The Effect of Three Tillage Systems on Soil Bulk Density and Porespace Distribution

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Many grain producers in Kentucky use a 3 crop in 2 year rotation of corn followed by small grain-soybeans, and commonly no-till the soybeans and corn in order to intensively use sloping land for continuous grain production. Because of the intensity of machinery traffic in this system, growers are concerned that continuous no-till management may cause compaction, and that such fields may need occasional primary tillage. In order to obtain information regarding this situation, we conducted a test for 3 years on the farm of Philip Lyvers, in Marion County, Kentucky, in a field which was being used in a corn-small grain-soybean rotation. Since the field had sizable areas of both Pembroke and Beasley soils, we made measurements on both soils before beginning the study, and again, 3 years later.

The Pembroke is a highly productive, deep, well drained red soil which occurs widely throughout the intensive grain producing areas of the Pennyroyal Area of Kentucky. The Beasley soil, although classified as a well drained soil, percolates water slowly due to a high clay content in the subsoil. Because of this, it dries at a slower rate than the Pembroke, sometimes causing delays in getting machinery onto the field.

Experimental Procedures

Three tillage systems were evaluated under actual farm conditions on a field which had previously used for corn-smallgrainsoybean production to determine their effect on soil bulk density and on soil porespace distribution. Tillage systems tested were: (1) no-till of all crops, (2) chisel plow-disk before corn or soybeans, and (3) spring disk and plant with a no-till planter. Tillage treatment strips of 300 ft length and 36 ft width were laid off on the Beasley soil and divided into 4 plots of 75 ft length each for grain harvest measurements. Large, intact cores of soil (3 ins dia. x 3 ins height) were taken from 3 locations within each of the 300 ft tillage strips on the boundary between the 1st and 2nd, 2nd and 3rd and 3rd and 4th plots (75 ft intervals) at depths of 0 to 3 and 3 to 6 inches for use in making measurements on physical characteristics. Cores were initially taken on June 6, 1983, just prior to harvest of barley from the field. Cores were taken again at the same depths from the same location in each tillage strip on June 4, 1986, from a wheat crop in order to determine if the three tillage systems used in the 3 year interim had changed the physical characteristics. Identical sampling was made on the Pembroke soil with the exception that harvest plots were only 60 ft in length,

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with the result that cores were taken from 4 locations within each tillage strip rather than 3. Large strips and plots of this size were used to make it possible for use of farm equipment throughout the study. Because of the large area required, tillage strips were not replicated across the field. In order to get some measure of soil variation, soil physical characteristics were measured within each tillage strip, at 3 locations on the Beasley soil and at 4 locations on the Pembroke soil, as described above. Yields were measured from each tillage strip by using the producer's field combine and weighing all the grain taken from a 4-row combine swath width through each individual strip (300 ft length). All production techniques and use of machinery on these plots was identical to that used by the producer in his commercial farm operation, the only difference being the tillage system used during the 3 year study.

Large and small porespace were measured with the pressure membrane technique after complete water saturation of the cores. Total porespace was calculated from bulk density measurements. Porespace was divided into two fractions: large pores and small pores. These were expressed as percentage of total porespace. Large porespace holding water was determined from the amount of water lost from cores after equilibration at 60 cm of water pressure. Small porespace was calculated from the amount of water remaining in cores after equilibration at 60 cm water tension. Large porespace which did not hold water was determined by the difference between total porespace and the sum of large and small pores holding water and was expressed as percentage of large pores. Bulk density was determined from volume of soil cores (347 cc) and oven dry (110^{o}C) weight of each core. Treatment averages for 1983 and 1986 were tested for significant differences using the t-test to test the null hypothesis that there were no real differences between 1983 and 1986 values.

<u>Results</u>

Bulk density and porespace distribution for the three tillage treatments are shown for the Pembroke soil in Figure 1 and for the Beasley soil in Figure 2 and in Tables 1 and 2. Statistical analysis of the treatment averages for 1983 and 1986 indicate that all differences shown except one were due to random chance and not to treatment effects. However, there was a consistent trend for increased content of large pores not holding water after 3 years, regardless of the tillage treatment.

Yields measured from the tillage strips are shown in Table 3. The initial barley yields shown for 1983 do not relate to the tillage treatments tested since that crop had been seeded before the initial soil parameters were measured in June, 1983. As such, differences shown in barley yields for 1983 only represent variability among the individual strips. Double-crop soybean yields were lower than expected both in 1983 and 1984 due to droughty conditions prevalent during July-September. Soybean yields on both soils tended to be slightly better for the disk-plant treatment in both years. There was a large tillage treatment effect on barley yields on both soils in 1984 in favor of no-till seeding of barley. This was due to severe winterkill of seedlings on chisel-disk and disk-plant treatments. Better overwinter survival of seedlings on no-till strips was thought to be due to presence of greater amounts of surface residues. Corn yields in 1985 were very good, with no-till yielding better on the Beasley soil and disk-plant yielding better on the Pembroke soil. Wheat yields in 1986 were low due to severe winterkill. Treatment differences were small on the Beasley soil, but no-till wheat did better on the Pembroke soil than the other two treatments.

Conclusions

Three continuous years of no-till planting (soybeans-barley-soybeans-corn-wheat) caused no significant changes in bulk density and porespace distribution in the 0 to 3 inch and 3 to 6 inch layers of Pembroke and Beasley soils as compared to chisel plow-disk and disk-plant tillage systems. There was no evidence that occasional primary tillage would be required to improve soil physical properties in this field. No-till seeding of barley and wheat resulted in less winterkill during the adverse winter freezes of 1984 and 1985, providing for better stands and higher yields.

Table 1. The Effect of Three Tillage Systems on Certain Physical Characteristics of a Pembroke Soil After 3 Years.

	0-3 Inch Depth						3-6 Inch Depth					
	No-Till		Chisel		Disk		No-Till		Chisel		Disk	
Physical Characteristic[1]	1983	1986	1983	1986	1983	1986	1983	1986	1983	1986	1983	1986
Bulk Density, g/cc	1.49	1.43	1.45	1.36	1.42	1.34	1.48	1.51	1.46	1.44	1.41	1.44
Total Porespace, %	44	46	45	49	47	50	47	43	45	46	47	46
Small Pores, % of Total Porespace	38	40	37	37	38	38	36	36	36	37	36	37
Large Pores Holding Water, % of Total Porespace	6	6	8	12	9	12	11	7	9	9	11	9
Large Pores Not Holding Water, % of Large Porespace	0	8	1	11	1	10	4	10	1	10	2	10

[1] Av 4 plots/tmt; Treatment averages with an asterisk (*) indicate significant (p=.05) differences between 1983 and 1986 measurements; Treatment averages without an asterisk did not significantly change between 1983 and 1986.

Table 2. The Effect of Three Tillage Systems on Certain Physical Characteristics of a Beasley Soil After 3 Years.

	0-3 Inch Depth						3-6 Inch Depth					
	No-Till		Chisel		Disk		No-Till		Chisel		Disk	
Physical Characteristic[1]	1983	1986	1983	1986	1983	1986	1983	1986	1983	1986	1983	1986
Bulk Density, g/cc	1.23	1.35	1.31	1.38	1.32	1.44	1.46	1.48	1.43	1.47	1.42	1.52
Total Porespace, %	54	49	51	48	50	46	45	44	46	44	46	43
Small Pores, % of Total Porespace	42	39	42	42	41	40	38	40	39	40	37	40
Large Pores Holding Water, % of Total Porespace	12	10	9	6	9	6*	7	4	7	4	9	3
Large Pores Not Holding Water, % of Large Porespace	3	10	2	7	3	8	1	9	1	7	3	6

[1] Av 3 plots/tmt; Treatment averages with an asterisk (*) indicate significant (p=.05) differences between 1983 and 1986 measurements; Treatment averages without an asterisk did not significantly change between 1983 and 1986.

Table 3. Crop Yields, 1983 to 1986.

	1983		1984		1985	1986
Tillage System	Barley[1]	Soybeans	Barley	Soybeans	Corn	Wheat
	bu/acre					
			Pembroke Soil			
No-Till	70	24	80	32	164	25
Chisel-Disk	59	18	57	32	159	15
Disk-Plant	61	26	58	34	182	16
			Beasley Soil			
No-Till	50	18	81	21	171	25
Chisel-Disk	62	18	34	19	153	25
Disk-Plant	57	24	30	25	152	27

[1] Yields taken from strips prior to implementation of tillage treatments.

Figure 1. Volume Distribution of Pembroke Soil.

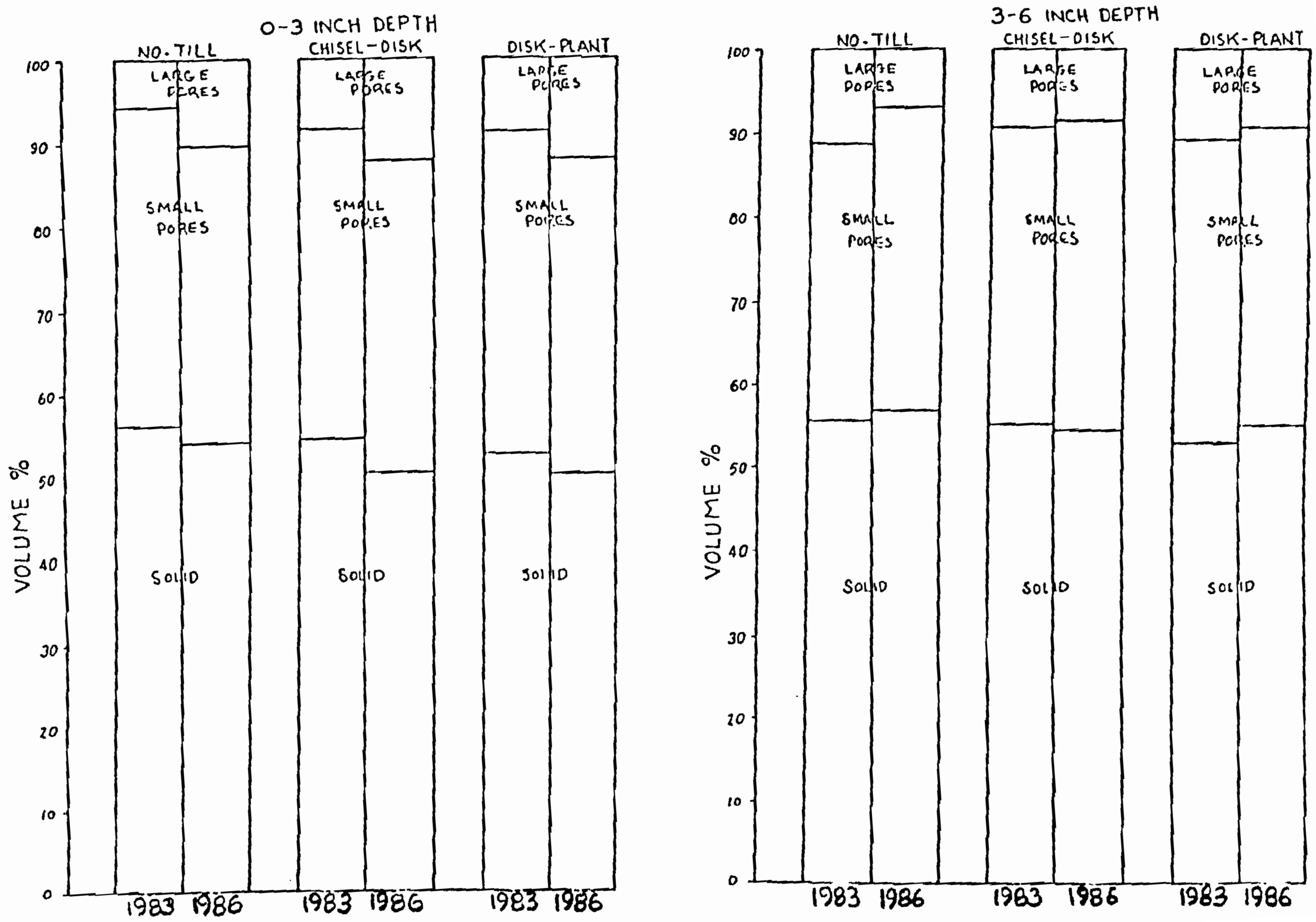
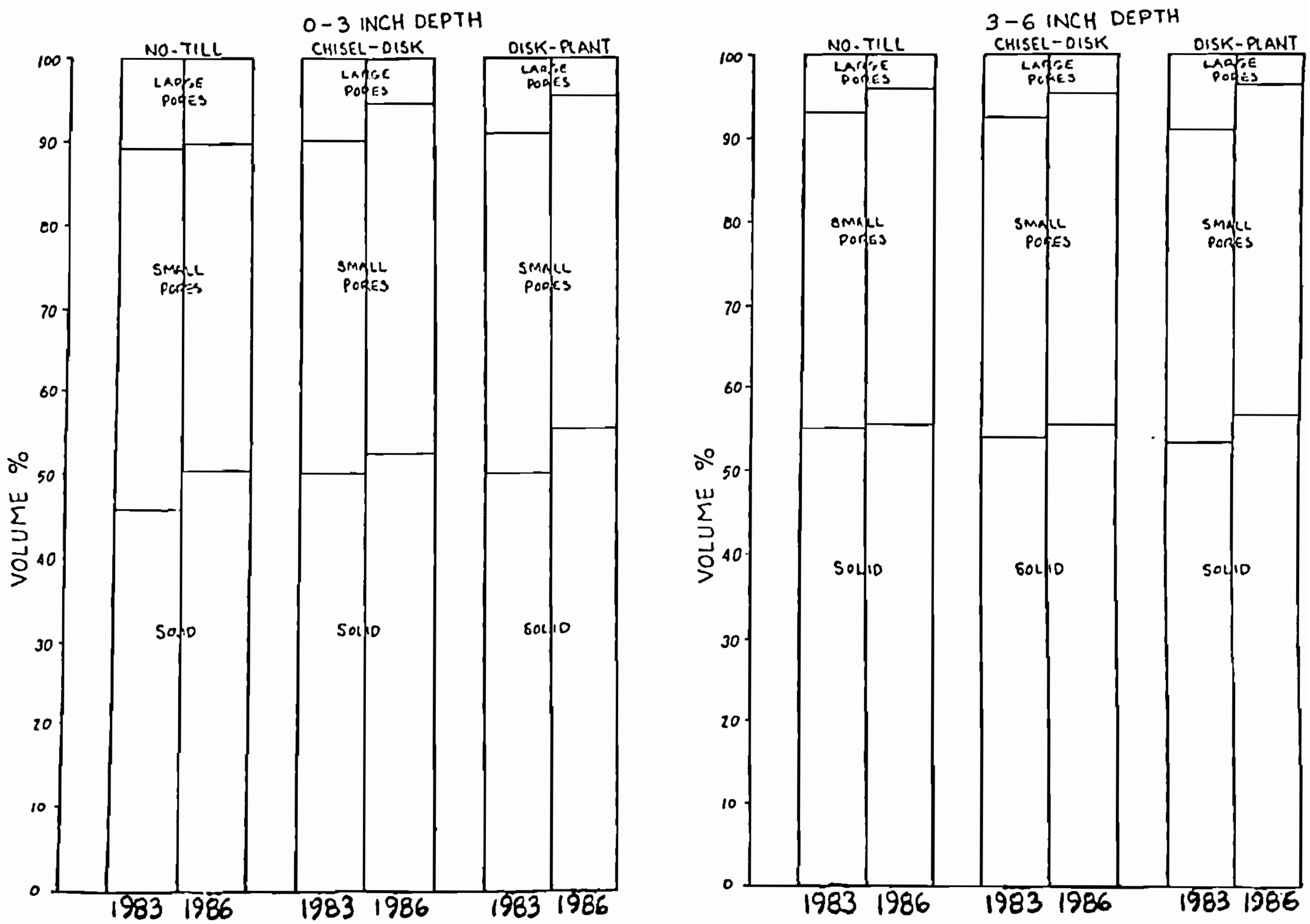


Figure 2. Volume Distribution of Beasley Soil.



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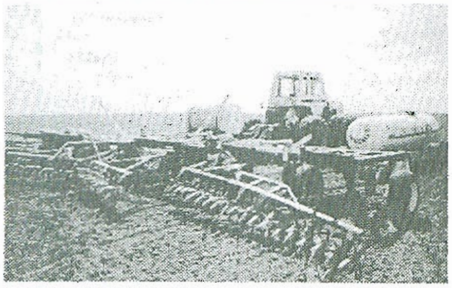
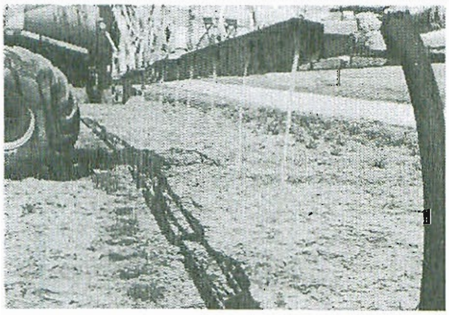

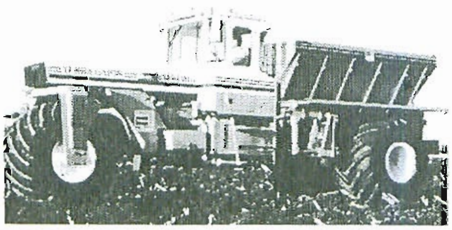
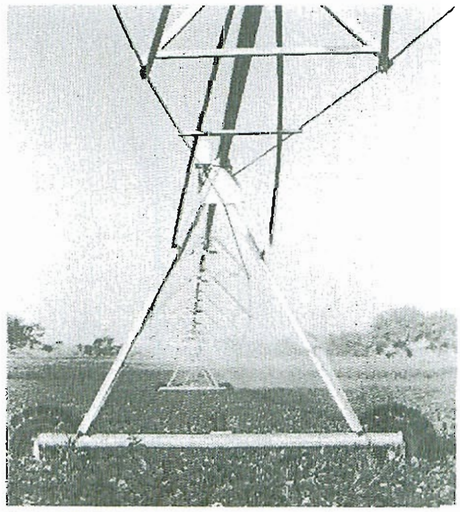
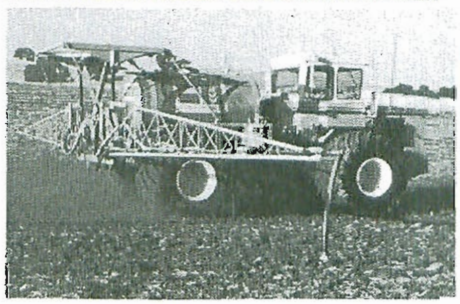

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