THE EFFECT OF FALL STUBBLE MANAGEMENT ON OVER-WINTER RECHARGE AND GRAIN YIELD

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INTRODUCTION

Water is the single most important factor governing crop production in the prairie provinces. Previous studies indicate that 1 cm of available water increases grain yield of wheat by 70-120 kg ha^{-1} (Staple and Lehane, 1954a, b; de Jong and Rennie, 1967). There is also a strong interaction between amount of available water and response to applied fertilizer (Viets, 1962; de Jong and Rennie, 1967; Power, 1983).

Manipulation of the snow cover by fall stubble management offers the greatest potential for increasing the available water on the Canadian prairies (de Jong and Stepphun, 1983). A review of the methods and previous studies on stubble management for snow catch has been given by de Jong and Steppuhn (1983).

In the fall of 1981, the Innovative Acres Project was initiated by the Department of Soil Science, University of Saskatchewan, as part of the Government of Saskatchewan's FarmLab Program. The objective of the Program was to develop a management package to maximize productivity and at the same time maintain high soil quality through water efficient farming practices. A major component of the package was fall stubble management to maximize snow water capture. The purpose of this paper is to summarize the information collected on the effects of fall stubble management on snow water recharge. The effects of management will be assessed with respect to slope position (upper, middle, lower) and an indication of the subsequent affects on grain yield will be given.

METHODS

A description of the FarmLab cooperator sites has been given by Rennie et al. (1984). Each of the sites has two adjacent (40 acres) fields, one with additional fall stubble management for snow capture. Within each field, 12 permanent benchmark sites (4 upper, 4 middle, 4 lower) were established on a transect. At each of the benchmark sites neutron moisture casings were installed to a depth of 130 cm. Soil water content was measured in 20 cm layers starting at 10 cm depth using a neutron moisture probe. Surface (0-10 cm) soil water was determined gravimetrically and combined with bulk density values obtained from cores taken at the benchmark sites. Soil water measurements were taken in the spring (seeding), harvest, and late fall at all sites. Over-winter soil water recharge is taken as the difference in soil water storage (130 cm depth) between the fall and spring readings.

In 1982-83 and 1983-84 approximately 30 paired fields were monitored for a total of 1440 individual slope positions. Four fall managements were monitored: (1) standing stubble, (2) standing stubble with additional snow strips, (3) fall cultivated stubble, and (4) fallow (cultivated during fallow year). The extra snow strips were obtained using a simple swather attachment developed at the Agriculture Canada Research Station in Swift Current. The attachment leaves strips of taller stubble but harvests the heads of the grain.

RESULTS AND DISCUSSION

A summary of the average over-winter soil water recharge for different managements for the 1982-83 and 1983-84 winters are given in Tables 1 and 2, respectively. Significant differences in over-winter recharge occur at different slope positions with 2 to 4 cm more soil water recharge occurring on the lower slopes compared to upper slopes. During a year of good snow fall (1982-83) additional strips on stubble increased recharge gains on lower compared to upper slopes. In most cases there was a general increase in recharge downslope. The additional 2 to 4 cm of soil water recharge in the lower slopes is probably an underestimation of the actual recharge in lower slopes since areas of very high snow catch or runoff accumulation would be subject to temporary flooding in the spring, making accurate measurement impossible due to excessive leaching and evaporation. The affects of an additional 2 to 4 cm of available water on subsequent fertilizer response has been discussed by Kachanoski et al. (1985).

A summary of the paired field comparisons of different fall managements on over-winter soil water recharge is given in Tables 3 and 4. In all three years fallow recharge was essentially zero and the net gain in recharge from fall standing stubble over fallow was equal to the snow capture under the standing stubble. Fall cultivation resulted in 1 to 2 cm less recharge than standing stubble with significantly less recharge occurring on the fall cultivated upper slopes where the water is needed. Regardless of stubble recharge, stubble plus strips had approximately 1 cm more recharge than stubble. A summary of the effects of fall management on over-winter soil water recharge using stubble recharge as the standard is given in Fig. 1.

Average differences in spring soil water content between fallow fields and those that have been cropped the previous year have been estimated at 4.5, 3.5, 1.8 and 0.3 cm (0-122 cm depth) for fields in the Brown, Dark Brown, Black, and Gray and Dark Gray soil zones, respectively (de Jong and Steppuhn, 1983). Thus the additional 1 cm of snow water recharge due to stubble plus strips will not be enough to offset the extra 4.5 cm of available soil water in fallow fields in the Brown soil zone. The extra snow catch should offset most of the extra water found in fallow in the Black soil zone and should significantly decrease the relative risk of stubble cropping in the Dark Brown soil zone. Snow trapping is not necessary in the Dark Gray and Gray soil zones since on average complete recharge occurs with normal stubble management. Methods of increasing snowmelt infiltration while maintaining conditions for good snow capture need to be developed, especially in the Brown and Dark Brown soil zones.

Analyzing the effects of snow water capture on subsequent yield is difficult since the different fall managements also affect fertility status, seed bed preparation, soil temperature and other factors. Using an average water-use efficiency of 100 kg grain ha^{-1} per cm of water use, the stubble plus strips should result in 90-100 kg ha^{-1} more grain than stubble and 250-300 kg ha^{-1} more grain than fall cultivated stubble. This assumes spring soil water is limiting to crop growth even in the lower slopes which will not be the case in the northern parts of the province.

Significant gains in soil water recharge are possible by not cultivating the stubble in the fall. A comparison of wheat yields for paired stubble and fall cultivated stubble with similar added fertilizer is given in Table 5. Significant yield gains were measured in the standing stubble especially at the mid slope position. The lower water use efficiency in the lower slope position indicates that either leaching and loss of soil water by deep drainage is occurring, or possibly more fertilizer should be added to this position to make better use of the water present.

CONCLUSIONS

Lower slopes had an average 2 to 4 cm more over-winter soil water recharge than upper slope positions, with the relative difference being modified depending on fall management. The swather attachment which creates strips of higher stubble resulted in 1 cm more soil water recharge than standing stubble regardless of stubble snow catch. Fall cultivation of stubble resulted in 1.5 to 2.0 cm less soil water recharge than standing stubble which also translated into measurable yield differences of approximately 200 kg ha^{-1} per cm.

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Table 1. Average over-winter soil water recharge, 1982-83 (cm/130 cm).

	# fields	Upper	Middle	Lower	L-U*
Stubble + strips	14	4.0	4.5	8.3	4.3
Stubble	29	3.7	4.0	5.8	2.1
Cult. stubble	9	2.9	6.8	6.8	3.9
Fallow	4	2.24	0.6	1.4	-1.0

*Lower-Upper, all significant at 5% probability level

Table 2. Average over-winter soil water recharge, 1983-84 (cm/130 cm).

	# fields	Upper	Middle	Lower	L-U*
Stubble + strips	12	3.0	4.0	4.8	1.8
Stubble	16	3.0	3.8	5.3	2.3
Cult. fallow	8	2.6	1.9	3.5	0.9
Fallow	10	0.6	1.0	1.8	1.2

*Lower-Upper, all significant at 5% probability level

Table 3. Effect of fall management on soil water recharge due to snow capture (winter 1982-83 and 1981-82).

Fall management	No. field comparisons	Soil water recharge (cm)				
		Slope position				Average (1981-82)
		Upper	Middle	Lower	Ave.†	
		1982-83				
Stubble	3	2.4	2.7	4.0	2.8	2.3
Fallow		-1.0	-2.7	-1.9	-2.0	-0.6
Change		3.4**	5.3**	5.9*	4.8	2.9
Stubble	9	4.5	4.6	7.3	5.0	2.4
Cult. stubble		1.4	3.4	7.1	3.3	0.9
Change		3.1**	1.2	0.2	1.7	1.3
Stubble + strips	9	4.7	4.8	7.7	5.2	3.4
Stubble		3.8	4.4	5.4	4.3	2.4
Change		0.9*	0.4	2.3*	0.9	1.0

†Based on 35% upper, 50% middle, and 15% lower slopes

*Difference is significantly >0 at $\geq$5% probability level

**Difference is significantly >0 at $\geq$1% probability level

Table 4. Effect of fall management on soil water recharge due to snow capture (winter 1983-84).

Fall management	No. field comparisons	Soil water recharge (cm)			
		Slope position			
		Upper	Middle	Lower	Average†
Stubble	3	2.4	2.4	7.3	3.1†
Fallow		0.7	0.4	0.6	0.5
Change		1.7*	2.0	6.7*	2.6
Stubble	6	3.9	5.0	4.6	4.6
Cult. stubble		2.7	1.9	3.7	2.5
Change		1.2*	3.1**	0.9	2.1
Stubble + strips	4	3.3	5.2	3.4	4.3
Stubble		2.1	4.3	4.9	3.5
Change		1.2	0.9	-1.5	0.7
Stubble + strips	8	4.5	5.0	6.5	5.1
Fallow		1.3	1.3	1.8	1.4
Change		3.2**	3.7**	4.7**	3.7

†Based on 35% upper, 50% middle, 15% lower slopes

*Difference is significantly >0 at 5% probability level

**Difference is significantly >0 at 1% probability level

Table 5. Measured yield gains (1983 and 1984 growing season, 6 sites).

Slope position	Wheat yield (kg/ha)			Extra stubble snow water recharge (cm)	W.U.E. (kg grain/ cm H_2O)
	Stubble	Cult. stubble	Δ		
Upper	1915	1735	175	0.9	194
Middle	2390	1990	400	1.5	270
Lower	2290	2150	140	1.4	100

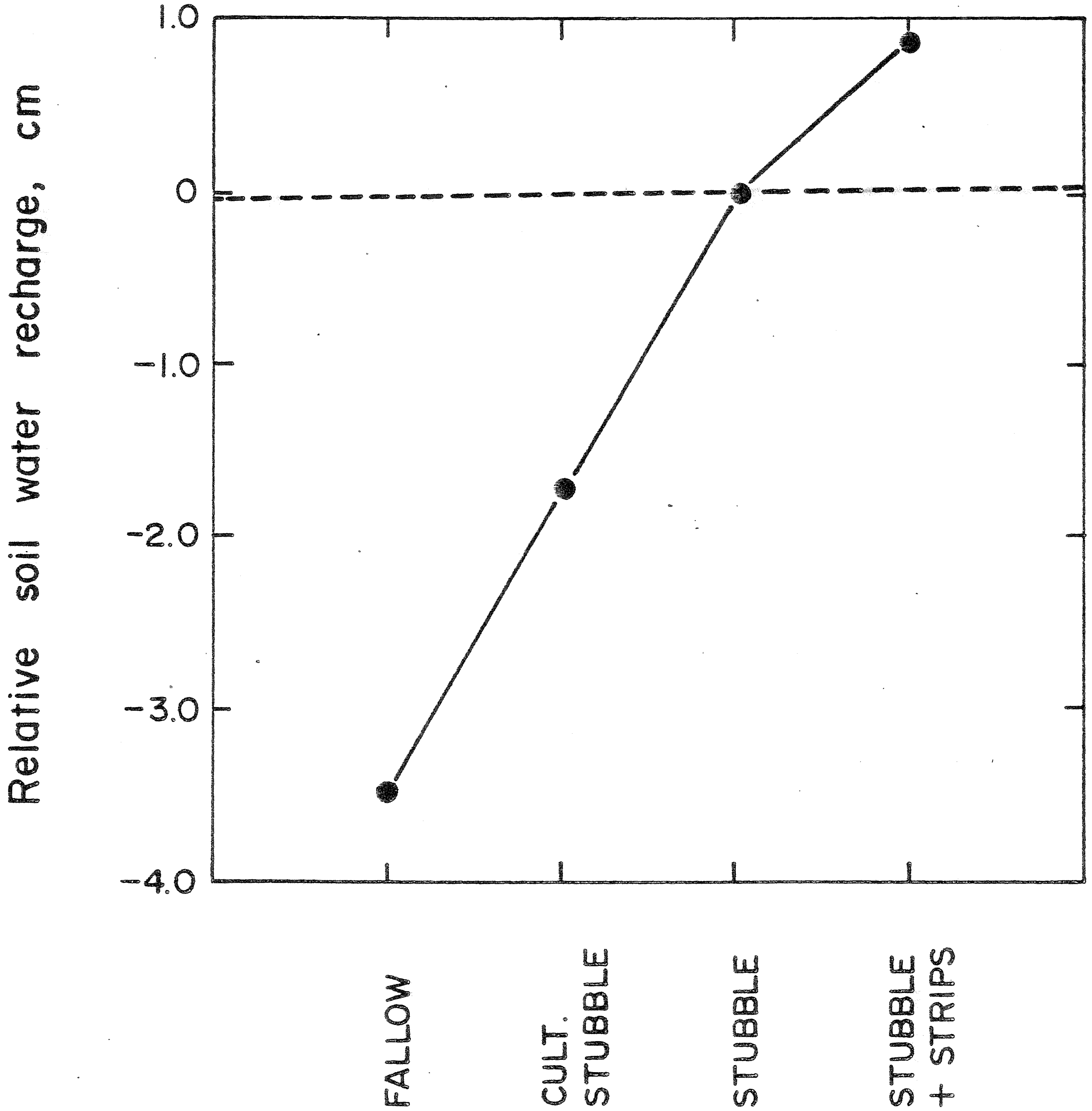

Figure 1. Effect of fall stubble management on relative snow water recharge.