SURFACE CLOD PRODUCTION CHARACTERISTICS OF SOME TILLAGE MACHINES ON A CLAY LOAM SOIL

by

A. Wenhardt

Member C.S.A.E.

Experimental Farm, Research Branch, Canada Department of Agriculture, Swift Current, Saskatchewan.

INTRODUCTION

Soil erosion by wind on the Great Plains region of the Prairie Provinces in Western Canada is not of recent origin. MacKay (11) reported severe soil drifting at the Indian Head Experimental Farm in 1889. At the same time MacKay (11) also reported on the importance of summer fallowing in a crop production programe. The practice of summerfallowing became quite general early in the present century. By 1934 almost 15 million acres of land were being summerfallowed and by 1958 the area had increased to over 25 million acres. Palmer (13) stated that soil drifting usually occurred during the spring months over most of the Prairies. In Southern Alberta it is often severe in the late autumn and also during the winter months when chinook winds melt the snow and leave the ground bare. In addition, Palmer (13) described the severe drought which occurred on the Prairies from 1931 to 1937, and which was accompanied by severe insect damage and periods of high winds. This created a situation which resulted in widespread soil drifting. The situation was further aggravated, as the drought continued, by the disappearance of trash caused by a succession of poor crops.

The importance of trash cover as a protective measure against wind erosion has been described by a number of workers (8, 9, 13, 14, 15, 17). Studies by Anderson (1), Cole and Morgan (5), Siddoway *et al.* (15), and by Woodruff and Chepil (17) have shown that tillage machinery plays an extremely important role in the matter of trash conservation as well as in the production of cloddy surface soil for wind erosion control.

Woodruff and Chepil (18) have described the effect of the one-way disk and the sub-surface sweep on surface soil cloddiness. Lyles and Woodruff (10) have described the influence of moisture content and type of tillage action on the structure and surface soil condition produced at the time of tillage. Chepil (3) has stated that the percentage of soil particles greater than .84 mm in diameter is a simple index for estimating erodibility by wind. Unpublished data (2) obtained at this Farm have shown that if a soil contains 60 per cent or more fine material (less than .84 mm in diameter) the hazard of wind erosion is high.

This paper presents the results of studies initiated at Swift Current to measure the surface clod structure resulting from some common tillage implements during an entire summerfallow period. The effects of natural weathering (late fall and over winter) as well as spring tillage and seeding operations on surface clod structure were also studied.

METHODS AND MATERIALS

The studies were conducted on a Wood Mountain clay loam soil described by Mitchell *et al.* (7) and covered a period extending from the spring of 1958 up to and including the 1961 seeding operations. The four tillage treatments reported in this study were part of a larger experiment containing eight treatments quadruplicated in a randomized block design. The plots were 80 feet wide and 600 feet in length. This size of plot was used to permit normal operation of the standard tillage machinery.

During the summerfallow seasons of 1958, 1959 and 1960 three tillage operations were required for what was considered adequate weed control. Soil samples for surface clod structure measurements were taken for each summerfallow period as follows: (1) after the first tillage operation, (2) after the second tillage operation, (3) after the third and final tillage operation, (4) just prior to freeze-up, (5) prior to preseeding tillage in the following spring, (6) immediately after seeding.

The soil samples were taken at random and the sample sites were identified to prevent chance resampling. Five samples were taken from each plot for each treatment at each date. The samples were air dried to a constant weight and were then processed in a multiple rotary sieve similar to the one described by Chepil and Basil (4). The results were expressed in terms of per cent fine material less than .84 mm in diameter and subjected to statistical analysis.

The treatment means were tabulated in graphic form and any means within a sampling date, without the same letter, are significantly different at the 5 per cent level by the Duncan (6) test.

Tillage Machinery

The machines used for the various tillage operations are shown in Table 1.

The *one-way disk* was an 8-foot machine set to cut at a wide disk angle for all field work in accordance with the suggestions of Thompson and Kemp (16). The machine was equipped with 24-inch diameter disks having a 3½-inch concavity and spaced at 8-inch intervals.

The *heavy-duty cultivator* was a 10-foot machine equipped with high lift, 16-inch shovels arranged in three gangs for an effective spacing of 12 inches between the shovels and a spacing of 30 inches between each gang.

TABLE 1

TILLAGE TREATMENT NUMBERS, TILLAGE MACHINES FOR PRIMARY AND SECONDARY TILLAGE OPERATIONS AND TREATMENT DESIGNATION

Treatment Number	Primary Tillage	Second and Third Tillage	Treatment Designation
1	one-way disk	disk	disk
2	one-way disk	heavy duty cultivator	disk-cultivate
3	blade cultivator	blade cultivator	blade
4	plow	heavy cultivator and rodweeder	plow, cultivate and rodweed

The *blade cultivator* was equipped with a single standard that carried an 8-foot, 67½ degree Vee blade with a 4-inch lift.

The *plow* was a tractor-mounted 2-bottom reversible plow equipped with a slow turn moulboard and 14-inch shares.

The *cultivator* and *rodweeder* combination was a standard 10-foot heavy duty cultivator equipped with high lift, 16-inch shovels on the first two gangs and 2-inch chisel points on the rear gang. A ground driven rodweeder attachment (square shaft type) was mounted directly behind the 2-inch chisel points. While the chisel points cut slightly deeper than the cultivator shovels the rodweeder rod operated at approximately the same depth as the cultivator shovels.

A *one-way flexible disk harrow* (disker) was used for the preseeding tillage operation. A *double disk press drill* was used for seeding the grain.

All tillage operations were conducted at a speed between 3and 4 miles per hour and at a depth of 3 to 4 inches. Moisture samples were taken with a sampling tube at the 0- to 3-inch and 3- to 6-inch depth prior to each tillage operation from 1959 on.

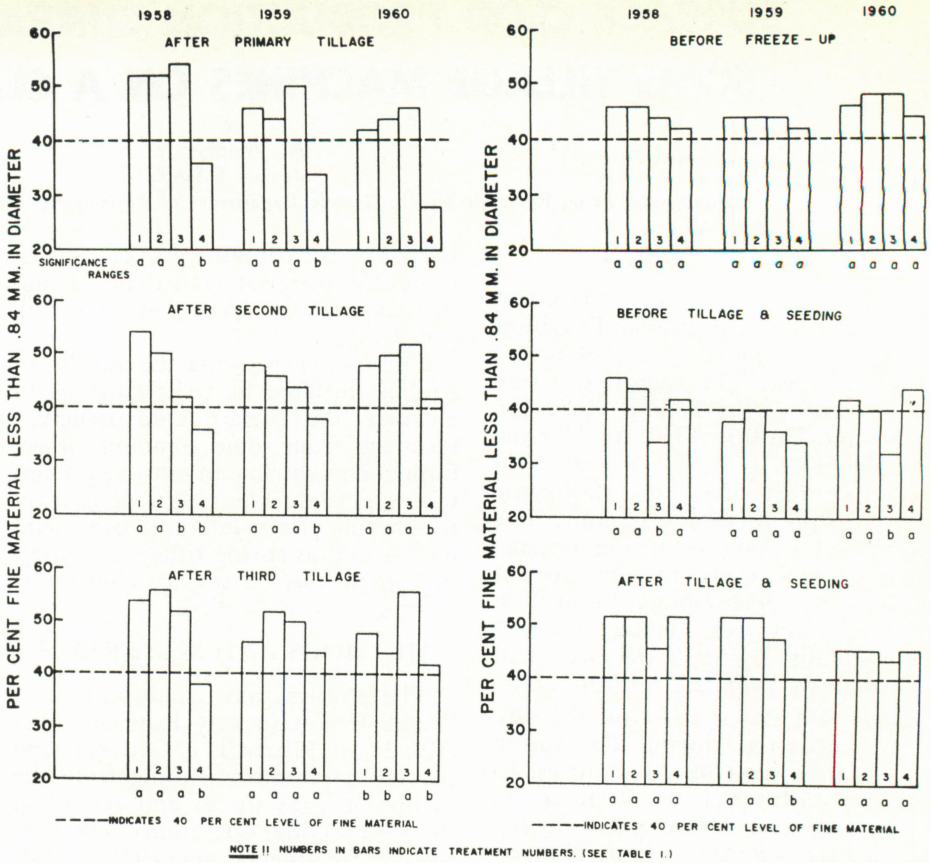

Figure 1. The per cent fine material at 6 sampling dates for a 3-year period.

RESULTS AND DISCUSSION

The dates of tillage operations and soil moisture conditions in the tillage profile are given in Table 2. The data in Table 2 show that only three tillage operations per year were considered necessary for adequate weed control during the period for which this study was underway. The soil moisture conditions at the time of tillage were well above the wilting point.

Effect of Tillage Operations During Summerfallowing on Surface Clod Structure

Primary Tillage — The results in Fig. 1 show that the surface clod structure produced by the plow yielded significantly less fine material than did the one-way disk or the blade treatments. These data are similar to those of Lyles and Woodruff (10).

Second Tillage — The data in Fig. 1 shows that in 1958 the blade treatment and the plow, cultivator and rodweed treatment produced significantly less fine material than either the disk treatment or the disk-cultivate treatment. In 1959 and 1960 the plow, cultivate and rodwood treatment produced significantly less fine material, than did the disk, the disk-culivate, or the blade treatments.

Third and Final Tillage — The data show that in 1958 the plow, cultivate and rodweed treatment produced significantly less fine material than did the disk, the disk-cultivate, or the blade treatment. The 1959 data for this operation show that there was no significant difference due to any one treatment. The measurable effect of the initial tillage disappeared after further tillage operations and weathering. The 1960 data for this operation show that the disk, the disk-cultivate, and the plow, cultivate rodweed treatment produced significantly less fine material than did the blade treatment.

TABLE 2
CALENDAR AND DATE OF TILLAGE OPERATIONS AND SOIL MOISTURE CONDITIONS

Calendar of Tillage Operations	Tillage Operations Date of	Per cent of Water* in soil at depth of 0-3 in.	3-6 in.
1958			
Primary Tillage	June 6, 1958	—	—
Second Tillage	July 14, 1958	—	—
Third Tillage (final)	Aug. 5, 1958	—	—
Tillage Prior to Seeding	May 15, 1959	—	—
1959			
Primary Tillage	June 1, 1959	14.2	17.6
Second Tillage	July 13, 1959	14.1	21.3
Third Tillage (final)	Aug. 8, 1959	13.7	20.0
Tillage Prior to Seeding	May 11, 1960	14.9	19.4
1960			
Primary Tillage	May 30, 1960	18.6	19.6
Second Tillage	July 12, 1960	17.1	20.7
Third Tillage (final)	Aug. 16, 1960	18.5	17.3
Tillage Prior to Seeding	May 16, 1961	15.4	19.5

* field capacity—21.0 per cent wilting point—10.0 per cent

Effect of Weathering On Surface Sod Structure

Prior to Freeze-up – The data in Fig. 1 show there were no significant difference between tillage treatments the soil at this sampling period.

Overwinter Just Prior to Preseeding Tillage – The data in Fig. 1 show no breakdown of the surface clod structure for any one treatment in any of the three years during which this study was carried out. On the contrary, the surface clod structure on the blade cultivate treatment yielded significantly less fine material than did the remaining treatments under study in 1959 and 1961. This indicates some consolidation had occurred.

Effect of Preseeding Tillage and Seeding on Surface Clod Structure

Immediately After Tillage and Seeding – The results in Fig. 1 show that there was a considerable increase in the per cent fine material for all treatments in all years. However, in 1960 the surface clod structure on the plots receiving the plow, cultivate and rodweed treatment during the summerfallow period had significantly less fine material.

General – The data from the primary tillage operations were consistent for the three consecutive years of the study. Subsequent tilage and weathering and preseeding tilage and seeding operations destroyed any difference in the effects of the primary tillage operations.

SUMMARY AND CONCLUSIONS

The surface clod structure production characteristics of some tillage machinery, as used in a series of summerfallowing operations on a clay-loam soil, have been measured. The effects of weathering and the influence of preseeding tillage and seeding operations have also been measured.

The plow produced more clods and less fine material than did the disk or the blade cultivator during the primary tillage operations. Subsequent tillage operations removed the differences produced by the primary tillage. There was no consistent evidence of breakdown of the surface clod structure from fall to spring. On the contrary, there was evidence of some consolidation. The preseeding tillage and seeding operations resulted in a breakdown of the surface clod structure, regardless of previous treatments. There was no evidence of wind erosion on the plots involved in this study.

REFERENCES

1. Anderson, D. T. Surface Trash Conservation with Tillage Machines. Can. J. Soil Sci. 41: 99-114. 1961.

2. Annual Report, Soil Research Laboratory, Experimental Farm, Swift Current, Saskatchewan.

3. Chepil, W. S. Soil Conditions that Influence Wind Erosion. U.S.D.A. Tech. Bull., 1185. 1958.

4. Chepil, W. S., and F. Bisal. A Rotary Sieve Method for Determining the Size Dstribution of Soil Clods. Soil Sci. 56: 95-100. 1943.

5. Cole, J. S. and G. W. Morgan. Implements and Methods to Control Soil Blowing on Northern Montana Plains. U.S.D.A. Farmers' Bull. 1797 revised by O. R. Mathews. 1954.

7. Duncan, D. B. Multiple Range and Multiple F. Tests. Biometrics 11: 1-42. 1955.

7. Handbook of Agricultural Statistics Part I. 1908-1958. Dominion Bureau of Statistics, Agricultural Division, Crops Section. The Queen's Printer and Controller of Stationery, Ottawa, 1959.

8. Hill, K. W. Soil Drifting. Its Causes and Control. Can. Dept. Agric. Pub. 1896. Rev. 1956.

9. Krall, James L., James F. Power and Trueman W. Massee. Summerfallowing Related to Erosion and Wheat Production. Montana Agr. Expt. Stat. Bull. 540, 1958.

10. Lyles, Lon, and Woodruff, N. P. The Effect of Soil Moisture and Tillage on Soil Cloddiness for Wind Erosion Control. Presented to the A.S.A.E. Annual Meeting, Columbus, Ohio, 1960.

11. MacKay, A. Experimental Farm for Northwest Territories Report. Appendix to the report of the Minister of Agriculture. Printed by Brown Chamberlain, Printer to the Queen's Most Excellent Majesty. 1890.

12. Mitchell, J., H. C. Moss and J. S. Clayton. Soil Survey Report No. 12. Univ. Sask. 1944.

13. Palmer, A. E. Cultural Practices for the Control of Wind Erosion of the Soils in Western Canada. Empire J. Expt. Agr. 13: 125-134. 1945.

14. Power, J. F., T. S. Aasheim and G. P. Hartman. Spring Wheat Production and Soil and Water Conservation as Influenced by Methods of Summerfallowing on a Chestnut Soil in Northeastern Montana. Soil Sci. Soc. Amer. Proc. 22: 460-463. 1958.

15. Siddoway, F. H., H. C. MacKay and K. H. Klages. Dryland Tillage Methods and Implements. Idaho Agr. Expt. Sta. Bull. 252. 1956.

16. Thompson, J. L. and J. G. Kemp. Analyzing Disc Cuts Graphically. Ag. Eng. 39: 5. 285-287. 1958.

17. Woodruff, N. P., and W. S. Chepil. Implements for Wind Erosion Control. Ag. Eng. 37: 751-754 and 758. 1956.

18. Woodruff, N. P., and W. S. Chepil. Influence of One-Way Disc and Sub-surface Sweep Tillage on Factors Affecting Wind Erosion. Trans. of A.S.A.E. Vol. 1: 81-85. 1958.

Continued from page 32

hitch points for improved performance of the O.W.D.H.

The ability of an O.W.D.H. to till hard dense soils may be increased without increasing the operating expenses unnecessarily by close coupling of the tractor to the implement and providing a hitch point to the left of centre and as low as possible.

The stability of an O.W.D.H. may be increased by obtaining a greater change in the lead of the rear furrow wheel for a given change in the disk angle.

REFERENCES

1. Bainer, R., Kepner, R. A. and Barger, E. L. Principles of Farm Machinery. Wiley & Sons, New York. 1955.

2. Clyde, A. W. Measurements of Forces on Soil Tillage Tools, Ag. Eng., Jan., 1936.

3. Grunlagenforschung d. Landtechnishe, Sept., 1957.

4. Kremer, H. and Sohne, W., Ability of Rigid Non-Driven Wheels to Absorb Lateral Forces, Ag. Eng. Inst., Volkenrode, Germany.