# MANAGING SNOWCOVERS IN GRAIN FIELDS HARVESTED FOR STRAW FIBER

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## ABSTRACT

Agriculture across the Northern Great Plains and Canadian Prairies depends on snowcover resources for dryland crop production in semi-arid environments. On average, between 15 to 35% of the mean annual precipitation within this region falls as snow. Selecting the harvest method and controlling the stubble height of grain crops are among the techniques available to farmers and ranchers for managing the snow that falls upon or blows across their fields. Recently, the "green economy" has placed a demand for the same crop straw normally left on the land as tall stubble in order to manage or "trap" the winter snow. Considerable crop stubble is now harvested and converted to useful bio-products, and more straw for fiber will be utilized in the future. This creates a challenge to devise new equipment and improve techniques in order to harvest both crop grain and straw but also maintain enough standing stubble to retain snow for subsequent crop production. One technique uses a "stripper" rather than the standard sickle header on the combine to harvest the grain-filled seed-heads when ripe. The stripper leaves ample straw which can be harvested later in various ways to also trap snow and manage snowcovers. Preliminary field results with the stripper in harvesting wheat, flax, lentils, barley, and other crops encourage the continuation of field trials to evaluate snow retention with the implement. (Keywords: Snow management, Stubble management, Snow control, Stripper header, Dryland crop harvest, Soil-water management)

## INTRODUCTION

Snow, as a natural composite of water and air, can effectively be controlled to benefit crop growth and increase commodity production. It is an agricultural resource that can be managed to enhance on-farm water supplies, to insulate over-wintering crops from low temperatures, to obtain an extra measure of root-zone water for increasing crop production, and to ameliorate saline soil conditions by supplying extra water for leaching. Snowcover accumulations can be advantageously controlled to benefit dryland crop production, especially in cool, semi-arid climates. Forage, grain, and oilseed producers can harvest their crops and purposely leave standing stubble with which to retain snow in desired places rather than allow the wind to blow the frozen water off their fields. Besides directly insulating seeded crops and contributing to root-zone soil waters, snow management also prevents soil erosion control, directs snowdrifts away from accumulating over roads and rails, and creates natural winter landscapes for wildlife and beautiful scenery. Crop harvest methods which leave stubble of adequate height are among those techniques available to farmers and ranchers for managing the snow that falls upon or blows across their fields (Steppuhn, 1981).

Grant and Ramirez (1975) estimated that from 1/6th to 1/3rd of the annual precipitation over the Northern Great Plains and the Canadian Prairies falls as snow. At any location, a wide fluctuation in snowpack accumulation may occur from year to year; deviations measuring ±40% of the average occur. Mean annual snowfall water equivalents of 30 mm in the southeast (Kansas) and 130 mm in the northeast (Manitoba) exemplify a common areal spread (Grant and Ramirez, l975). Although amounts such as these seem low in comparison to snowfall accumulations over humid regions, they represent a sizeable resource when totaled over a vast area such as the Great Plains and Prairies. The water equivalent associated with this region's mean annual snowfall nears 170 billion cubic meters, an amount approaching the mean annual volume of water flowing from the Great Lakes into the St. Lawrence River (Water Survey of Canada, 1974).

### Snow Transport

Control over the deposition of snow on fields and pastures involves regulation of the wind. The forces which keep a particle of snow air-borne result from the wind's turbulent character. Within any horizontal wind stream, turbulence causes individual elements of air to move in all directions, even upward against gravity. This upward, transient force buoys the particles of snow moving in a wind stream, regardless whether the transported snow

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Paper Presented Western Snow Conference 2009

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originates from snow covering a landscape or from snow falling as precipitation. The mass flux of wind-transported snow decreases geometrically with height above the surface (Budd et al. 1966; Schmidt 1982b). In the lower few centimeters, particles of snow move by saltation, a wind-driven process where the particles leap repeatedly in a series of jumps initiated by impacts from other jumping particles returning to the surface. Above the saltation layer, the lighter particles are suspended in the turbulent air stream (Schmidt 1982a).

The transport of snow by both saltation and suspension occurs almost entirely within an aerodynamic boundary layer created by the shear stress associated with the movement of air over land and snow surfaces. The net horizontal wind speed ($U_z$) within the lower portion of the boundary layer at any height Z above the land surface datum can be described by the well-known logarithmic relationship,

$$U_z = (U_*/k) \ln \left(\frac{Z-d_o}{Z_o}\right) \qquad (1),$$

(Lyles et al., 1974; Kind, 1981; Panofsky and Dutton, 1984). The parameter $U_*$, the friction velocity, is defined by $(\tau_o/\rho_f)^{0.5}$, where $\tau_o$ refers to the shear stress at the lower boundary of the aerodynamic layer, and $\rho_f$ symbolizes the fluid density of the air. Von Karman's constant (k) is usually assumed to equal 0.4, while the coefficient $Z_O$ varies with the character of the surface and defines an aerodynamic roughness parameter. The effective roughness length ($d_o$) equals the displaced height of the plane above the datum where the logarithmic wind profile begins. This equation implies a condition of steady-state, and is usually integrated over time when applied to snow transport.

During every snowstorm under every set of snowcover conditions, a shear stress ($\tau_{0t}$) exists which must be exceeded in order to transport snow (Schmidt, 1980). This stress corresponds to a threshold friction velocity ($U_{*t}$) which Schmidt (1982a) uses to calculate the transport rate of the saltating snow of the fluid moving at the mean height of the saltation layer. Pomeroy and Gray (1990) have applied Schmidt's function for the snow transport rate to agricultural fields by adding various coefficients plus a function from Lyles and Allison (1976) which accounts for the drag imposed by standing grain stubble.

The mass flux of snow transported at any time in the suspension layer equals the mass concentration multiplied by the mean downwind particle velocity; on average, this velocity equals that of a parcel of air moving downwind (Schmidt, 1982b). Pomeroy and Male (1992) added empirical approximations and integrated the mass flux over the depth of flow (from the top of the saltation layer to the top of the boundary layer) to obtain a function for the transport of wind-suspended snow. By including expressions for surface conditions and integrations based on mean horizontal wind speeds, Pomeroy et al. (1993) presented a snow-transport model for windy agricultural environments.

**Snowcover Deposition and Erosion**

The quantity of snow which is added or removed to or from a snowcover per unit time, changing its depth (D), depends on the transport rates for saltating and suspended snow, the rate of snowfall, and the rate of sublimation from the transported snow and snowcover (Tabler, 1973, 1975; Tabler and Schmidt, 1986; Pomeroy et al., 1993). Snowcover erosion occurs when wind speeds (and therefore transport rates) increase or when the snowfall rate is less than the surface erosion rate. Conversely, snowcovers accumulate mass when the speed of the snow-laden wind decreases or turbulence is enhanced by a change in aerodynamic roughness. Within the course of a snowstorm, snowcovers may be accumulating at one moment and, with a change in conditions, eroding the next. Deposition and scour may also occur simultaneously in separate locations. The processes involve a dynamic equilibrium based on the quantities of snow: falling as precipitation, transported with the wind, and sublimated while moving. Growers of dryland agricultural crops who are interested in managing their snow resources require information on how to determine the expected quantities of snow that will be retained on their fields with stubble of different heights left after harvest. Steppuhn (1994) devised a working relationship to determine the maximum volumetric capacity for snowcover retention associated with standing wheat and barley stubble in windy environments.

For every set of conditions involving mean horizontal wind speed, surface roughness, snowfall rate, and ambient weather, a unique snowcover depth ($D_{max}$) exists which equals $d_o$, where the friction velocity ($U_*$) equals the threshold friction velocity ($U_{*t}$) for snow transport (Schmidt 1980). This implies that if $D > D_{max}$ (e.g. following a snowfall without wind), snowcover erosion during a future wind storm is likely because $U_* > U_{*t}$ at the snow surface; if, however, $D < D_{max}$, snowcovers will likely grow when snow is available and when $U_* < U_{*t}$ at the surface. If these implications are true, then a unique volumetric snowcover capacity, defined by $D_{max}$, exists for each set of ambient and snow transport conditions. Maximum retention may be reached within minutes during the first snowstorm or may require successive additions from subsequent storms throughout the accumulation season. The tendency for snowfall to stop before the wind abates to the speed such that $U_* < U_{*t}$ typically results in after-storm (or after-season) snowcover depths either below or at $D_{max}$.

**Snowcover Retention Capacity for Crop Stubble**

It is well known that under windy conditions the snowcover retention capacity of an over-wintering field of crop stubble will exceed that of the bare field and that the capacity will increase with stubble height (Smika and Whitfield, 1966). The theoretical basis for a relationship between stubble height and the maximum depth to which a snowcover will tend to accumulate within standing stubble relates to the friction encountered by the snow-laden wind as it moves through the stubble. Besides the internal friction related to the mass concentration of the snow in transport, the individual stems of, say wheat or barley stubble, act as roughness elements which impose a drag on the wind moving around them. If the elements are far enough apart, the intervening land or snow surfaces between the elements also contribute to the overall drag (Raupach, 1992). The total drag force ($T_d$) equals the sum of the surface ($S_d$), the internal ($I_d$), and the stem form drag ($F_d$),

$$T_d = S_d + I_d + F_d \qquad (2).$$

The relative contributions of $S_d$ and $F_d$ depend primarily on the number of stems per unit area (the stem population), whose reciprocal defines the average stem spacing (R), i.e., the aerodynamic "room" around each stem (Tabler and Schmidt, 1986). In "crowded" stubble fields where R is small (around 75 $cm^2$ or less), form drag dominates. As R gains ground, $S_d$ contributes increasingly more and $F_d$ less until, at R = 1000 $cm^2$, the effect of the stubble becomes irrelevant.

The form drag imposed by upright, crop stubble is influenced by the shape and composition of the stems forming the stubble, resulting in effects which can be incorporated into a drag coefficient, $C_{Hd}$. Albertson et al. (1960) defined the drag force ($F_d$) imposed by objects submerged in a fluid stream, which when combined with $C_{Hd}$ equals:

$$F_d = (0.5\, X_a\, C_{Hd}\, \rho_f\, U_H^2) \qquad (3),$$

where $X_a$ is the projected cross-sectional area of the object normal to the mean wind direction, i.e., the "silhouette area", $\rho_f$ designates the fluid density of air, and $U_H$ equals the mean horizontal wind speed at the top of the exposed stubble. Lyles and Allison (1976) suggest that the shape of a single stem comprising the stubble could be approximated by a cylinder of diameter B whose rounded sides face the wind with a silhouette area $X_a$. The cylinder has length L equal to the distance the stem protrudes above the snowcover surface, such that:

$$X_a = L\, B \qquad (4).$$

If Equation (1) provides the theoretical basis for the transport of snow by either saltation or suspension, a mean $U_H$ value exists such that $U_* = U_{*t}$ for the existing stubble and ambient conditions:

$$U_H = \frac{U_{*t}}{k} \ln\left[\frac{(H-d_o)}{Z_o}\right] \qquad (5),$$

where H equals the mean stubble height measured from the land surface datum. In such a wind regime, without snowfall, the snowcover at $D_{max}$ would neither accumulate nor erode, and $D_{max} = d_o$. Under the assumption that snowfalls during windy snowstorms terminate before the winds stop, and that trailing wind speeds in most storms behave similarly, one may also define $D_{max}$ at the end of the storm or accumulation period as the difference between the average height of the stubble (H) and the mean length of the exposed stems (L) observed at the end of the storm:

$$D_{max} = H - L \qquad (6).$$

This definition (Equation 6) equalized with $d_o$ and solved for L can be substituted into Equation (5), the terms rearranged, and with exponentiation of this new equation gives:

$$L = Z_o\, e^{k(U_H/U_{*t})} \qquad (7).$$

The roughness parameter ($Z_o$) encompasses all the factors related to the overall drag, and ($U_H/U_{*t}$) defines the wind speed profile associated with stubble of height H and friction velocity $U_*$ applied at $D_{max}$. These terms are not readily measurable, but they suggest empirical substitutes with the drag partitioned by R and the variation in wind speed linked to H:

$$L = \alpha\,(R/B)\,e^{\beta H} \qquad (8),$$

where H, R, and B can be regressed with L to estimate coefficients α and β. If the number of individual stems of the stubble decreases and the elements become sufficiently dispersed, the effect of H on L would diminish, leaving the simple relationship of $L = \alpha\,(R/B)$ suggested by Tabler and Schmidt (1986). On the other hand, if the number of individual stems increased, a condition would evolve such that R would cease to affect L, and those terms which include R and B could be deleted. It would seem appropriate for a general equation to include terms which evaluate the effects of stem spacing and diameter. This is accomplished by adding conditions where R > 1000 cm$^2$ excludes the effect of the stubble (and its $F_d$) and where R < 1000 cm$^2$ increases $F_d$ until at R = 0 drag from $S_d$ is nil:

$$L = \alpha\,\frac{1000}{(R+B)}\,\frac{R}{B}\,e^{\beta((1000-R)/1000)H} \qquad (9),$$

If all variables are evaluated in centimeters, the effective upper limit in stem spacing of 1000 cm$^2$ (where the mean distance between wheat and barley stems equals 31.6 cm) can be adjusted if observations suggest another limit.

## MANAGING SNOWCOVERS IN GRAIN FIELDS

### Snow Management Techniques during Crop Harvest

Any practice which induces snow to accumulate preferentially and results in an advantage in the production of dryland field crops qualifies as an agricultural snow management technique. The crop may benefit directly from the snow as when snow insulates the plants from cold temperatures, or indirectly later during the growing season when the melt water is utilized for crop growth. Farmers and ranchers tend to depend on snow management techniques which involve harvesting field crops in the fall before entering winter. Steppuhn et al. (1986) grouped these techniques into four categories: alternate-height swathing; un-harvested leave strips; stubble leave strips; tall uniform stubble (straight combining).

#### *Alternate-Height Swathing*

Some crops must be double swathed to obtain a single windrow of sufficient quantity to thresh efficiently.

Table 1. Mean snowcover accumulated on uniform and on alternate height stubble from conventional and double swathing near Swift Current, Saskatchewan, 1972-84 (Nicholaichuk et al., 1984)

| Year | Uniform Stubble | | | Alternate Height Stubble | | |
|---|---|---|---|---|---|---|
| | Stubble Height | Snow Depth | Water Equivalent | Stubble Height | Snow Depth | Water Equivalent |
| | (cm) | (cm) | (mm) | (cm) | (cm) | (mm) |
| 1972-73 | 28 | 8 | 13 | 30 & 13 | 9 | 16 |
| 1973-74 | 15 | 30 | 77 | 23 & 15 | 37 | 119 |
| 1974-75 | 15 | 22 | 54 | 23 & 13 | 27 | 53 |
| 1975-76 | 15 | 19 | 53 | 15 & 8 | 18 | 45 |
| 1976-77 | 25 | 14 | 30 | 25 & 13 | 16 | 40 |
| 1977-78 | 31 | 21 | 60 | 31 & 15 | 31 | 98 |
| 1978-89 | 23 | 29 | 68 | 31 & 13 | 30 | 85 |
| 1979-80 | 11 | 9 | 24 | 27 & 11 | 12 | 38 |
| 1980-81 | 15 | 00 | 00 | 27 & 13 | 00 | 00 |
| 1981-82 | 15 | 17 | 48 | 33 & 15 | 29 | 79 |
| 1982-83 | 20 | 17 | 33 | 37 & 20 | 18 | 34 |
| 1983-84 | 18 | 16 | 41 | 34 & 19 | 21 | 43 |
| 12-year mean | 19 | 17 | 42 | 28 & 14 | 21 | 54 |

Nicholaichuk et al. (1984) demonstrated that grain fields near Swift Current, Saskatchewan, swathed alternately tall and short during this operation, retained significantly more snowcover over a 12-year period than fields cut uniformly short (Table 1). The water equivalents respectively averaged 42 and 54 mm in mid-winter snowcovers for uniform and alternating-height stubble swathed in widths of about 8 m.

Alternate height stubble is easily obtained by straight combining or by double swathing with a windrower. In straight combining, the height of the cutting bar of the header can be adjusted while the implement is in motion to obtain the desired height wherever required. In double swathing, either one or two windrowers swath the crop wherein the cut grain from the tall-cutting implement is conveyed to the windrow of the low-cut swath.

***Un-harvested Leave Strips***

The first known trial of leaving tall strips of un-harvested grain for snow-retention was conducted during the winter of 1975-76 with a durum wheat crop grown near Leader, Saskatchewan (Steppuhn 1980). During the harvest of the durum, test strips 30 cm wide of standing wheat 60-80 cm tall were left un-harvested and spaced 1, 2 and 3 swather widths apart (with an 18-foot (5.5-m) swather) on fields scheduled to be sown in the following spring. The leave strips at their respective spacings increased snow volumes by averages of 88, 80 and 70% over that accumulated on the non-stripped stubble, which averaged 21.1 cm in depth as presented in Table 2.

Table 2. Mean March 1976 snow depths measured on 0.41 ha test blocks in three fields near Leader, Saskatchewan, 1975 durum wheat stubble and 30 cm wide crop leave strips spaced every one, two, or three swather widths (5.5-m swather), Winter 1975-76 (Steppuhn 1980)

| Treatment (September1975) | Spacing | Crop Investment | Snow Depth |
|---|---|---|---|
| | (m) | (% of crop) | (cm) |
| Non-Leave-stripped | | | 21.2 |
| Leave-strip spaced: | | | |
| One swather width | 5.3 | 5.45 | 39.8 |
| Two swather widths | 10.7 | 2.72 | 38.6 |
| Three swather widths | 16.0 | 1.84 | 36.0 |

In another test with un-harvested leave strips, a 20.2 ha (50 acre) field of spring wheat located 5 km east of Saskatoon, Saskatchewan, was swathed in October 1977, 12.1 ha (30 acres) conventionally and 8.1 ha (20 acres) by leave-stripping (Steppuhn 1980). Leave strips measured 40 cm in width and were spaced on 12.9 m centers which amounted to an un-harvested crop area equaling 3.1% of the total. The conventionally-swathed portion of the field yielded 2216 kg/ha and left a standing stubble of 15 cm in height. The un-harvested crop investment in leave strips was computed as the product of the un-harvested area and the conventional yield, 3.1% x 2216 kg/ha = 68.7 kg/ha. Snowcover retention, surveyed in March 1978, showed that the leave-strips had trapped an average water equivalent of 89 mm more than had the conventional stubble (Table 3). Soil water gains measured between fall and spring averaged 53 mm greater under the strip treatment compared to the conventional stubble. Each additional mm of water has been associated with an increase in subsequent spring wheat yield of 9-16 kg/ha as reported by Staple and Lehane (1954), and others. If a conservative figure of 8 kg/ha/mm were assumed, the return from the leave-strip treatment accounted for an extra yield of 53 times 8 kg/ha/mm or 424 kg/ha and the ratio of return from investment equaled 424/68.7 or 617%.

Table 3. Snowcover and soil water (5-80 cm profile) for a spring wheat field 5 km east of Saskatoon, Saskatchewan, 8.1 ha (20 acres) snow managed during Winter 1977-78 using un-harvested leave strips compared to 12.1 ha (30 acres) conventionally swathed (Steppuhn, 1980)

| | Snowcover (March 10, 1978) | | Soil Water | | |
|---|---|---|---|---|---|
| Treatment (September 1977) | Depth | Water Equivalent | Fall 1977 | Spring 1978 | Difference |
| | (cm) | (mm) | (mm) | (mm) | (mm) |
| Conventionally swathed | 12.8 | 33 | 191 | 243 | 52 |
| Un-harvested Leave Stripped | 36.8 | 122 | 230 | 335 | 105 |
| Difference | 24.0 | 89 | 39 | 92 | 53 |

***Stubble Leave Strips***

Attachments to swathers have been devised which harvest all the grain and leave tall-standing stubble strips for snow retention. Two types of attachments have been developed: deflectors, which bend the standing crop to the side allowing the stems to be cut closer to the seed heads; and clippers with separate sickle-bars positioned above the main cutting sickle for a short clip to cut seed heads only. Shape and height of the resulting strips vary with the attachment. Deflectors produce leave strips with wide bases (90-180 cm) tapering to 15 cm or less at their tops, 10-22 cm below initial crop height. Clippers form strips of rectangular profile with various dimensions, widths between 60-180 cm and heights 15-20 cm below that of the crop. Tall stubble leave strips formed by prototype swather attachments were initially tested by Steppuhn (1986) during the winter of 1979-80 near Saskatoon, Saskatchewan, on a heavy clay soil. Both deflector and clipper strips increased snowcover by two-fold or more over the conventional snow catch (Table 4). Over-winter soil water gained an average of 39% and 107% with deflector and clipper, respectively. Respective harvest treatments also enhanced grain yields in the subsequent crop of Neepawa spring wheat by 93% and 135%. Additional stubble leave-strip testing was pursued by Nicholaichuk et al. (1984) under the Swift Current climate during the three winters of 1981-84. Average snowcover increased 44% in the deflector and 69% in the clipper test blocks (Table 5).

Table 4. Mean snowcover depth and water equivalent, over-winter soil water gain (5-90 cm profile), and subsequent Neepawa spring wheat yield realized on Southern Heavy Clay by snow-trap swathing with deflector and clipper type swather attachments, 1979-80, Kernen Farm near Saskatoon, Saskatchewan (Steppuhn, 1986)

| Swathing (Sept. 1979) | Snowcover (Mar. 1980) Depth | Snowcover (Mar. 1980) Water Equiv. | Winter Soil Water Gain | Spring Wheat Grain Yield | Snowcover (Mar. 1980) Depth | Snowcover (Mar. 1980) Water Equiv. | Winter Soil Water Gain | Spring Wheat Grain Yield |
|---|---|---|---|---|---|---|---|---|
| | (cm) | (mm) | (mm) | (kg/ha) | (cm) | (mm) | (mm) | (kg/ha) |
| | North Set | | | . | South Set | | | . |
| Conventional | 18 | 42 | 52 | 1163 | 18 | 44 | 58 | 988 |
| Snow-Trap | | | | | | | | |
| Deflector | 43 | 114 | 86 | 2158 | 36 | 84 | 65 | 1989 |
| Clipper | 46 | 122 | 134 | 2576 | 43 | 118 | 91 | 2454 |

Table 5. Mean mid-winter snowfall, and snowcover water equivalent and percent of snowfall measured on fields harvested by swathers with snow management clipper and deflector attachments, near Swift Current, Saskatchewan (Nicholaichuk et al., 1986)

| Year | Snowfall | Snowcover Water Equivalent Deflector | Snowcover Water Equivalent Clipper | Snowcover Water Equivalent Check | Percent of Snowfall Deflector | Percent of Snowfall Clipper | Percent of Snowfall Check |
|---|---|---|---|---|---|---|---|
| | (mm) | (mm) | (mm) | (mm) | (%) | (%) | (%) |
| 1981-82 | 100 | 97 | 122 | 63 | 97 | 122 | 63 |
| 1982-83 | 90 | 44 | 42 | 32 | 48 | 46 | 35 |
| 1983-84 | 50 | 53 | 64 | 41 | 106 | 128 | 82 |
| Average | 80 | 65 | 76 | 45 | 84 | 99 | 60 |

***Uniform Tall Stubble***

Most crop remains, if left standing, provide excellent opportunity for retaining a large fraction of the snow which falls or blows across most fields under snow management. If the stubble fills to capacity, the resulting snowcovers are usually uniform to the effective height ($D_{max}$) of the stubble (Willis et al., 1969). Winter wheat usually survives successfully under uniform stubble with heights of 9 cm for frost-hardy varieties and 20 cm or more for others (Brun, 1984).

Harvest operations, whether by straight combining or by windrow and thresh, typically result in standing crop stubbles of uniform height. However, windrowing the crop with a swather requires a relative low cut (15-20 cm) for placement of the windowed grain. Swather cuts tend to limit the heights of the residual stubble regardless of crop height, and restrict the capacity of the stubble to retain all the snow available, resulting in a relatively low storage capacity. Straight combining presents opportunity for obtaining larger volumetric capacities for snowcover retention; stubble height is limited only by crop height at the time of harvest for grain and by investment choice for forages. Leaving uniform stubble by direct combining is the chosen snow-control technique by most grain producers. They cite low-cost and the flexibility in choosing a snow-retention capacity more equal to the snow quantities available as deciding factors. Steppuhn et al. (1986) measured an average increase in snow water equivalent of 60% by straight combining compared to swath-windrow harvesting of a 1979 wheat crop near Saskatoon, Saskatchewan (Table 6).

Table 6. Mean stubble height, and snowcover depth, density and water equivalent measured in February 1980 for various control techniques for the resulting spring wheat stubble, Kernen Farm, 5 km east of Saskatoon, Saskatchewan (Steppuhn et al. 1986)

| Snow Control Technique | Stubble Height | Snowcover | | |
|---|---|---|---|---|
| | | Depth | Density | Water Equivalent |
| | (cm) | (cm) | (g/cm) | (mm) |
| Swather, Low-cut | 22.9 | 23.8 | 0.180 | 43 |
| Swather, High-cut | 39.4 | 37.5 | 0.171 | 64 |
| Straight Combine | 39.6 | 39.2 | 0.175 | 69 |

## HARVESTING STUBBLE FOR STRAW FIBER

One component of the “green economy” relates closely to the byproducts grown in association with agricultural field crops. Flax crops are well-known for the excellent quality of their fiber and are used in the production of fine linen and paper. Cotton and hemp fibers make useful clothing, rope, and many cloth products. Grass and field straw have served as roofing and in various building material. In addition, industry is finding ways to convert the byproducts of grain and oilseed crops into composites, fuel, plastics, solvents, pharmaceuticals, adhesives, paints, dyes, ink, etc. The consequence is a competing demand for the same field-crop stubble used to control snow deposition and manage snowcovers in agricultural fields.

The heightened demand for straw and other crop residue for the green economy encourages farm implement manufacturers to invent and develop field equipment capable of harvesting specific crop components (grain, chaff, and leaf parts) and leave the straw stubble as a fiber byproduct. One such development has been the stripper header attached to a conventional grain-threshing combine (Figure 1) (Shelbourne 2009). “The basic concept of the

Figure 1. A grain stripper header attached to a combine operating in a Saskatchewan wheat field.

stripper header is that a rearwards rotating rotor positioned in the front of the header is fitted with eight rows of stripping fingers that strip grain from the crop as the combine moves the header forwards while the rotor spins backwards (Figures 2 & 3). The speed of the rotor can be varied according to crop conditions. After the grain has

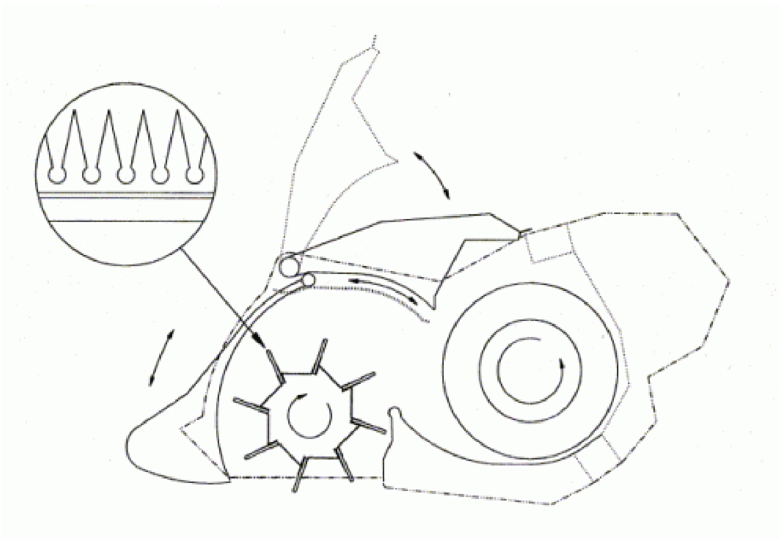

Figure 2. End view of a stripper header moving from right to left with stripping fingers on a rotor rotating rearward in the direction shown.

Figure 3. Stainless steel stripping fingers with cupped ends mounted on the rotor of a stripper header

been stripped by the rotor, a series of deflectors within the header deflect the grain back into a conventional auger and pan. The auger then moves the material to the centre where it enters the feeder-house of the combine. Eighty-five percent of the grain is threshed by the header, meaning that the material entering is predominately grain, chaff, leaf and minimal straw. The benefit of this reduced bulk entering the combine is significantly improved threshing capacity and efficiency." Nearly all of the stubble (straw) left standing in the field represents the maximum available from the crop (Figure 4). If the standing straw is harvested with a swather, dried in a windrow, and bailed, it can be cut in ways to also manage the snow expected during the following winter. For example, a high-cut leave-strip of the stubble should control the snow.

Trials with the stripper header harvesting wheat, flax, lentil, barley and other crops have been conducted on the Canadian Prairies (Lafond et al. 2009, and others). Some of these trials have included qualitative checks for effectiveness of the standing stubble left: (1) after harvesting the grain, and (2) after cutting and utilizing the straw minus a fraction left for snow management. As expected, when the snow arrives, snowcovers accumulate following Eq. 9 as demonstrated in a block of barley stubble from which only the grain was harvested with the stripper header leaving all the straw standing (Figure 5). If narrow strips of the tall stubble straw are left standing and spaced 15 m apart across the field, conditions for snowcover accumulation approach those described in Tables

Figure 4. Lentil straw stubble left standing by a combine with a grain stripper header.

Figure 5. Snowcover accumulation in a block of Saskatchewan barley stubble harvested with a stripper header with the straw left un-harvested.

4 and 5. Trials leaving such strips conducted in Saskatchewan visually confirmed that they could likely be applied to manage snowcovers for agricultural benefit (Figure 6). Additional testing is needed to obtain specific data relating the actual quantity of snow water-equivalent captured to the spacing of the stubble leave-strips. In other field trials, leave strips of lentil and flax stubble left standing to trap snow also showed promise (Figure 7).

Figure 6. Leave strips of tall-standing stubble left after: (1) stripping grain with a stripper header, and (2) cutting the bulk of the straw with a swather.

Figure 7. Snowcover following flax grain harvested with a stripper header and the straw stubble cut uniformly.

## ACKNOWLEDGEMENTS

The authors gratefully appreciate and acknowledge the contributions of Mark Covell, Clay Schwartz and Bryan Nybo in the research reported herein.

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