CONSERVING CROP RESIDUE FOR EROSION PROTECTION ON SUMMERFALLOW

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Abstract

Conserving crop residues on the soil surface has proven to be one of the most effective means of controlling wind erosion on summmerfallow. Tillage practices are constantly changing and some recent trends have given rise to concern over their effect on wind erosion; namely the widespread use of mounted harrows on cultivators and use of higher tillage speeds. Results of these studies suggest that both practices decrease residue conservation on summerfallow. Use of mounted harrows decreased residue conservation by approximately 50% compared with cultivators alone. Similarly, increasing tillage speeds from 5 to 10 to 15 km/h decreased residue conservation to approximately 50 and 30 percent resp. of that conserved at 5 km/h. Depth of tillage had little effect on residue conservation after 2 operations but deeper tillage significantly reduced residues in subsequent operations. Where herbicides were substituted for tillage operations, both total and anchored residues increased as the number of tillage operations replaced was decreased. These results indicate that elimination of mounted harrows would have a very substantial impact on wind erosion. Where weed control needs to be enhanced, occasional use of trailed rod weeder attachments would be preferred. Reducing tillage speeds and minimizing depths of operation would also be beneficial. Where initial residue levels are low, substituting herbicides for some or all tillage operations will likely be required to provide adequate protection.

Introduction

Controlling wind erosion is based on the principle of reducing windspeeds at the soil surface to a threshold value below which no erosion will occur (Chepil and Woodruff,1963). The value of crop residues in reducing wind erosion in this way has been evaluated by a number of workers (Anderson,1968; Bisal,1968; McCalla and Army, 1961). In fact conservation of an adequate residue cover has been shown to be one of the most effective means of preventing wind erosion.

The effect of tillage equipment on losses of residue cover from the soil surface has also been extensively studied. Wide blade type equipment and rod weeders have been shown to be quite effective for residue conservation while disc type implements were much less effective and cultivators were intermediate (Anderson,1961,1968; Allen and Fenster,1986). Soil conditions and the way that equipment was used, also influenced residue conservation.

Tillage practices are constantly evolving in response to development of equipment and changing production conditions. At the time of settlement of the prairies the plow was used most commonly but was later replaced by disc and more recently sweep type cultivators. Currently the trend is to use mounted harrows on cultivators and to use higher tillage speeds. These 2 trends have given rise to concerns that they may be contributing to increased wind erosion.

These studies were undertaken to evaluate these and other factors affecting residue conservation with heavy duty and field cultivators and to evaluate the effectiveness of

various herbicide treatments to replace tillage and conserve crop residues.

Materials and Methods

The studies were conducted on cereal crop stubble. The preceding cereal crop was harvested with a combine harvester equipped with straw spreaders that distributed the residues uniformly on the field. Initial (pre-tillage) crop residue levels were approximately 3.5 and 4.0 tonnes/ha in 1985 and 1986 respectively. Crop residue measurements were made using the method described by Anderson (1961) on several one meter square areas in each plot. Residue sampling was done prior to application of tillage treatments and following specified numbers of operations. Residue conservation was expressed as percentage of initial residues remaining.
Equipment studies were conducted on barley stubble in 1985 and 1986 using two cultivators, a heavy duty cultivator (H.D. cult) and a field cultivator (F.cult.) The H.D. cult. was suited for use in primary and secondary tillage and was equipped with 41 cm wide sweeps on 30 cm centres. This machine was used either alone; with mounted tine harrows (MTH) (4 rows of 9.5 mm dia. tines); or with a trailed rod weeder (TRW) attachment (32 mm rod) linked to each of the rear cultivator shanks. The F. cult. was equipped with 28 cm sweeps on 20 cm centres and was also operated alone or with mounted tine harrows (4 rows of 8 mm dia. tines). This cultivator was best suited for secondary tillage but could be used for light primary tillage.
Tillage operations were performed at speeds of 6-8 km/h. The H.D. cult. was operated at a depth of approximately 10 cm for the first operation and 7.5 cm for subsequent operations. Corresponding depths for the F. cult. were 7.5 cm for the first operation and 5-6 cm for subsequent operations. Treatments were applied to strips approximately 8 m wide and 35 m long. Ten residue samples per tillage treatment were taken prior to tillage (May) after 2 operations (July) and after 4 operations (Oct).
In 1985, a tillage speeds study was conducted with a F. cult. without mounted harrows. A 4 replicate split plot RCBD with numbers of operations as main plots and speeds as sub plots was used. Residue sampling (5/plot) was done prior to application of treatments (May) and again at the end of the season (October). Where fewer than 4 tillage operations were performed, glyphosate was used for weed control in place of the second and third tillage operations.
In 1986 a tillage depths study was conducted with the F. cult. using a 4 replicate RCBD. Residue sampling (5/plot) was done prior to treatment application (May) after 2 , 3 and 4 operations in July, August and October respectively.
From 1986 to 1990, a study was conducted to evaluate the influence of various combinations of tillage and herbicides used for weed control on summerfallow on residue conservation. The studies were conducted on barley stubble in 1986 and on wheat stubble from 1987-90 in a 4 replicate RCBD with a plot size of 2 m by 5 m. The treatments consisted of;

1. Tillage as required, (fall tillage plus 4-5 operations depending on weed growth)
2. 2,4-D in fall, Heritage applied and incorporated in June, tillage as required.
3. 2,4-D, tillage once, Rustler as required (3-4 times/year).
4. Glean in fall, Roundup as required (3-4 times/year).

Fall tillage was done with a heavy duty cultivator and all subsequent tillage operations

were done with a field cultivator equipped with tine harrows operating at speeds of 6-8 km/h and depths of 7 to 8 cm.
Surface residues were measured in fall at the end of the fallow period.

RESULTS AND DISCUSSION

I. Equipment studies
In primary tillage (first operation on stubble) the heavy duty (HD) cultivator cleared residues well. However, where the trailed rod weeder (TRW) attachment was used on this machine, the rod required 6 to 15 metres to penetrate the soil, causing residues to pile up. In subsequent operations the rod penetrated well. In primary tillage and the first subsequent operation, residues tended to accumulate on the shanks of the field cultivator but did not cause plugging. At times the mounted harrows tended to bunch residues into small piles, at other times they spread bunched residues or had little effect on residue distribution.
The field cultivator alone was the most effective for conserving residues (Table 1) after 2 and 4 operations although not significantly more effective than the HD cultivator alone or with the TRW attachment after 4 operations. The HD cultivator equipped with a TRW attachment conserved more residues than the HD cultivator alone after 2 operations but not after 4. The most significant effect on residue conservation was shown where mounted harrows were used on either machine. The heavier type of harrows used on the HD cultivator were more destructive of residues than those on the field cultivator. There are a variety of types of mounted harrows available and it is likely that crop residue conservation could be affected by numbers of tines per unit area, the type or size of tines as well as settings used to provide more or less aggressive action.

Table 1. Conservation of Crop Residues on Summerfallow: Effect of Tillage Equipment after 2 or 4 Operations (1985-86 average).

tillage equipment	% of original residues conserved after 2 operations	4 operations
heavy duty cultivator		
- alone	63.7	32.5
- with trailed rod	70.7	34.0
- with mounted harrows	26.3	11.2
field cultivator		
- alone	79.0	37.9
- with mounted harrows	44.5	19.7
LSD (P= 0.05)	6.8	7.5

During the course of these studies, it was observed that there were differences in how some of these attachments affected weeds and the cloddiness of the soil surface

(Figure 1). The mounted harrows tended to shatter soil clods exposing roots of weeds associated with the clods. This tended to leave a powdery surface. By contrast, the trailed rod inverted weeds exposing their roots to drying. This tended to bring soil clods to the surface while allowing smaller particles to drop between the clods.
All machines did an adequate job of controlling weeds, although the mounted harrows and trailed rod appeared to improve weed kill on some occasions. The only very noticeable difference was that considerably more volunteer barley germinated where the rod was used than for other treatments. This may have been due to packing action by the rod.
In a conventional tillage summerfallow system using HD and field cultivators it would be preferable to use the HD cultivator alone for primary tillage because of its ability to penetrate harder soils and handle higher levels of residues. The field cultivator may work for primary tillage, where residue levels are moderate to low and where the surface soil is relatively soft, but in most cases is best adapted for secondary tillage. Trailed rod weeder attachments appear to be adapted for occasional use to enhance weed kill under less than ideal conditions or to level the soil surface. Repeat operations with the TRW left residues poorly anchored and subject to loss. Where crop residues are heavy, mounted harrows may be useful to spread residues or enhance weed kill but not should be used under moderate or low residues conditions.

II. Speeds and depths of operations

Results of the 1985 study on tillage speeds indicated that residue conservation increased as tillage speeds decreased (table 2) and that trend occurred regardless of the number of tillage operations (no significant speed x operation number interaction). Field cultivators are normally operated at speeds of 7-10 km/h and current recommendations are to use speeds of 8-10 km/h for incorporation of some soil applied herbicides. In some cases speeds of 10-13 km/h are recommended on product labels for herbicide incorporation.
These results would suggest that tillage at 7-10 km/h would be suitable where residue levels are moderate to high. Higher tillage speeds should be avoided on summerfallow but may be helpful where stubble cropping is practiced after a high yielding crop. Where residue levels are low on summerfallow, consideration should be given to reducing speeds to 5 to 7 km/h.

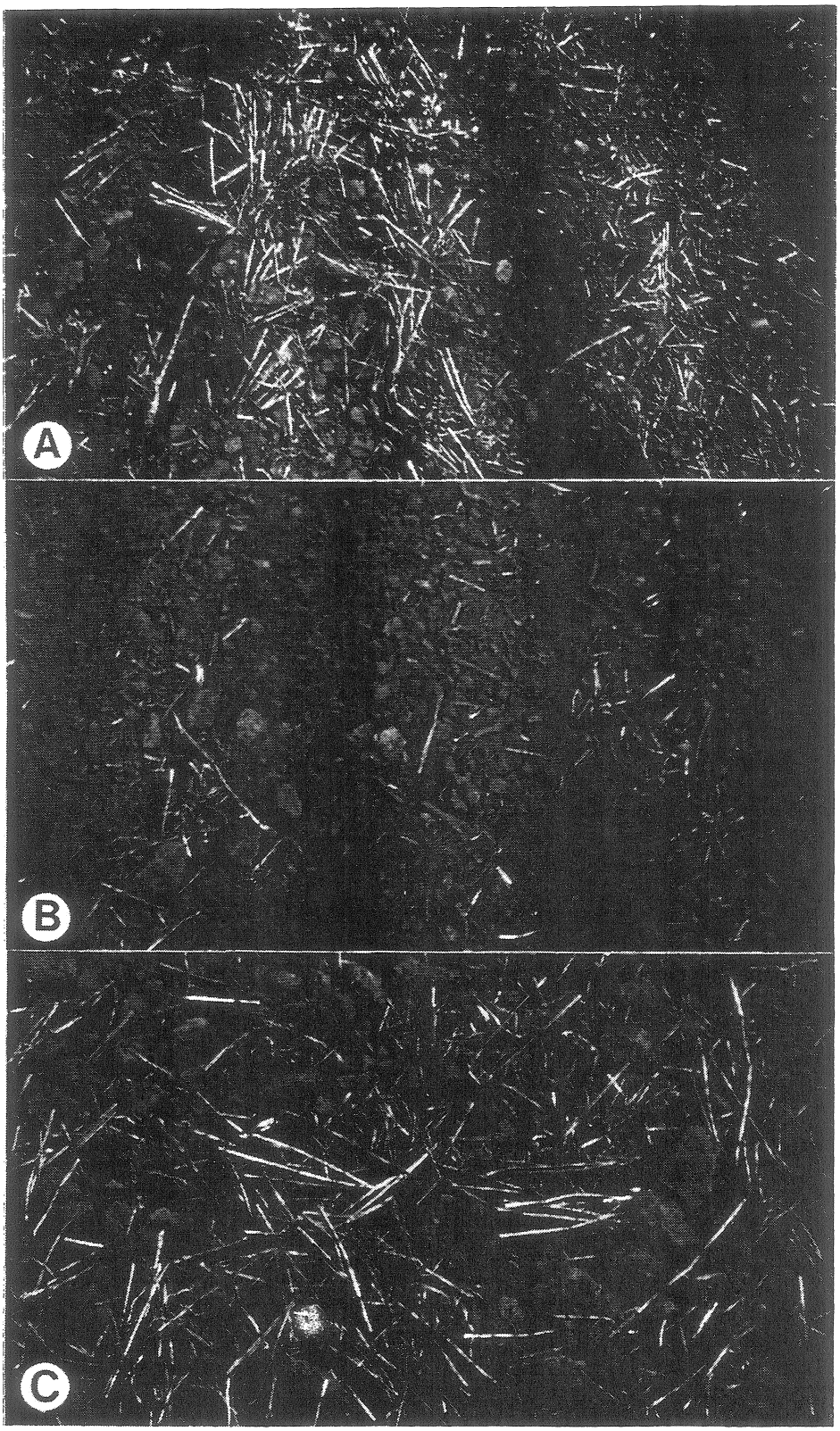

Figure 1. Appearance of the Soil Surface after three Tillage operations with: (A) a heavy duty cultivator alone; (B) a heavy duty cultivator with mounted tine harrows; (C) a heavy duty cultivator with a trailed rod weeder attachment (Aug 1985).

Table 2. Conservation of Crop Residues on Summerfallow: Effect of Tillage Speeds with a Field Cultivator after 2 to 8 Operations. 1985

	speed of operation km/h			
no. of operations	5	10	15	mean
2	57.7*	34.1	26.0	39.3
4	43.4	22.5	11.9	25.9
6	30.9	12.8	6.0	16.6
8	18.5	8.2	3.0	9.9
mean	37.6	19.4	11.7	

LSD (P=0.05) for comparing means for no. of operations = 4.5; for tillage speeds = 3.9

* residues conserved as % of original residues

In the 1986 tillage depth study, differences due to tillage depth were small after 2 operations (table 3) but became more evident after 3 or 4 operations. The results suggest that if deep (10 cm) tillage is required it should be done early in the growing season with shallower subsequent operations.

Table 3. Conservation of Crop Residues on Summerfallow: Effect of Tillage Depth with a Field Cultivator after 2 to 4 Operations, 1986.

	depth of operation (cm)	
no. of operations	5	10
2	45.5*	44.0
3	31.7	25.1
4	16.7	8.6
mean	31.3	25.9

* residues conserved as % of original residues

III. Herbicide studies:

Where tillage only was used for weed control during the summerfallow period, less residue remained on the soil surface than where herbicides were used in place of one or more tillage operations (table 4). Because of the small plot size used (2m by 5 m) significant quantities of residues were dragged from the plot area into the roadways between plots particularly with the first two tillage operations. Where 2,4-D was applied in fall and Heritage incorporated the following year, only slightly more residues were conserved than for tillage only. 2,4-D replaced fall tillage while Heritage

application usually replaced one tillage operation. Where 2,4-D and Rustler were used to replace all but one tillage operation, residue conservation was enhanced over treatments where more tillage was performed. However, even with one tillage operation the amount of residue remaining was less than 25% of original residues in most years. Residue conservation was greatest where all tillage was replaced by herbicides, but was still less than 50% of original residues. In other studies conducted under a range of soil and climatic conditions (Anderson, 1971; Fenster and Wicks, 1982; Linwall and Anderson 1981) residue conservation with chemical fallow was 62-70% of original residues. It is possible that wind losses of poorly anchored residues was higher than would be typical for a field scale due to the small plot size used in this study.

On soils of this type a residue cover of 1000 kg/ha is generally considered adequate to protect against wind erosion. In this study, tillage fallow had sufficient residue cover in 1 of 5 years while the 2,4-D fall; Heritage plus tillage fallow did not have adequate residue cover in any year. The treatment with only one tillage had adequqate cover in 2 years while chemical fallow had adequate residue cover in 4 of 5 years.

Table 4. Crop Residue(kg/ha) Conservation with Several Combinations of Tillage and Herbicides at Scott, 1986-90.

Treatment	Year					Mean
	1986	1987	1988	1989	1990	
Initial residues	4058	3025	3186	2705	3337	3262
Tillage only	1015	614	309	54	188	254
2.4-D fall: Heritage, & Tillage	890	383	207	21	219	324
2,4-D fall; 1 Tillage, Rustler	1068	1175	752	158	741	779
Glean fall; Rustler as required	2581	1611	1761	854	1784	1718

These results suggest that a significant increase in residue cover can be achieved by using residue conserving tillage practices. Such practices include reducing or eliminating use of mounted harrows on cultivators, reducing tillage speeds and minimizing depths of operation as well as reducing numbers of operations. Where initial residue levels are low, substitution of herbicides for some or all tillage operations may be required. Where combinations of tillage and herbicides are used, little improvement will be achieved unless residue conserving tillage practices are used.

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