Conservation Tillage Studies on a Clermont Silt Loam Soil

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Introduction

Conservation tillage systems have become increasingly popular as a means for a farmer to save time and fuel in the preparation of land for planting, as well as for reduction of soil erosion. It is important that an appropriate tillage system be chosen for a given soil type, since tillage techniques vary in their adaptability to different soils. Studies at Purdue have resulted in some guidelines for choosing a tillage system to fit a particular soil (Galloway et al., 1981), but more work is needed on soil properties and crop growth on "problem" soils, as they are affected by tillage.

The Clermont soil occurs extensively in southeastern Indiana and southwestern Ohio. Its morphology and hydrology have been described by King and Franzmeier (1981). The Clermont silt loam is a Typic Ochraqualf with a 0-2.0% slope, about 73.0% silt, 10.0% clay, and less than 1.0% organic carbon in the plow layer, and a fragi-like pan at a depth of about 3 feet. The soil has several problems which make it difficult to manage. 1) The soil is highly erosive in spite of the flat to gently sloping topography, due to the high silt and low organic matter contents. Eroded rills and channels could be observed even on gentle slopes at the farm. 2) Trafficability is usually poor in the spring, due to wetness problems, which results in delayed planting and reduced yield potential. The wetness is due to a seasonally high water table and to the slow hydraulic conductivity of the plow pan. 3) Rooting depth can be restricted by the excessive spring wetness. This can result in aeration problems in the spring and drought problems in mid-summer.

It was hypothesized that with appropriate tillage techniques, the management problems on the Clermont soil could be reduced. The objective of this experiment is to determine the adaptability of varous tillage systems to the Clermont soil, with respect to (1) early crop growth, crop yield, and rooting patterns, and (2) soil physical properties, including soil stability against erosion, soil temperature and water content, trafficability, and hydraulic conductivity. The results of measurements taken during the first three years of this long-term study are discussed here.

Experimental Treatments and Methods

Four tillage treatments and two crop rotation treatments were replicated four times in a randomized block design. Tillage treatments were spring moldboard plow and disk twice, fall chisel and disk twice in spring, spring disk twice, and no-till. Plow, chisel, and disk plots were cultivated once. Crop rotations were continuous corn and corn-soybeans. Seeding rate was 24,000 seeds/acre for corn and 124,000 seeds/acre for soybeans (calculated from actual measure of 48 lbs/acre, with data from Wilcox, et al., 1981).

Stands were not significantly affected by tillage except for no-till beans in 1980 which had a severe infection of phytophthora root rot. Corn stands averaged 21,900 and 20,400 plants per acre for 1980 and 1981 respectively, while soybean stands averaged 8.1 and 6.6 plants per foot in the same years. Planting dates for corn were June 9, 1980, June 17-18, 1981, and April 28-29, 1982, and for soybeans were June 10, 1980, June 18-19, 1981, and May 20, 1982. Weed control was adequate on all plots.

Percent surface residue cover was estimated by a photographic grid technique within a day after planting. A rectangular frame (76 cm x 51 cm) is placed on the ground and centered over a row, such that the frame extends 38 cm on either side of the row to the row middles (76 cm row spacing used in planting). A color slide is then taken from a nearly vertical angle over the soil and frame. The slides are projected onto a gridded screen with the same relative dimensions as the frame. The number of intersections of residue pieces with the 50 grid marks on the screen is counted and multiplied by 2 to get percent surface cover. Three adjacent rows in the center of each plot were photographed and counted to obtain an average value for each plot.

Size distribution of water-stable aggregates was determined by the Yoder sieving procedure, as described by Kemper and Chepil (1965). In this procedure, aggregates between 2mm and 8mm in diameter are oscillated on a nest of 4 sieves under water for 10 minutes, and the weight of aggregates remaining after sieving is determined. Soils which are more water-stable will have more large aggregates remaining after sieving. An average diameter is calculated based on the weight of soil in each size class rather than on the number of aggregates in each class. The calculation of this mean weight diameter (MWD) is used to reflect the thought that a few large aggregates are more important than many small aggregates in determining the resistance of surface soil to raindrop detachment and erosion.

The data were statistically analyzed using analysis of variance tests. Duncan's multiple range test (Steel and Torrie, 1960) was then performed (95.0% confidence level) on those data where tillage was a significant treatment effect.

Results and Discussion

Residue cover and size distribution of water stable aggregates

Percent surface residue cover remaining after planting (Table 1) showed the typical trend of more cover with less intensive forms of tillage. Plowing buried esentially all crop residues, no-till systems left the surface nearly totally covered, and chisel and disk systems were intermediate. Cover was less following soybeans across all tillage methods, due to the lower production of residue by soybeans than by corn. Two-way analysis of variance showed that the effects of tillage, previous crop, and the interaction of tillage and previous crop were all highly significant (99.0% confidence level).

The concentration of residues near the soil surface with reduced tillage protects the soil surface from raindrop inpact and aggregate disruption, and also supplies organic matter for microbial production of stable aggregates. Mean weight diameter of water stable aggregates, measured immediately prior to planting, showed a significant trend of larger stable aggregates with reduction in tillage

TABLE 1. *Percent surface residue cover measured shortly after planting, 1982.*

Tillage	Previous Crop: Corn	Previous Crop: Soybeans
Plow	0a†	0a
Chisel	12b	2ab
Disk	17c	3b
No-till	96d	87c

†Values in the same column followed by the same letter were not statistically different at the 5.0% level.

TABLE 2. *Size distribution of water-stable aggregates (0-7.5 cm depth) prior to planting, April 28, 1982.*

Tillage	Mean Weight Diameter (mm) Rotation		
	CC[1]	BC[2]	CB[3]
Plow	0.78 a[4]	0.68 a	0.74 a
Chisel	0.97 a	0.60 a	0.91 ab
Disk	0.95 a	1.34 b	1.15 b
No-till	0.73 a	1.18 b	1.10 ab

[1]continuous corn
[2]corn in 1982, following 1981 soybeans
[3]soybeans in 1982, following 1981 corn
[4]values in the same column followed by the same letter were not statistically different at the 5.0% level.

intensity, especially in the soybeans-corn and corn-soybeans rotation plots (Table 2). Although there was a significant increase in residue cover (Table 1) and stable aggregate size (Table 2) with reduction in tillage intensity, there was no significant correlation between cover and aggregate size at the April sampling date. The smaller aggregate size in the no-till plots compared with the other tillage treatments in continuous corn is thought to be due to wetter soil conditions which could have caused aggregate breakdown during sample preparation.

Stable aggregate sizes measured at mid-summer (Table 3) were greater than those measured in April for all treatments, showing the typical increase in aggregate size and stability during the first half of the growing season, due to microbial decomposition of crop residues. The trend of increased aggregate size with reduced tillage intensity was even more evident in July than in April. No-till plots generally had the largest stable aggregates due to the high concentration of residues near the surface. Even the chisel systems, which incorporate residues vertically into the soil to depths of about 4-5 inches, left enough residues near the surface to improve stability. Surface residue cover prior to planting and July stable aggregate size were significantly correlated (99.0% level), with a correlation coefficient of 0.66.

At the July sampling date there was also a significant effect of crop rotation on aggregate size, with the soybean plots having smaller aggregates than the two rotations that were growing corn. This more erosive soil condition under soybeans has often been observed by farmers and researchers but is not yet understood.

TABLE 3. *Size distribution of water-stable aggregates (0-7.5 cm depth), July 26, 1982.*

Tillage	Mean Weight Diameter (mm) Rotation		
	CC1	BC[2]	CB[3]
Plow	1.49 a[4]	0.91 a	0.87 a
Chisel	1.76 ab	1.82 b	1.39 b
Disk	2.13 bc	1.98 b	1.87 c
No-till	2.33 c	2.69 c	2.33 c

[1]continuous corn
[2]corn in 1982, following 1981 soybeans
[3]soybeans in 1982, following 1981 corn
[4]values in the same column followed by the same letter were not statistically different at the 5.0% level.

TABLE 4. *Plant height (in) 8 weeks after planting, 1981.*

	Corn Height		Soybean Height
	Prior crop		
	corn	soybeans	corn
Plow	101 b†	101 a	30 a
Chisel	103 b	99 a	32 b
Disk	101 b	100 a	32 b
No-Till	93 a	95 a	30 a

†Values in the same column followed by the same letter were not statistically different at the 5.0% level.

Crop growth and yields

Plant height 8 weeks after planting was measured as an index of early growth rates (Table 4). Corn heights were lower in no-till plots than in plow, chisel, and disk plots, probably due to the cooler soil temperature caused by heavy residue cover (temperature data not shown). The reduced growth rate was more significant for continuous corn than for corn following soybeans due to the difference in residue cover following these two crops. Soybean heights were significantly affected by tillage, but not in any consistent trend with tillage intensity.

Two-way analysis of variance (95.0% level) showed corn yields to be significantly affected by tillage in 1981, by previous crop in 1982, and by the interaction of tillage and previous crop in 1980, 1981, and 1982 (Table 5). The effect of tillage on yield was primarily due to lower yields with no-till systems compared to other tillage systems under continuous corn culture. When corn followed soybeans, there was no significant effect of tillage on yield. The significant interaction term indicates that adaptability of different tillage systems becomes more important under continuous rowcrop culture, or conversely, that the choice of tillage system is less critical under rotation systems. In 1982, corn yields following soybeans were significantly greater than continuous corn yields, indicating some type of positive rotation effect.

Soybean yields (Table 6) were not significantly affected by tillage in any of the three years of the study, except for no-till plots in 1980. No-till yields during 1980 were very low due to a large amount of Phytophthera root rot, which was minimized in subsequent years by planting a resistant variety.

Summary and Conclusions

1. No-tillage and shallow tillage over a 3-year period have increased the water-stable aggregate size of the surface of the Clermont silt loam.

TABLE 5. *Corn yields (bu/acre), 1980-1982.*

	Previous Crop					
	Corn			Soybeans		
Tillage	1980	1981	1982	1980	1981	1982
Plow	114	123 b†	187	116	122 a	197
Chisel	122	131 b	194	112	119 a	187
Disk	117	125 b	181	120	120 a	196
No-Till	105	105 a	160	120	116 a	197

†Values in the same column followed by the same letter were not statistically different at the 5.0% level.

TABLE 6. *Soybean yields (bu/acre), 1980-1982.*

	Previous Crop		
		Corn	
Tillage	1980	1981	1982
Plow	39	43	52
Chisel	40	41	51
Disk	40	39	52
No-till	19*	42	49

*Phytophthera root rot reduced yield.

2. Percent surface residue cover after planting was greatest for no-till, intermediate for disk and chisel systems, and lowest for plow systems. Cover was greater following corn than following soybeans.
3. Early corn growth rates were slower in no-till systems than plow, chisel, and disk systems.
4. Corn yields were depressed in no-till treatments following corn, but were similar to conventional systems when corn followed soybeans. Soybean yields were unaffected by tillage treatment when Phytophthora root rot was not a problem.

Results from the first three years of this study indicate that no-till may be a viable management system for the Clermont soil, when used in a corn-soybean rotation. Yields of both corn and soybeans are comparable with other tillage systems, when weeds are controlled and when Phytophthora-resistant soybean varieties are used. Surface soil stability has also been increased by leaving crop residues near the soil surface, and this may ultimately help reduce erosion and improve the overall structure of the Clermont soil.

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