Crust Strengths of Two Indiana Soils as Influenced by Soil Properties and Tillage

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Introduction

Soil crusting reduces plant emergence (Taylor, 1962), and is a significant problem on many Indiana soils. Careful examination of the characteristics of soils that lead to crusting is needed before appropriate practices to control crusting can be devised. Crust strength is affected by soil moisture content, organic matter content and other factors. The effect of the crust on seedling emergence is also affected by the crop and size of the seed (Arndt, 1965a & b; Parker and Taylor, 1965).

Penetrometers have normally been used to measure crust strength in the field. Brossman *et al.* (1982) demonstrated an alternate technique that worked well under greenhouse conditions. It has the advantage over penetrometers of measuring the pressure required to break through the crust from below, and the disk used was similar in size to a soybean seed.

Materials and Methods

Two soils on the Purdue University Agronomy Farm near West Lafayette were studied. The soils were divided into three conditions based on drainage and landscape position. Condition I was a poorly drained Chalmers soil in a depression landscape position. It is classified as a fine-silty, mixed, mesic Typic Haplaquoll. Condition II was also a Chalmers, but better drained and transitional to Condition III. Condition III was a somewhat poorly drained Raub soil on a landscape swell position. It is classified as a fine-silty, mixed, mesic Aquic Argiudoll. The Chalmers soils have a silty clay loam to silt loam surface texture characterized by a coarse granular structure and a high organic matter content (4.8-6.4%). The somewhat poorly drained Raub soil has a silt loam surface texture and differs from a Chalmers soil in having a lower organic matter content (2.6-3.8%).

Experimental Design

The field was divided into 18 plots each 9 m. x 29 m. Each soil condition was represented by six plots.

Following fall plowing, the plots within each soil were randomly assigned either zero or one or two disk harrow treatments as spring secondary tillage. The disk harrow treatments were then split with each plot randomly assigned either zero or one power harrow treatment. There were six possible treatments, replicated twice, within each soil condition.

All plots were fall plowed with a moldboard plow and disk harrowed with a light 15 foot finishing disk. A 10 foot Neimeyer TE 300 oscillating power harrow was used for the power harrow treatment. A John Deere max-emerge planter was used both years for planting.

Becks 65X (MO 17 x B73 single cross) corn (Zea Mays) was planted May 9, 1980 at a population of 65,000 Seeds/ha. Nitrogen at a rate of 280 kg/ha was applied as anhydrous ammonia (NH_3).

In 1981 each treatment was prepared as in the previous year and planted to Century soybeans (Glysine max) on May 29, at 55 kg/ha.

Laboratory Analysis

Bulk density (coated clod method) and the particle size distribution procedures were those of the Purdue University Soil Characterization Laboratory (Franzmeier, *et al.*, 1977). The mean weight diameter of water stable aggregates was measured according to Yoder's method (Kemper and Chepil, 1965). All samples were taken at a depth of 0-8 cm.

Field Measurements

Within each half plot two 5.3 meter sections in two different rows were marked on the day of planting and plants were counted each day thereafter to obtain emergence data.

Crust strength was measured by burying five 1.2 cm diameter buttons in the two center rows of each split plot. Each button was planted approximately 1.3 cm. deep by first making a hole 2.5 cm. in depth and slipping the button sideways into the adjacent undisturbed soil so it was firmly imbedded 1.3 cm. from the surface. The depression was then refilled and lightly tamped down. After a rain and subsequent drying out period, crust strength was measured by the amount of pressure it took to remove the button. Figure 1 shows the portable apparatus that was used. The button was attached to a string which was in turn attached to a spring scale. The pressure was applied by a constant addition of water to the bucket (~ 0.8 ℓ/min. The scale was read as the button broke through the soil. In 1980 a laboratory spring scale was used which had a constant reading scale. In 1981 a scale was used which had a maximum reading guage. This maximum reading guage considerably reduced the variability in readings. A soil sample was taken from each split plot to determine moisutre content at the time crust measurements were taken.

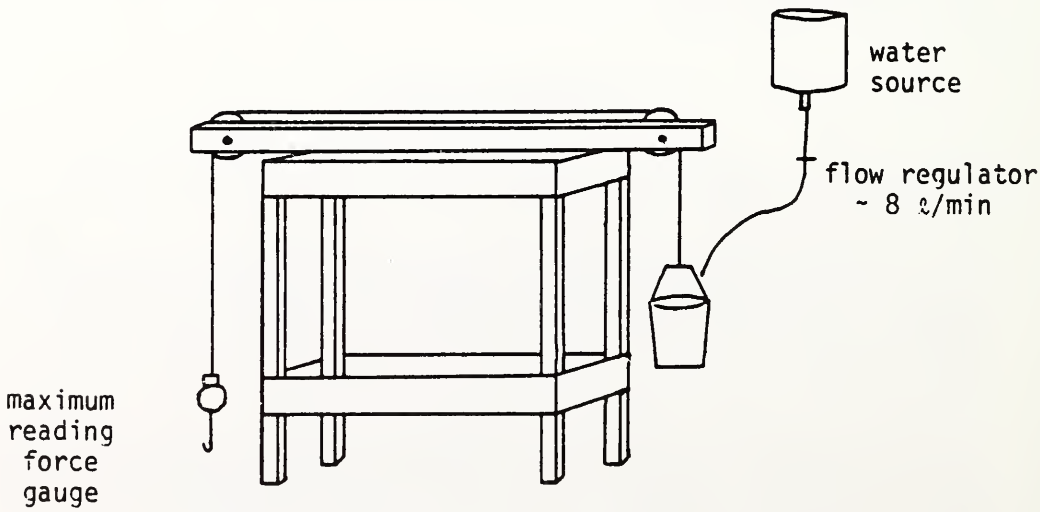

FIGURE 1. *Apparatus used to measure crust strength.*

Two 5.3 m sections from two different rows in each half plot were hand harvested to determine corn yield. Soybean yields were obtained from machine harvest.

Results

Table 1 contains the measurements of bulk density. There are no statistically significant differences (at 0.10 level) in the bulk density data.

There were no statistically significant differences in the wet aggregate stability of the three soil conditions. The well structured, Chalmers soil in Condition I had a slightly higher average mean size of water stable aggregation than either of the other two soils. The Raub soil which has the poorest structure also has the lowest average mean of water stable aggregation.

Crust Strength

There are differences in crust strength between the three soil conditions (Table 3). In 1980, even with a great deal of variability in the data because of the scale used,

TABLE 1. *The effects of different tillage treatments on three soils as measured by Bulk Density g/cm ÷ (coated clod method).[1]*

Tillage		Soil		
Trips with Power Harrow	Trips with Disk Harrow	Chalmers Depression	Chalmers Intermediate	Raub
		g/cm^3	g/cm^3	g/cm^3
1	0	1.52	1.63	1.62
1	1	1.63	1.59	1.62
1	2	1.58	1.51	1.55
0	0	1.59	1.50	1.56
0	1	1.70	1.62	1.58
0	2	1.75	1.70	1.61

1 Samples taken from the surface.
Not significant at 0.05 level.

CV = main plot/soils 4.8%
CV = sub plot 5.3%

TABLE 2. *The effect of tillage treatment on three soils as measured by Mean Weight Diameter of water stable aggregates.*

Tillage		Soil		
Trips with Power Harrow	Trips with Disk Harrow	Chalmers Depression	Chalmers Intermediate	Raub
		mm	mm	mm
1	0	0.90	0.69	0.99
1	1	0.70	0.56	0.55
1	2	0.91	0.84	0.45
0	0	0.59	0.49	0.60
0	1	1.15	0.76	0.82
0	2	0.79	0.94	0.49

Not significant at 0.05 level.
CV = main plot 27%
CV = subplot 17%

TABLE 3. *Crust strength measurements (g/cm^2) for each soil condition and secondary tillage treatment.*

Tillage		1980 Soil						1981 Soil					
Trips with Power Harrow	Trips with Disk Harrow	Chalmers Depression		Chalmers Intermediate		Raub		Chalmers Depression		Chalmers Intermediate		Raub	
		g/cm^2	$\%H_2O$	g/cm^2	$\%H_2O$	g/cm^2	$\%H_2O$	g/cm^2	$\%H_2O$	g/cm^2	$\%H_2O$	g/cm^2	$\%H_2O$
1	0	810	15	1085	14	1200	11	233	7	629	7	874	6
1	1	724	14	822	11	1272	16	186	7	520	7	774	6
1	2	960	14	1004	16	1284	14	193	7	277	6	842	6
	Average	831		970		1252		204		478		830	
0	0	736	12	930	14	1203	15	505	6	568	6	709	6
0	1	800	11	1172	10	1346	8	333	7	526	4	785	6
0	2	770	12	709	21	1109	14	208	8	303	5	642	6
	Average	769		973		1219		349		466		712	
average across soil		a		a		a		b		c		d	

Columns with different letter are significantly different at 0.01 level.

	1980	1981
CV main plot =	21.8%	39.9%
subplot =	19.7%	33.0%

soil condition had a statistically significant influence (0.10 level) on crust strength when all treatments are averaged. In 1981, the technique used to measure crust strength was refined and the degree of variability reduced. The effect of soil condition on crust strength when averaged for all treatments was highly significant (0.01 level). The overall differences between the data collected in 1980 and 1981 was due to the technique being refined in 1981 and crust strength measurements being taken in a drier period in 1981. The moisture content of the soil averaged 14% in 1980 and 6% in 1981. Although crust strength increases as the soil becomes drier, it does so only until the point of cracking. Cracking decreases crust strength as the emerging button takes advantage of the natural cracking in the soil. Whole crusted areas are lifted instead of a break in the crust immediately surrounding the button. Seedlings are capable of this same action (Arndt, 1965a & b).

Emergence

The data for 1980 shows no statistically significant difference in emergence of corn seedlings either due to soil or tillage treatment (Table 4). In 1981 there is a

TABLE 4. *The average total number of plants emerged per 5.3 meters.*

TILLAGE		1980 Crop: Corn Soil			1981 Crop: Soybeans Soil		
Trips with Power Harrow	Trips with Disk Harrow	Chalmers Depression	Chalmers Intermediate	Raub	Chalmers Depression	Chalmers Intermediate	Raub
		# emerged	# emerged	# emerged	# emerged	# emerged	# emerged
1	0	22	20	18	126	128	125
1	1	20	20	21	125	130	125
1	2	22	19	19	127	121	130
	Average	21	20	20	126	127	127
0	0	20	20	18	119	117	124
0	1	20	19	19	116	129	124
0	2	22	19	22	130	121	122
	Average	21	19	20	122	122	124

Not significant at 0.05 level

CV main plot = 5.2% 1980
CV subplot = 4.9% 1981

CV main plot = 5.0% 1980
CV subplot = 9.7% 1981

statistically significant effect (0.10 level) on emergence of soybean seedlings produced by the power harrow for each soil conditions averaged over all treatments. This may relate to the sifting of the finer particles which decreased the effective crust strength and allowed greater emergence.

Yield

Any differences in corn and soybean yields either among soils or due to tillage treatment were slight and not statistically significant (Table 5 and 6). The tendency for less secondary tillage to result in lower soybean yields appeared to be related to weed control, but the difference was not statistically significant.

TABLE 5. *1980 corn yield (Tonnes/ha) as related to soil and secondary tillage treatment.*

Tillage		Soil		
Trips with Power Harrow	Trips with Disk Harrow	Chalmers Depression	Chalmers Intermediate	Raub
		T/ha	T/ha	T/ha
1	0	10.50	10.29	10.56
1	1	9.08	10.83	11.24
1	2	9.89	10.83	10.97
0	0	10.97	9.49	10.45
0	1	9.96	10.63	11.10
0	2	10.16	10.76	10.63

Not significant at 0.05 level.

Summary and Conclusions

During the two years of the study the secondary tillage treatments used had no statistically significant effect on bulk density or wet aggregate stability of the soils. Little change had been expected because of the brevity of the treatments. In 1981 the Chalmers in the depression had an average crust strength of 276 g/cm^2; the intermediate Chalmers, 472 g/cm^2; the Raub, 771 g/cm^2. The Chalmers soils were well structured, and crust strength may not be as easily affected by management as the Raub. Emergence of soybeans was increased by the power harrow.

It may be possible to draw in references regarding some common management practices. On these particular soils, no increase in yield was obtained from increased secondary tillage. Modern planters and cultural practices may not require as many secondary tillage operations as was previously thought necessary to obtain an adequate seed bed and plant population.

This study demonstrated the field capability of the crust strength measurement that was used. There is virtually no disturbance of the soil involved, and it can be successfully done on plots planted to field crops using standard practices.

Literature Cited

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TABLE 6. *1981 Soybean yields (Tonnes/ha) as related to soil and secondary tillage treatment.*

Tillage		Soil		
Trips with Power Harrow	Trips with Disk Harrow	Chalmers Depression	Chalmers Intermediate	Raub
		T/ha	T/ha	T/ha
1	0	2.7	2.3	2.5
1	1	3.2	3.3	3.1
1	2	2.9	3.1	2.9
0	0	2.6	2.3	2.5
0	1	3.1	3.2	3.4
0	2	2.8	3.0	3.2

Not significant at 0.05 level.

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