IMPACT OF LONG-TERM SUMMERFALLOW PRACTICES IN SOUTHERN ALBERTA

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ABSTRACT

Crop rotations with a high frequency of fallow remain the dominant practice in the semiarid northern Great Plains. The use of tillage to control weeds during fallow increases soils exposure to wind erosion. A long-term summerfallow management study was initiated on a clay loam soil at Lethbridge in 1955. Between 1977 and 1991 fallow treatments of tillage alone, herbicide alone and combinations of tillage and herbicide were compared. During this most recent 15-year period, average spring wheat (Triticum Aestivum L.) and barley (Hordeum Vulgare L.) yields were similar regardless of fallow treatment, with a 3.1 bu/acre difference between highest and lowest yielding treatments for wheat, and a 4.1 bu/acre difference for barley. Summerfallow managed using summer herbicides, followed by fall blade, resulted in the highest grain and grain N yields for wheat and barley, and highest soil nitrate-N concentration. Herbicides alone maintained the highest amount of crop residue cover and plant-available water at seeding. Surface (0-4 ft) and profile (0-10 ft) nitrate-N concentrations were highest for one-way disc, 70-100% higher than the lowest treatment, herbicide alone. While the herbicide alone treatment had the highest percentage of wind erodible aggregates in the spring, its maintenance of crop residue cover provided the best protection to wind erosion. The maintenance of surface residues becomes critical to erosion protection in the absence of tillage, particularly in years of low residue cover. Producers using a cereal-fallow rotation are encouraged to consider herbicides alone or herbicide-tillage combinations for summerfallow as the best means of ensuring adequate erosion protection and optimizing grain yield potential.

INTRODUCTION

Fallow is an important component of dryland cropping systems in the semi-arid regions of the Great Plains. While fallow has been identified as a contributor to soil loss by erosion, it plays a major role in increasing soil moisture storage and minimizing the impact of drought relative to recrop fields. The risk of wind erosion during the fallow period is greatly increased if drought limits residue production from the previous crop, and/or the residues and weeds are buried by tillage in the misconception that 'black fallow' (no residues or weeds on surface) is the desired

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misconception that 'black fallow' (no residues or weeds on surface) is the desired condition. Chinook winds are inherent to erosion losses in southern Alberta. They are characterized by highly erosive winds gusting up to 75 mi/h and induce numerous freeze-thaw-wet-dry cycles during winter and spring (Larney et al., 1993). Maintaining crop residues on the soil surface is critical to minimizing the impact of Chinook conditions. Therefore, the objectives of this study were to evaluate the influence of fallow management systems on the production and quality of spring wheat and barley, and the maintenance of crop residue cover for erosion control.

MATERIALS AND METHODS

The experiment is located on a clay loam soil at the Agriculture Canada Research Station in Lethbridge, Alberta. Organic carbon concentration in the surface 6 inch soil layer is 1.9%. The mean annual precipitation at Lethbridge is 15.8 in, 52% of which is received during the May to August growing season.

In 1955, two adjacent strips of land were established in a spring wheat-fallow rotation with eight fallow management treatments, with each plot 20 by 130 ft in a six-replicate randomized complete block design. Between 1955 and 1966 all treatments involved variations of fall and spring tillage. Results from this period have been reported by Anderson (1961, 1964).

The use of herbicides, alone and in combination with tillage, was initiated in 1967. Wheat yield responses for the period 1968-76 were reported by Lindwall and Anderson (1981) and Zentner and Lindwall (1982). Chang and Lindwall (1989) reported on the 20-year (1967-86) fallow treatment effects on various soil-water related properties.

Since 1977, and for the purpose of this paper, the treatments under consideration include:

1. One-way disc
2. Herbicide alone (no-till seeded)
3. Heavy-duty cultivator
4. Wide blade cultivator
5. Herbicide during summer, fall blade

All tillage and herbicide treatments were timed for optimum weed control on fallow. Also in 1977, the experimental area was divided in half, with barley seeded on the West half of each block and spring wheat on the East side. This addition to the study resulted in each experimental unit having the dimension 20 by 65 ft. Starting in 1985, monoammonium phosphate fertilizer was applied with the seed at a rate of 30 lbs P_2O_5/acre. Recommended herbicides were used for in-crop broadleaf and grass weed control.

Soil moisture samples were collected in the spring prior to seeding from wheat plot areas in increments of 6 in., to a depth of 60 in. Moisture content was determined after oven-drying for 24 hr at 220 °F. Plant-available water at seeding was calculated as the difference between measured soil moisture content and the permanent wilting point (-15 bar moisture content) previously determined for each depth in each plot (Lindwall and Anderson, 1981). Prior to seeding anchored and loose wheat residue samples were collected from a 1 sq. yd area for determination of residue cover dry weight. Residue cover at seeding, as a percentage of original crop residue cover after harvest, was calculated as:

% original = (residue dry wt./(previous crop yield x 1.5) x 100) [Eq. 1]

Soil nutrient samples were collected in the spring prior to seeding from each plot for the depths 0-6, 6-12 and 12-24 in. This soil sample represented a composite collected from both the wheat and barley seeded areas within each plot.

RESULTS AND DISCUSSION

Grain yield variability was low between fallow treatments in average wheat and barley yields for the 15 year period from 1977 to 1991 (Table 1). Treatment 8 produced significantly ($P \leq 0.05$) higher grain and grain N yields for wheat. A review of individual years indicates that where significant ($P \leq 0.05$) differences were recorded between fallow treatments (12 of 15 years), Treatment 8 was either highest yielding or grouped with the highest yielding fallow treatments (data not shown). Treatment 2 was significantly ($P \leq 0.05$) lower yielding than the other four fallow treatments. The low wheat yields recorded with herbicides alone (Treatment 2) is contradictory to previously reported results from this study, when during the period 1968 to 1976 Treatments 2 and 8 produced similar grain yields (Lindwall and Anderson, 1981). A review of individual year results indicates that in only five of the 15 years considered did Treatment 2 yield similar to Treatment 8, while in all other years it was grouped with the lowest yielding treatments (data not shown). However, the range between highest and lowest yielding fallow treatments was only 2.8 bu/ac for wheat.

Barley yields showed a similar response to wheat, with Treatment 8 significantly ($P \leq 0.05$) out yielding all other fallow treatments with the exception of Treatment 3 (Table 1). An evaluation of the 11 individual years when a significant ($P \leq 0.05$) treatment response was recorded between fallow treatments for barley showed Treatment 8 as the highest yielding, or grouped with the highest yielding treatments (data not shown). Lowest yield with the herbicide alone treatment (#2) was recorded in seven of the 11 years when a significant ($P \leq 0.05$) difference in barley

Table 1. Wheat and barley grain yield and protein concentration, and Plant-available water at seeding.

Fallow Tmt.	Wheat		Barley		PAW†
	Grain	Protein	Grain	Protein	
	(bu/ac)	(%)	(bu/ac)	(%)	(in.)
1	29.7 b	15.7 a	56.0 bc	12.1 b	5.9
2	28.6 c	15.5 b	54.4 d	12.1 b	6.6
3	30.0 b	15.9 a	57.1 ab	12.2 ab	6.4
4	30.1 b	15.6 b	55.1 cd	11.9 c	6.2
8	31.4 a	15.9 a	58.5 a	12.3 a	6.1

†PAW = Plant-available water at seeding, the difference between measured soil moisture content and the permanent wilting point (-15 bar moisture content).

yields was observed (data not shown). All treatments yielded within 7.6% of each other, with only 4.1 bu/ac separating the highest and lowest yielding treatments.

Grain protein concentration range between fallow treatments was only 0.4% for both barley and spring wheat (Table 1). All spring wheat treatments produced grain protein concentration in excess of the 13.5% minimum required for protein premium, while barley grain protein concentration was less than the 12.5% maximum acceptable for malt production.

Plant-available water (PAW) at seeding ranged from a low of 5.9 in. for Treatment 1, to a high of 6.6 in. with Treatment 2, during the period 1984 to 1991 (Table 1). These two treatments represent the extremes in tillage intensity and crop residue conservation in this study. Increased PAW at seeding can have a positive effect on crop emergence in dry springs, and may be partially attributable to the increased residue cover maintained with the herbicide only fallow treatment (Table 2). Treatment 2 had higher total residue cover at seeding than Treatment 1. However, the increased soil moisture at seeding with Treatment 2 did not translate into increased yields for either wheat or barley, indicating adequate PAW regardless of fallow treatments. While these PAW values are slightly higher than those previously reported during the 1968 to 1976 period for this study (Lindwall and Anderson, 1981), treatment differences followed an almost identical ranking.

Crop residue in the spring prior to seeding was highest for the herbicide alone treatment, while one-way disk retained the lowest amount (Table 2). For total surface residue prior to spring seeding, fallow treatments were ranked: herbicides only > herbicides + fall blade > blade > heavy-duty cultivator > one-way disk (Table 2). Fallow treatments using a one-way disk or heavy-duty cultivator did not maintain adequate residue cover for erosion protection in this study, using the critical level of 750 lb/ac (McCalla and Army, 1961). The aggressive mixing of soil and residues associated with disk and cultivator operation increase straw burial and the potential for soil erosion by wind. The only difference between Treatments 2 and 8 was that Treatment 8 received one pass of a blade cultivator while Treatment 2 received none.

Table 2. Tillage treatments, crop residue cover and profile nitrate-N.

Fallow Tmt.	Tillage operations	Residue cover	% original	Nitrate-N 0-4 ft	Nitrate-N 0-10ft
		(lb/acre)		(lb/acre)	(lb/acre)
1	2	364	17	59	292
2	0	1352	62	28	174
3	3	597	24	43	207
4	3	1048	44	35	210
8	1	1114	46	50	269

Profile nitrate-N was lowest with the herbicide only treatment, highest with the one-way disc (Table 2). The amount of nitrate-N present in the crop rooting profile ranged from 16% (Tmt. 2 & 4) to 21% (Tmt. 3) of total nitrate-N for the profile. Treatments with high nitrate-N levels in the profile showed high nitrate-N concentrations at all of the individual 10 depths measured.

Wind erodible aggregates (WEA) were found to display a negative relationship with tillage intensity, with the percentage WEA increasing with a decrease in tillage intensity (Table 3). Using the critical WEA or 60% for the onset of wind erosion (Anderson and Wenhardt, 1966), the wide blade cultivator, herbicide only and combined herbicide + fall blade treatments are at high risk to

Table 3. Wind erodible aggregates (WEA) in fall and spring, and wind velocities required to initiate wind erosion (combination of wind erodible aggregates and residue cover).

Fallow Tmt.	Fall WEA	Spring WEA	Initiation velocity
	(%)	(%)	(m/sec)
1	39.4	57.5	12.1
2	52.2	63.6	13.8
3	43.2	57.1	13.1
4	47.5	61.4	13.0
8	50.3	63.5	12.9

wind erosion, particularly if drought limits surface residue cover. However, these same three treatments had the highest level of crop residue cover at seeding. This residue cover is critical in increasing the wind speed required to initiate soil erosion. While the percentage WEA was low for the one-way disc in the spring, the low level of residue cover incresaed its susceptability to low wind velocities to initiate wind erosion. These results indicate the critical role of crop residue cover for erosion protection, and increase the importance of summerfallow management practices which maintain residue cover.

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