximum root growth and water extraction with the combination of intensive tillage, i.e. complete disruption and surface tillage, and no traffic is indicated by the marked decrease in soil water content in this treatment.

Treatments had minimal effect on soil water use below the 40 cm depth (Table 6). This supports data from 1988 (Fig. 3) that indicate relatively little root growth below 40 cm. Cassel et al. (1985) described maximum rooting depth of corn on a similar soil as the depth that roots were observed plus 0.10 m. This depth was 0.35 m in their study and was obtained 57 days after planting.

CONCLUSIONS

In a drought year, grain yields increased with intensity of deep tillage; deep tillage without surface tillage optimized yields. In both a drought year and a year of above average rainfall, surface tillage increased grain yield in the absence of deep tillage. Soil strength and soil water measurements confirmed the detrimental effect of traffic after intensive tillage. Traffic negated the effects of surface tillage on stover production in both years. The lack of any grain yield response to applied traffic, in addition to soil water measurements, however, suggests that corn can compensate for reduced rooting capacity in wheeled interrows by increased rooting in non-wheeled interrows. This study will be continued in order to determine the long-term effects of traffic and tillage interactions on soil properties and crop responses.

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