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Performance of Tillage Implements in a Stubble Mulch System. II. Effects on Soil Cloddiness[1]

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SYNOPSIS. Under field conditions, effects of stubble mulch tillage implements on soil cloddiness varied widely from year to year. During initial tillage, 2-inch chisels, 32-inch sweeps, and a one-way disk operated 4 inches deep produced a more cloddy soil surface than a rodweeder with shovels, an 8-foot V-sweep, or a one-way disk operated 2 inches deep. During subsequent tillage, a given implement increased or decreased cloddiness depending on type of previous tillage and soil moisture at time of tillage.

PRINCIPAL purpose of the stubble mulch system of farming is to maintain residues on the soil surface for protection against erosion hazards. The effect of this method of tillage on soil is important for the control of wind and water erosion, seed germination, and soil crusting. Thus, another important aim of stubble mulch tillage is to produce clods on the soil surface sufficiently large to resist movement of soil by wind and water, to improve infiltration, and to place fine soil material beneath the surface for prevention of surface crusting.

Results of a three-year field study to measure soil cloddiness from tillage with six different implements used in stubble mulch farming are presented. Soil cloddiness was measured after both initial and subsequent tillage operations.

METHODS AND PROCEDURES

Data were obtained at Alliance, Nebraska, during the three 1959–62 seasons on a Keith very fine sandy loam. All treatments were randomized and replicated three times. The implements and methods of use are described in previous publications (2, 9).

Surface soil samples were taken after each tillage operation. A composite sample of soil weighing approximately 20 pounds was obtained by combining 6 partially filled shovels of surface soil from 0- to 1-inch depth taken at random from each plot. Size distributions and mechanical stability of clods were determined by dry rotary sieving procedures described by Chepil (1).

Analyses of variance procedures were applied to data on percentage and mechanical stability of dry aggregates (commonly called clods) greater than 0.84 mm. in diameter. Dry aggregates greater than 0.84 mm. in diameter are regarded nonerodible by wind. Treatment means were tested with the Duncan multiple range test (3). Data on clod size distribution were displayed by means of cumulative logarithmic plots of sieve size versus percentages larger than a given size.

RESULTS AND DISCUSSION

Cloddiness Produced by Initial Tillage

On the average, group I implements (2-inch chisels, the 32-inch sweeps, and the one-way disk operating 4 inches deep) produced a higher percentage of clods greater than 0.84 mm. in diameter and with greater mechanical stability than group II implements (rodweeder with shovels, the 8-foot V-sweep, and the one-way disk operating 2 inches

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Table 1. Average percent of clods > 0.84 mm. in diameter after initial tillage.

Tillage implement	Clods >0.84 mm. in diameter						3-year aver.
	1959		1960		1961		
	%	Stat. signif. *	%	Stat. signif. *	%	Stat. signif. *	%
One-way disk, 4" deep	75.0		73.9		65.3		71.4
Statistical significance *							
2-inch chisels	74.6		74.4		71.7		73.6
Statistical significance*							
32-inch V-sweeps	72.6		79.4		69.5		73.8
Statistical significance*							
8-foot V-sweep	59.0		76.9		59.8		65.2
Statistical significance*							
Rod weeder with shovels	55.5		75.5		70.9		67.3
Statistical significance*							
One-way disk, 2" deep	50.6		72.4		63.0		62.0
Statistical significance*							

No significant difference

* ↑——↑ Indicates significance at 5% level by Duncan multiple range test.

Table 2. Average mechanical stability of clods after initial tillage.

Tillage implement	Mechanical stability of clods						3-year aver.
	1959		1960		1961		
	%	Stat. signif. *	%	Stat. signif. *	%	Stat. signif. *	%
One-way disk, 4" deep	86.0		89.4		81.7		85.7
Statistical significance*							
2-inch chisels	83.8		88.5		75.9		82.7
Statistical significance*							
32-inch V-sweeps	80.8		85.9		85.1		83.9
Statistical significance*							
8-foot V-sweep	71.1		86.3		77.5		78.3
Statistical significance*							
Rodweeder with shovels	70.9		89.0		82.0		80.6
Statistical significance*							
One-way disk, 2" deep	67.1		87.8		82.8		79.2
Statistical significance*							

No significant difference

* ↑——↑ Indicates significance at 5% level by Duncan multiple range test.

deep) (Tables 1 and 2). In 1959, every implement of group I gave results with differences statistically significant from every one of group II. In 1960, differences in percent of clod and mechanical stability were insignificant. In 1961, some implements of group I gave results with differences statistically significant from some of group II.

Implements that produced the greatest percentage of clods greater than 0.84 mm. in diameter also produced the greatest percentage of all other sizes (Figure 1). Thus, percentage of clods above any diameter greater than 0.84 mm. can be used as an index of soil cloddiness. Therefore, in this paper the percentage of clods greater than 0.84 mm. will be called cloddiness.

Cloddiness Produced by Second and Subsequent Tillage

Tillage with the various implements produced different effects on percentage and mechanical stability of clods in different years (Tables 3 and 4). The differences in percentage and mechanical stability of clods were nonsignificant except in 1961. Analyses of variance for percentage of clods greater than 0.84 mm. in diameter indicated that 84% of the variation was due to random sampling error, 4.0% to effects of years, and only 1.4% to effects of implements, while for mechanical stability of clods 72% was due to random sampling, 4.7% to years, and 1.3% to implements. Because of the extreme variability, it is difficult to draw any definite conclusions regarding the influence of implements on changes in percentage and mechanical stability of clods when the implements are used for second and subsequent tillage of fallow.

The 3-year average results showed that the 32-inch sweeps used after the rodweeder with shovels, after the 2-inch chisels, or after the 8-foot V-sweep produced the

Table 3. Average change in percentage of clods > 0.84 mm. in diameter resulting from second cultivation with different implements.

Implement		Average increase (+) or decrease (−) in percentage of clods > 0.84 mm. in diameter						3-year aver.
Second cultivation	Previous cultivation	1961 %	Stat. sign. *	1960 %	Stat. sign. *	1959 %	Stat. sign. *	%
Rodweeder with shovels	8' V-sweep	+9.5		−10.2		−0.4		−0.4
8' V-sweep	8' V-sweep	+8.6		− 6.0		−0.9		+0.6
Rodweeder with shovels	One-way	+6.3		− 2.8		−2.1		+0.5
32" sweeps	One-way	+0.9		− 3.2		−3.0		−1.8
8' V-sweep	One-way	+0.8		− 6.3		−6.3		−3.9
One-way	8' V-sweep	−1.2		− 2.9		−4.3		−2.8
One-way	One-way	−1.6		− 1.2		−8.2		−3.7
Rodweeder	32" sweeps	−2.0		− 1.8		−1.1		−1.6
32" sweeps	32" sweeps	−5.4		− 6.8		−3.1		−5.1

No signif. diff. (1960) No signif. diff. (1959)

* ↑——↑ Indicates significance at 5% level by Duncan multiple range test.

Table 4. Average change in mechanical stability of clods resulting from second cultivation with different implements.

Implement		Average percent increase (+) or decrease (−) in mechanical stability of clods						3-year aver.
Second cultivation	Previous cultivation	1961 %	Stat. sign. *	1960 %	Stat. sign. *	1959 %	Stat. sign. *	%
Rodweeder with shovels	8' V-sweep	+16.6		+1.4		+8.7		+8.9
8' V-sweep	8' V-sweep	+ 8.0		+4.1		+5.3		+5.8
One-way	One-way	+ 7.2		−1.5		−1.0		+1.6
One-way	8' V-sweep	+ 6.8		+1.6		+9.5		+5.9
Rodweeder with shovels	One-way	+ 6.2		+0.4		+4.0		+3.5
32" sweeps	One-way	+ 2.7		−0.1		+2.5		+1.7
8' V-sweep	One-way	+ 2.6		+0.4		+0.9		+1.3
Rodweeder	32" sweeps	+ 1.3		+2.0		−0.2		+1.0
32" sweeps	32" sweeps	− 2.7		+3.5		+5.3		+2.0

No signif. diff. (1960) No signif. diff. (1959)

* ↑——↑ Indicates significance at 5% level by Duncan multiple range test.

greatest degree of cloddiness (Figure 2). The one-way after the 8-foot V-sweep or after the one-way ranked next in order of cloddiness, followed by the 8-foot V-sweep after the 8-foot V-sweep, the rodweeder after the 8-foot or the 32-inch sweeps, the 32-inch sweeps after the 32-inch sweeps, and finally by the rodweeder with shovels after the 8-foot V-sweep. The maximum difference in clods greater than 0.84 mm. in diameter from the foregoing tillage sequences was about 15%.

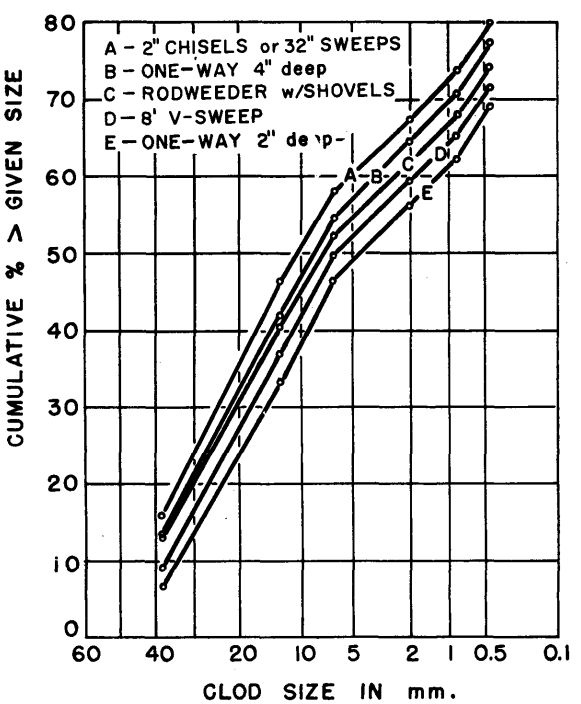

Figure 1. Size distribution of clods produced by 6 different tillage implements during initial tillage. Curves represent 3-year average data for each implement.

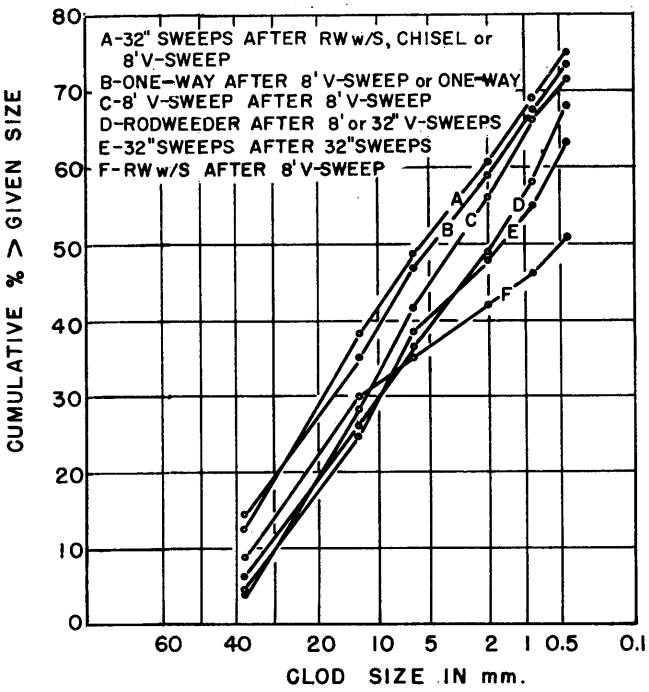

Figure 2. Size distribution of clods produced by different implements during second and subsequent tillage. Curves represent 3-year average results for each treatment.

CONCLUSIONS

The most significant information is the indication of extreme variability of soil cloddiness produced with tillage implements. Variation occurred from year to year and from field to field, particularly after second and subsequent tillage of fallow. Previous research (4) has indicated that soil density has a pronounced effect on soil cloddiness. Bulk density of the soil was not measured; however, since the soils were essentially of the same texture and the fields had the same tillage and cropping history, probably the soil density would be about the same each year. This leaves sampling errors, crusting due to intense rains, hardness of clods, and soil moisture as probable factors responsible for most of the variability. Soil moisture at time of initial tillage varied between years; 1959 was the driest and 1961 the wettest. Moisture differences were not large; however, previous research (5) has shown that even small differences substantially affect soil cloddiness. Estimates of variability indicate 52% of the variation in mechanical stability and 49% of the variation in percentage of clods greater than 0.84 mm. in diameter were probably due to rain or soil moisture effects.

Initial tillage results tend to agree with the one-way disk and the 8-foot V-sweep comparison of Wenhardt (7), the disk and the 10-inch sweep comparisons of Winkelblech and Johnson,[4] and the one-way and the 5-foot sweep comparisons of Woodruff and Chepil (8). They agree with the high soil moisture content results of Lyles and Woodruff (5) but do not agree with them on low moisture content results. Overall averages from this study showing that the cloddiest surface is produced by the 32-inch sweeps disagree with those of Siddoway (6) who showed that significantly more soil aggregates greater than 0.84 mm. in diameter were produced by the one-way disk than by 30-inch sweeps.

Wenhardt (7) did not find as much variability from the second and subsequent tillage of fallow as found in this study. His results showed that the second cultivation with an 8-foot V-sweep used on land initially tilled with a sweep increased cloddiness by about 5% and the third cultivation decreased it by about 7%. His results also showed that the second cultivation with a one-way reduced cloddiness by 3% but the third cultivation had essentially no effect. Results of this study generally agree with those of Wenhardt and with a previous study by Woodruff and Chepil (9). They partially agree with those of Winkelblech and Johnson (8) who showed that the second cultivation with a disk increased cloddiness by 1% and the second cultivation with a sweep decreased cloddiness by 4%.

[4] Winkelblech, C. S., and Johnson, W. H. Soil aggregate separation characteristics of secondary tillage tool components. Paper No. 61–651 presented at Winter Meeting, Am. Soc. Agr. Eng., Chicago, Ill., 16 p. Dec. 1961.

SUMMARY

Results of a 3-year field study of soil cloddiness from tillage with 6 different implements commonly used in stubble mulch farming are presented.

Results varied from year to year, but the average data for implements used initially on undisturbed wheat stubble indicated that the cultivator with chisels 2 inches wide and the 32-inch sweep implement produced the highest degree of cloddiness at the soil surface, followed in order by the one-way disk operated 4 inches deep, the rodweeder with shovels, the 8-foot V-sweep, and the one-way operated 2 inches deep.

Data obtained after second and subsequent tillages varied widely, probably because of soil moisture variation at tillage. Generally the cloddiest surface was obtained with 32-inch sweeps on land previously tilled with the 8-foot V-sweep, the 2-inch chisels, or the rodweeder with shovels, and the one-way or the 8-foot V-sweep on land previously tilled with the 8-foot V-sweep.

Mechanical stability of clods varied more or less directly with the percentage of clods.

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