UPDATE ON SNOW MANAGEMENT RESEARCH AT SWIFT CURRENT

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INTRODUCTION

Extending the cropping system appears to be the most promising approach to solving problems of land degradation due to erosion and salinity (Renne, D.A, 1979). The extent of wind and water erosion and salinity has been documented in a series of Western Provincial Conferences on the Rationalization of Water and Soil Research and Management held in 1982 and 1983.

To extend the cropping system in an environment where water is limiting is a major problem faced by producers. (Nicholaichuk, 1982). Management of snow is considered a possible alternative.

The first study on management of snow was reported by Mathews at Scott in 1940. From a two year study, he concluded that yield increases from snow ridging were modest. (Mathews, 1940). In these tests, windrowing increased the natural accumulation of snow by 100 percent in the ridges and 30 percent between them.

In 1972, Steppuhn of the University of Saskatchewan Agricultural Engineering Department re-initiated a windrowing study at various locations in western Saskatchewan. (Steppuhn, 1980a). The 5-year study indicated that benefits were inconsistent. During two out of the five test years parallel ridges of snow spaced at 3.7 m apart on over-wintering stubble fields enhanced the deposition of wind-borne snow and increased soil moisture stored. For example, in one year (1973-74), there was actually a soil moisture gain of 51 mm (70 percent) compared to the test field not windrowed. Similarily, in a study conducted by Kirkland and Keys (1981) showed that snow ridging did not significantly increase the moisture reserves as compared to the check on fallow and stubble.

From windrowing studies, the following can be summarized (Steppuhn, 1980a):

1. Windrowing fallowed fields proved difficult and uneconomical due to limited capacity to store additional water;

2. Satisfactory ridges require two snow plowing operations, one early as permanent winter snow cover materializes (December) and another one in January;

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3. Functional barriers spaced 3.7 m apart can be obtained with a V plow 2.4 m wide - average cost per plowing amounted to less than one summerfallow operation;

4. Two passes with the plow in opposite directions as close to each other as possible insures ridges at the maximum height;

5. Direction-orientation did not affect trap efficiency;

6. Raising the plow by 3 to 5 cm reduces the amount of soil found mixed in the ridges and eliminates scouring the seedbed;

7. Soil and crop residue incorporated in the ridge enhance energy adsorption radiation, thereby causing the ridge to melt fairly rapidly;

8. The inter-ridged bare area took longer to thaw thereby reducing infiltration capacity;

9. Windrowing may be "miserable work" which often follows when air temperatures are often lower.

To overcome the foregoing difficulties with windrowing snow, the Agriculture Research Station initiated in the fall of 1972 a study in trapping snow by swathing at alternate heights. This practice was observed in the USSR by Dr. Art Guitard, former Director of the Swfit Current Research Station. The study of utilizing standing stubble for snow trapping was expanded in later years by an AERD contract with Dr. H. Steppuhn, University of Saskatchewan, to develop an equipment for leaving a strip of tall standing stubble to increase the trapping efficiency. Utilizing the encouraging results of this study, additional research was undertaken to assess the potential of snow management utilizing strips of tall standing stubble and permanent grass burners.

This paper will review some of the snow management studies conducted at Swift Current since 1972 and the possible effect on surface runoff.

SNOW MANAGEMENT

What is the potential for snow management? Generally, snow constitutes over 25 percent of the amount of precipitation received on the Canadian Prairies. The water equivalent of the snow averages between 700 to 1400 ml per year, depending upon location. Again, depending upon location, variability in annual amounts can also be high. For example, at Swift Current the amount of snow received may range from 49 percent below average to 75 percent above. Any planning of snow management must consider the highly variable nature of snowfall which is common to much of the prairie region.

Although snowfall over an area tends to be more uniform than rainfall, its accumulation and retention on the ground is highly heterogeneous. The accumulation of snow is usually greatest adjacent to farmyards, steep slopes in pasture and brush, while fallow accumulates the least amount of snow. The objective of any snow management practice is to achieve a more uniform distribution.

Snow management to increase soil water conservation requires that snow be trapped, distributed and held on the fields until the crop is grown. This also means that on melting, the water should have good opportunity to enter the soil rather than be lost by runoff. Barriers for snow management can be grouped into competitive and noncompetitive types, depending upon whether the barrier competes with the crop for the soil water supply.

NON-COMPETITIVE BARRIERS

(a) Swathing at Alternate Heights

Swathing at alternate heights is a form of snow management that has been investigated for a period of 12 years at the Swift Current Research Station. Treatments consisted of alternately swathing the wheat crop at two different heights using a self-propelled swather. The heights depended on the crop stand condition (Table 1). The control consisted of wheat that was swathed at a uniform height.

Table 1. Snowfall, snow accumulation and snow water equivalent on the uniform and nonuniform stubble system of snow management (1972-84) (cm)

		Uniform Stubble				Nonuniform Stubble			
Year	Snow-fall	Stubble Height	Avg. Snow Depth	Equiv. Moisture	% Trapped	Stubble Height	Avg. Snow Depth	Equiv. Moisture	% Trapped
1972-73	7.6	28	8	1.3	17	30 & 13	9	1.6	21
73-74	14.4	15	30	7.7	53	23 & 15	37	11.9	83
74-75	11.1	15	22	5.4	49	23 & 13	27	5.3	48
75-76	12.6	15	19	5.3	42	15 & 8	18	4.5	36
76-77	5.6	25	14	3.0	18	25 & 13	16	4.0	71
77-78	8.8	31	21	6.0	68	31 & 15	31	9.8	113
78-79	8.3	23	29	6.8	82	31 & 13	30	8.5	102
79-80	6.0	11	9	2.4	67	27 & 11	12	3.8	40
80-81	9.6	15	⊖	⊖		27 & 13	⊖	⊖	
81-82	10.0	15	17	4.8	48	33 & 15	29	7.9	79
82-83	9.0	20	17	3.3	36	37 & 20	18	3.4	37
83-84	5.9	18	16	4.1	70	37 & 19	21	4.3	73
Average		19	18	4.5	46	21	22	5.9	59

Gravimetric soil moisture samples at six location on each plot to a depth of 120 cm were taken to determine the soil moisture content in the spring and fall. Data is summarized.

⊖ Snow survey was not conducted prior to spring melt.

The average depth of snow trapped by non-uniform stubble was 4 cm or 22 percent more than on the uniform stubble. Additional water in the increased amount of snow trapped was 1.4 cm or 23 percent greater indicating an approximately linear relationship between depth and moisture equivalent.

During the 12-year period the practice of swathing at alternate heights resulted in additional storage of 1.8 cm of water on the average (Table 2). Depending on fall soil moisture conditions at the time of freeze-up, late fall rates, amount of winter snowfall and rate of spring thaw, the amount of stored moisture is highly variable. For example, in 1977 - 78, 5.2 cm of water was stored which is approximately the same amount that is normally stored by summerfallowing in southwestern Saskatchewan.

Table 2. Overwinter soil water storage efficiency from snowmelt and rainfall on uniform and nonuniform stubble system of snow management.

Year	Overwinter precipitation cm	Uniform Soil water intake cm	Uniform Intake efficiency %	Nonuniform Soil water intake cm	Nonuniform Intake efficiency %
1972-73	12.6	3.6	29	6.3	50
73-74	19.4	7.5	39	8.2	42
74-75	12.6	4.3	34	4.7	37
75-76	14.5	1.1	8	2.5	17
76-77	6.0	4.1	68	4.5	75
77-78	12.7	5.9	46	11.1	87
78-79	11.0	6.2	56	5.5	50
79-80	7.7	3.8	49	7.1	92
80-81	11.4	3.4	29	5.1	45
81-82	11.0	5.9	54	5.6	51
82-83	11.3	2.0	18	5.7	50
83-84	7.2	2.8	39	5.4	76
Mean	11.5	4.2	39	6.0	56

In utilizing 5 cm of stored moisture as a basis for deciding whether recropping is feasible, snow trapping by this method would make it possible to recrop in 9 out of the 12 years compared to 4 years out of 12 utilizing the conventional practice.

Another observation to make is with respect to intake efficiency. The average intake efficiency was increased by 15 percent, indicating exposed tall standing stubble must have had an effect on enhancing snowmelt infiltration. It is suggested that taller exposed stubble perhaps absorbs additional energy compared to snow covered stubble and thereby may cause soil to thaw more rapidly and thereby improve the infiltration of snowmelt.

Runoff measurements from 5 ha plots on which snow management was practiced tend to reflect the differences in the intake efficiencies, (Nicholaichuk W., 1983). Generally, over a five year period, runoff was higher in the uniform stubbled field compared to the non-uniform stubbled field which indicates runoff to be inversely related to the amount of water stored over winter (Table 3). Runoff observations should be treated with caution since topography of the fields used in the study tended to favor runoff conditions for the uniform snow management treatment.

Table 3. Runoff from snowmelt from a uniform and nonuniform stubble system of snow management

Year	Snowfall	Uniform Stubble	Nonuniform Stubble
		cm	
1972-73	12.6	0.8	1.4
73-74	19.4	8.9	2.4
74-75	12.6	4.0	6.8
75-76	14.5	10.1	6.8
83-84	7.2	0.4	0.4
Mean	13.3	4.8	3.6

(b) Trap Strips

A concept developed in 1979 consists of leaving a strip of tall standing stubble that acts as a barrier to trap snow on stubbled fields. Development of the concept was continued during 1979 and 1980 with two Agriculture Canada AERD contracts with the Department of Agricultural Engineering of the University of Saskatchewan (Steppuhn, 1980b). At Swift Current two types of strips spaced at 6.4 m are being evaluated. The first type consists of leaving a strip of tall standing stubble that is created by using a deflector-type attachment mounted on a conventional swather. The second type of leave-strip is created by using a clipper type of attachment mounted on a conventional swather which leaves a narrow strip of standing stubble with the heads clipped off (Dyck etal 1982).

Only 3 years of study have been devoted to this trap system of snow management. The clipper system tended to trap more snow than the deflector attachment (Table 4). The clipper system left more erect standing stubble that tended to provide additional turbulence for compacting snow within the tall strips of tall standing stubble. On the average, the clipper system trapped 15 percent more snow than the deflector system. In addition, the clipper system trapped 39 percent more snow than the uniform stubble used as a check.

Table 4. Snowfall and accumulation on a trap strip stubble system of snow management compared to uniform stubble

Year	Snowfall	Equiv. moisture of trapped snow			% snowfall trapped		
		Deflector	Clipper	Check	Deflector	Clipper	Check
1981-82	10.0	9.7	12.2	6.3	97	122	63
82-83	9.0	4.4	4.2	3.2	48	46	35
83-84	5.0	5.3	6.4	4.1	106	128	82
Mean	8.0	6.5	7.6	4.5	84	99	60

Trap strips, either the deflector or clipper type, were on an average 20 and 36 percent more effective in trapping snow over the same three year period compared to the alternate height stubble method. In comparing the two systems, the trap strip offers a greater potential capacity because of the physical configuration.

In terms of soil water storage, the trap system by either the deflector or clipper method increased the stored water by as much as 2.2 and 3.6 cm, respectively (Table 5). This increase in water storage represents an intake efficiency of 62 percent for the deflector and 74 percent for clipper compared to 38 percent for the check. In other words, the intake efficiency for the clipper is near double the control. In comparison to the alternate stubble heights the intake efficiency was found to be considerably higher than either control or the alternate height system. This suggests that a significant barrier created by the clipper system may act as a heat sink during the thaw period and result in increased moisture trap.

Table 5. Overwinter soil water storage efficiency from snowmelt on the trap strip system of snow management

Year	Overwinter Precipitation	Soil water intake			Intake Efficiency		
		Deflector	Clipper	Check	Deflector	Clipper	Check
1981-82	11.0	8.0	12.1	5.7	73	109	52
82-83	11.3	4.3	4.4	2.6	38	39	23
83-84	7.2	5.5	5.4	2.8	76	75	39
Mean	9.8	5.9	7.3	3.7	62	74	38

COMPETITIVE GRASS BARRIERS

In the northern Great Plains of U.S.A. barriers of tall wheatgrass planted in single or double rows spaced from 9 m to 15 m apart have proved effective for snow management (Black and Siddoway, 1976). Similar studies have been conducted at the Research Station at Swift Current since 1979 (Nicholaichuk, 1981).

The grass barrier system offers the potential for trapping more snow than the noncompetitive types. This is mainly attributed to the fact that the tall wheatgrass provides a barrier that is a meter in height or more. Data suggests that the barrier system traps approximately twice as much snow compared to the uniform stubble wheat (Table 6).

Table 6. Snowfall accumulation with a grass barrier system of snow management

		Equivalent of moisture trapped snow		% of snowfall trapped	
Year	Snowfall	Within barrier	Control	Within barrier	Control
1979–80	6.0	2.7	1.6	45	26
80–81	9.6	–*	–	–	–
81–82	10.0	12.9	6.6	129	66
82–83	9.0	6.2	3.5	69	39
83–84	5.0	6.3	3.1	126	62
Mean	7.9	7.0	3.7	92	48

* Snow survey was not conducted prior to spring melt

Not only did the barrier system trap offer an opportunity to trap more snow, the net increase in water stored was 73 percent greater than the control (Table 7). Results to date are similar to those reported by Black and Siddoway 1976.

Table 7. Overwinter soil water storage and efficiency from the barrier system of snow management

Year	Overwinter Precipitation	Barrier		Nonbarrier	
		Soil water intake (cm)	Intake efficiency (%)	Soil water intake (cm)	Intake efficiency (%)
1979-80	7.7	4.4	57	4.6	60
80-81	11.4	5.2	45	3.9	34
81-82	11.0	6.2	57	2.1	19
82-83	11.3	6.5	58	5.7	50
83-84	7.2	4.9	68	2.0	28
Mean	9.7	5.4	57	3.7	38

ENHANCEMENT OF SNOWMELT INFILTRATION

Data collected to date suggest that snow trapping techniques are successful in trapping snow. However, 12 years of data by swathing at alternate heights also suggests the benefits that can be attributed to snow management are highly variable due to reasons given earlier in this paper. To this end, an exploratory study has been initiated to determine whether snowmelt infiltration can be enhanced. (Nicholaichuk et al 1984).

Utilizing a conventional subsoiler and a 'Paraplow'* (Pidgeon 1983), a trial experiment was initiated to determine whether such tillage practices were beneficial on stubble land on which trap strips were prepared. Results for this one-year study (1983-84) are presented in Table 8.

Table 8. Effect on snowmelt enhancement practices on snow accumulation on a trap strip stubble system of snow management

Stubble treatment	Tillage treatment	Snow depth	Equiv. Moisture	Overwinter soil water intake
		----- cm	-----	
Clipper	Subsoiled	37	10.5	18.3
	'Paraplowed'	36	10.0	14.9
	Check	27	7.6	9.9
Deflector	Subsoiled	13	3.6	3.3
	'Paraplowed'	17	4.8	9.9
	Check	17	3.9	3.3
Uniform stubble	Subsoiled	15	3.5	3.9
	'Paraplowed'	17	4.0	4.3
	Check	20	4.5	5.9

From only one year's data, three observations are made. First, subsoiling or paraploughing between the strips of tall standing stubble did not appear to reduce the depth of snow trapped. Secondly, the practice of 'Paraplowing' did have a beneficial effect of enhancing snowmelt infiltration when compared to the control. Thirdly, the benefits attribued to these types of tillage practices are related to the amount of snow entrapped. On the uniform stubble, when a smaller amount of potential stored moisture was trapped, tillage had a detrimental effect on the amount of water that was stored.

The preliminary studies suggest that unique fall tillage practices to enhance snowmelt infiltration should be pursued.

*'Paraplow' is a trademark of the Howard Rotavator Company.

SUMMARY

Snow trapping by stubble management and by the use of permanent grass barriers providies a potential to provide additional water for recropping. Over a twelve year period, 15 percent more water was stored in the soil from swathing at alternate heights. The percentage increase was similar to the use of permanent grass barriers over a four year period. Utilizing the stubble trap strip for three years, 26 percent more water was stored. Depending on climate and soil moisture conditions, sufficient water can be stored for recropping and thereby eliminate the need for summerfallowing.

In terms of trapping snow, more than half of the snowfall received can be trapped by any of the techniques mentioned. As expected, the grass barriers offer the greatest potential to trap the most snow.

In order to enhance snowmelt infiltration, a preliminary study was conducted in 1983-84 that suggested snowmelt infiltration may be enhanced by fall tillage practices that utilize a Paraplow' and a subsoiler.

With respect to runoff, snow management did not adversely affect the amount of surface runoff and subsequent surface water supplies. As expected, runoff is inversely related to infiltration and highly dependent on climatic and soil moisture conditions.

FUTURE REQUIREMENTS

If snow management is to become a widely accepted practice there is still a need to perfect equipment for creating trap strips. Equipment must be able to cope with lodged grain and short grain during dry years. Perhaps consideration should be given to growing taller grain varieties if snow trapping is to become commonly practiced.

There is sufficient evidence to indicate trap strips can have a beneficial microclimate effect on an emerging and growing crop even under limited snowfall conditions.

Another practice of compacting snow by packing or harrowing should also be investigated. Apparently this practice is being adopted with success in the U.S.S.R. (Ukrainetz, 1985).

With respect to snowmelt infiltration enhancement, preliminary studies are encouraging. These studies should be extended to examine the potential benefits of snow trapping in combination with fall deep banding of fertilizers, subsoiling or parplowing for various soil types and climatic conditions.

Finally, the need for long-term snowtrapping studies under large field conditions should be recognized. Because of the variability in annual snowfall and conditions that affect snow trapping benefits, etc., long-term studies would allow for establishing the probability of reaping the rewards of this practice.