SOME FARM MACHINERY REQUIREMENTS FOR THE PALLISER TRIANGLE

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Captain John Pallister completed his reconnaissance survey of the Canadian prairies in 1859. Among the many factors discussed in his report (17) was the existence of a "region of arid plains, devoid of timber or pasture of good quality". This region extended northward from United States territory "forming a triangle having for its base the 49th parallel from longitude 100° to 114°W., with its apex reaching to the 52nd parallel of latitude." The report outlined the agricultural hazards of the area including late and early frosts, storms, grasshoppers, and drought. History has basically justified some of his observations. Periodic prolonged drought, frequent temporary drought, insect pests, and strong erosive winds form the background to agriculture in the area. The "Palliser Triangle" includes, for the purpose of this discussion, the Brown and Dark Brown soil zones of the Prairie Provinces. Moisture conservation and erosion control will be reviewed in relation to the use of tillage and seeding equipment to indicate the need for some functional improvements in the machines.

MOISTURE CONSERVATION

The introduction of the ancient practice of summer fallowing by Angus McKay (20) at Indian Head in 1889 was a first major step toward successful cereal crop producton on the prairies. Janzen *et al.* (9) reported that in southwestern Saskatchewan the average moisture conserved for the first 9 months of a 21-month fallow period, beginning in August, was 33 per cent of the precipitation received and for the last 12 months only 14 per cent. Studies (7, 9) have shown that cultivation of fallow by May 15 or earlier to control weeds can provide better moisture storage and yield than delayed cultivation.

Staple *et al.* (18) found that stubble land conserved 37 per cent and fallow land only 9 per cent of the over-winter snowfall. The difference was partially attributed to the wind blowing snow from fallow fields while upright stubble acted as a trapping agent. Weed control and snow trapping were found to be factors in reported yield grains from after-harvest cultivation of stubble land in preparation for spring seeding at Lethbridge (5). McCalla and Army (12) indicated that moisture conservation by stubble-mulch fallowing in semi-arid areas has not generally increased over that with bare fallow. However, under some conditions stubble mulching did store more moisture than ploughing. Experience in Western Canada (7, 16) has generally been that different cultural treatments have had only a small effect on the amount of moisture conserved in fallow provided that weed growth was controlled to the same extent.

It is apparent that improvements in weed control, particularly during the early spring, would be helpful in drought seasons. Cultural practices generally leave stubble and trash flattened or non-existent at the end of the tillage season. Practices or procedures that would increase the snow-trapping capacity of a fallow field by reorientating the trash to an upright or semi-upright position could lead to substantial improvement in dry years.

SOIL EROSION

Tillage and seeding equipment directly influence the three main factors that govern the wind erodibility of a dry field surface. These factors are the quantity and orientation of surface trash cover, the cloddiness of the soil surface, and the roughness of the surface. An exponential relationship (3) has been shown to exist between these factors and the amount of soil that erodes from a field. Generally, erosion resistance increases with heavier trash cover, greater cloddiness, and/or a rougher surface.

Chepil *et al.* (4) have suggested that reasonable protection against erosion by wind is obtained on most soils that are in an erodible condition if 1,500 pounds of flattened wheat stubble are present. Clay soils may require a slightly larger quantity while sandy soils may require as much as 3,500 pounds. Smaller quantities will provide an equal degree of protection if oriented in an erect or semi-erect position rather than flattened (16). Generally, from 60 to 100 pounds of wheat straw and stubble are produced with each bushel of wheat. A 20-bushel crop produces an original cover of 1,200 to 2,000 pounds. It is apparent that careful trash-conserving tillage must be used if the suggested safe levels are to be attained.

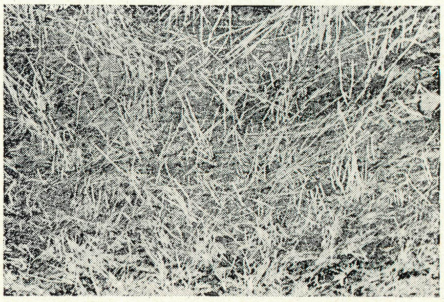

Figure 1. This type of trash cover (about 1,800 pounds per acre) is obtainable only by careful choice and use of tillage equipment.

The relationship between the relative proportions of clods of different sizes and the stability of a soil against an erosive wind has been well documented (16). Generally, there is a wind erosion hazard when a bare surface contains 60 per cent or more fine material (less than 0.84 m.m. in diameter). Differences exist between various primary tillage implements with respect to clod production (7, 11, 20, 21). Subsequent tillage, the occurrence of rain, and over-winter weathering effects also influence the clod structure (6, 11, 20). These effects are equally as important as primary tillage in determining erodibility over a period of time. Clod protection against wind action is transitory and so other agencies such as trash cover and a rough surface must also be utilized for long-time erosion resistance.

TILLAGE EQUIPMENT

Weed control is an essential element of summer fallow and seedbed tillage. Disk machines of the one-way type provide a satisfactory degree of weed control under most conditions if they are set to cut weeds completely. The control of well - established fibrous-rooted weeds with the heavy-duty cultivator or the wide-blade cultivator is difficult in moist soil. When the plants are undercut with sweeps

TABLE I

RESIDUE REDUCTION WITH TILLAGE EQUIPMENT

Type of equipment	Expected reduction in each tillage operation %	Range of reduction values reported %
Subsurface cultivators:		
Blade machines (sweeps 36" or wider)	10	−13 to 30
Sweep machines (sweeps 24" to 32")	10	−12 to 40
Rod weeder	10	−15 to 20
Rod weeder with semi-chisels	15	−5 to 45
Mixing implements:		
Blade pulling a treader	25	—*
H.D. cult. (sweeps 16" to 18") with attached rod weeder	15	−12 to 30
H.D. cult. (sweeps 16" to 18")	20	0 to 50
H.D. cult. with chisels 12" apart	25	—*
One-way disk (pans 24" to 26")	50	10 to 70
One-way disk (pans 18" to 22")	45	10 to 60
Tandem disk, offset disk	50	—*

*Insufficient data to establish a range.

TABLE II

WHEAT RESIDUE CONSERVATION MEASURED AFTER FALLOWING AND AFTER SEEDING[1]

Original cover	After fallowing: No. of operations[2]	After fallowing: retained %	After seeding: Seedbed tillage[2]	After seeding: retained %	Final cover
lb./A					lb./A
2,000	3 - O.W.	15	T.D., D.	6	120
3,200	3 - O.W.	8	Bl., R.W., D.	4	120
2,000	3 - Bl.	85	O.W., R.W., D.	20	400
3,200	4 - Bl.	62	Bl., R.W., D.	34	1,100

[1]Data from : Anderson (unpublished) Woodruff and Chepil (21).

[2]O.W. = one-way disk, Bl. = wide-blade cultivator, D. = drill, R.W. = rod weeder, T.D. = tandem disk.

or shovels, roots re-establish easily and tend to grow laterally. This is particularly evident if cool, showery weather is experienced subsequent to tillage. A second operation within a short time of the first may be required to effect reasonable weed control.

The use of the rod weeder attachment on the heavy-duty cultivator results in improved weed control but at the expense of some increase in power requirements (14). Paterson (13) reported that the use of rod attachments on the wide-blade cultivator increased weed control to a degree about equivalent to that obtained by an increase in speed from $3\frac{1}{2}$ to $4\frac{1}{2}$ miles per hour. Chase (2) concluded that rods and other attachments to the sweep cultivator had no major benefit in weed control. Thus, weed control with the sub-surface cultivator requires improvement.

Residue Management

Trash reduction by various tillage machines has been reported (1, 8, 12, 21). These data are accumulated in table I to show the expected reduction with each operation and the range of values reported. Negative values indicate that buried trash may be brought to the surface. This is most apparent when a considerable quantity of trash has been buried by a mixing implement such as the one-way disk or the heavy-duty cultivator.

Factors such as speed and depth of operation, stubble height and orientation, and the degree of soil pulverization produced during tillage influence trash conservation, particularly with the disk machine and the heavy-duty cultivator.

Residue is normally left in a flattened condition by most machines at the end of a fallow season. Treaders and stubble punchers offer one possible means of reorientating stubble residue. Thus, the efficiency of these machines for this purpose requires evaluation.

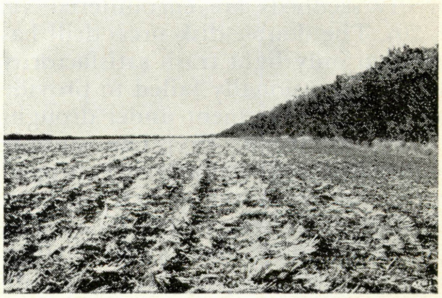

Figure 2. Heavy trash cover oriented in a partially upright position and well-managed, mature shelterbeds provide maximum erosion protection for this field near Conquest, Sask.

Trash conservation as measured over the total fallow and seeding period is illustrated in table II. The data in this table indicate that, where good trash protection is required on the seedbed, careful selection of machines for seedbed preparation is required. The disk machine of the one-way type and, to a lesser extent, the heavy-duty cultivator must be used with caution for summer fallowing and for seedbed preparation. Since the preparation of stubble land for seeding involves one or possibly two operations, a greater freedom of choice exists and mixing implements can be used to maintain erosion protection.

Surface Clods

Clod production by tillage equipment is influenced by type of machine, soil moisture, soil density, speed of operation, and soil type (10, 11, 20, 21). Generally, the mouldboard plough produces a greater number of erosion-resistant clods than either the one-way disk of the subsurface cultivator. However, the mouldboard plough is used to only a limited extent in prairie areas. The wide-blade cultivator produces a greater number of clods that the one-way disk when these machines are used in a dry soil. Tillage is normally carried out in a soil of intermediate moisture content. Under these conditions the relative effect of the two machines is reversed. The influence of subsequent tillage and weathering effects can soon obliterate the differences in clod production by the various machines used for primary tillage of fallow land (11, 20). These differences are important if erosion protection is desired when preparing a seedbed or when preventive tillage is required during the fall, winter, or early spring (7).

SEEDING EQUIPMENT

A wide variety of seeders have been made available for use in trash cover farming. The wide-spaced deep-furrow drill is most suited to seeding winter wheat, particularly when heavy trash or dry seedbeds are encountered (5, 8, 20). The double-disk press drill has handled only light trash satisfactorily and has occasionally failed to provide proper seed placement under drought conditions (6, 8, 15). The stubble mulch drill, particularly if equipped with a hoe or shovel opener, has been satisfactory in heavy trash (6, 8). The tillage action of the openers, when used on seedbeds prepared by a subsurface cultivator, has provided a total degree of weed control equivalent to that obtained with the one-way-disk-type seeder. Also, the semi-deep-furrow seeding principle utilized by some units has provided good seed placement under fairly dry seedbed conditions. Temporary drought conditions are not infrequent in semi-arid areas. Research experience (6, 7, 19) has shown that the one-way-disk-type seeder will give yield results equal to those from other methods. Excessive trash reduction is a limiting factor when used for seeding fallow land. Where trash is non-existent the clod-producing capacity of the one-way disk seeder is a useful feature from the standpoint of erosion control.

There is a paucity of research information with respect to stubble reduction by mulch-hoe drills. The possibilty that improved-hoe or shovel openers offer a means of orientating trash and clods to provide maximum erosion resistance requires intensive investigation.

SUMMARY

This review indicates that some changes in seeding and tillage equipment could result in a definite improvement in farming practices in semi-arid areas.

The weed control capability of the wide-blade cultivator and, to a lesser extent, the heavy-duty cultivator requires improvement so that maximum moisture conservation may be obtained from effective early tillage during the spring.

Some method must be found to provide better snow-trapping action by trash cover on fallow fields. The reorientation of trash into an upright position by tillage, particularly toward the end of the season, is a possibility. Improved erosion resistance will likely be a second benefit.

The mulch-hoe drill has found a definite place in the trash-cover farming technique in use on the prairies. Clod and trash placement into the ridge between the rows by the furrow openers requires study to improve the erosion resistance of the seeded field.

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