SNOW MANAGEMENT PRACTICES FOR INCREASING SOIL MOISTURE:
A PHYSICAL EVALUATION

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The paper examines the potential of snow management practices, used to increase snowcover accumulation, for increasing "spring" soil moisture reserves in the Prairie Environment. Examples are given which demonstrate that different stubble management practices are effective in trapping wind-transported snow. These results support the strong association between snowcover accumulation patterns and landscape variables (terrain, vegetative cover) found in the region.

It is emphasized that a linear association between snowcover depth and snowmelt infiltration should not be expected because of the effects of the physical properties of snowcovers, seasonal ablation processes and soil moisture and temperature regimes at the time of melt on the interaction. An empirical expression describing the relationship between infiltration, snow water equivalent and the moisture (ice) content of the soil layer, 0-30 cm, at the time of melt for frozen glacial and lacustrine Prairie soils which do not contain a large number of macropores and for conditions where the entry of water at the surface is not restricted by an impervious layer (e.g. a layer of ice) is presented. It is shown that the increase in infiltration per unit increase in snowcover water equivalent (SWE) decreases rapidly with increasing SWE and tends to a low, reasonably-constant rate. Because of this characteristic it is recommended that to make efficient use of the snow resource for augmenting soil water a crop should be harvested to provide for the trapping of a snowcover water equivalent which is governed by the "expected" soil moisture content at the time of freeze-up. A list of recommended heights of uniform stubble for different moisture conditions and infiltration efficiencies is presented.

It is suggested that to derive maximum benefit from snow management practices, in terms of soil water augmentation, it is necessary to apply them in combination with some tillage, subsoiling or other practice which increases the
number of macropores of a soil. A natural condition favouring snow management occurs in dry heavily-cracked clay soils.

Key words: snow management practices, snowmelt infiltration
Résumé

Ce papier examine la potentialité des pratiques d'aménagement de la neige (telles qu'utilisées pour accumuler une couverture de neige) pour augmenter les réserves d'eau "printanières" d'eau dans les sols des Prairies. Il est démontré, avec examples à l'appui, que les divers pratiques de maniement du chaume se prêtent effectivement à capter la neige transportée par le vent. Ces résultats soutiennent l'association entre l'accumulation de neige et les diverses variantes topographiques (terrain, couverture végétale).

Vu que l'infiltration est affectée par les caractéristiques de la couverture de neige, l'avancement de la saison de fonte, et les régimes de température et d'humidité du sol, il est souligné qu'une relation linéaire est peu probable entre l'épaisseur de la couche de neige et l'infiltration provenant de la fonte. Une expression empirique est présentée décrivant la relation entre l'infiltration, l'équivalent en eau de la couche de neige et l'humidité (teneur en glace) de la couche supérieure du sol, 0-30 cm, au début de la fonte. Cette relation s'applique aux sols gelés, d'origine glaciaire et lacustre, contenant peu de macropores, ainsi qu'aux situations où la surface du sol n'est pas rendue imperméable (i.e. par la présence d'une couche de glace). Il est démontré que le rythme d'augmentation d'infiltration en fonction de l'augmentation de l'équivalent en eau de la couche de neige (SWE) décroît rapidement avec la croissance de SWE, et atteint à la limite un taux faible et effectivement constant. A cause de ce caractéristique, et afin d'utiliser efficacement la ressource que représente la neige, l'aménagement du chaume devrait être prévu en fonction de capter un équivalent en eau de neige tel que dicté par l'humidité "anticipée" du sol au début de la saison de gel. Une liste de hauteurs recommandées de chaume uniforme est présentée pour une gamme d'humidités de sol et de taux d'efficacité d'infiltration.
Il est suggéré qu'afin de tirer un bénéfice maximum de la pratique d'aménagement de la neige, cela en terme d'augmentation des réserves d'eau dans le sol, il serait nécessaire de le pratiquer en conjonction avec un labourage, un fouillage, ou une autre activité qui augmente le nombre de macropores dans le sol. Les sols argileux fracturés par le dessèchement représentent une condition naturelle favorisant l'aménagement de la neige.

Mots clés: aménagement de la neige, infiltration, fonte des neiges
INTRODUCTION

General

The importance of water to the production of cereal grains under dryland farming is well-recognized. For the Canadian Prairies, the Saskatchewan Advisory Council on Soils and Agronomy (1982) recommends that root-zone water reserves of 125 mm and 100 mm are needed in the Brown and Dark Brown soil zones, respectively, at the time of seeding to achieve average yields. The recommendation is based on normal, or close to normal rainfall amounts throughout the growing period. Staple and Lehane (1952, 1954) and Staple et al. (1960) have suggested that soil water additions above certain base levels increase yield in varying amounts; e.g., each 25 mm of water above a moisture reserve of 262 mm to some variable limit may increase wheat yields from 230-400 kg/ha. Similarly, de Jong and Rennie (1969) reported increases in the yield of spring wheat in the range of 200-275 kg/ha for each additional 25 mm of water above the long-term normal precipitation for the relatively-humid, east-central region of the Province of Saskatchewan.

The mean annual amount of precipitation throughout a large part of the grain-producing area of the Prairies is in the range of 300-380 mm. Of the annual total, the relative amounts occurring as snow and rain may vary widely from year to year but tend to an average ratio of ~0.30. These general climatic statistics, considered with the strong dependency of yield on water availability, evince the recognized need for efficient water conservation measures in the region, particularly in view of the increased use of minimum, zero-till and continuous cropping practices.

Throughout the Prairies, neglecting large-scale water diversions and the development of irrigation schemes, snow represents the major source of manageable fresh water. Recently, there has been renewed interest on the potential of
managing snow to increase soil water reserves. Because of the type of snowfall throughout the winter months (usually low density and dry), the high exposure conditions (flat to gently undulating topography with low vegetation) and the climatic conditions (low temperatures and moderate to high wind speeds) of the area, the snowfall and snowcover are susceptible to drifting. Thus, a field of vegetation located downwind of an adequate fetch of snow will tend to fill from the deposition of wind-transported snow. The "filling-in" process is relatively orderly and readily observable when winds occur predominantly from one direction and the vegetation is uniform in height. Starting at the field boundary snowcover accumulates to a depth approximately equal to the height of vegetation for some distance into the field and exhibits a sharp decrease in depth at the advancing front. The pattern suggests that the major mode of transport of the snow particles is saltation, i.e., the movement of particles by a skipping action in a thin layer above the surface. Figure 1 is a cross-section of snow depth plotted with distance on adjacent fallow and stubble fields. These data show three common characteristics: (a) a smaller depth of snow on fallow than stubble; snow having been eroded from the fallow and deposited in the stubble, (b) a depth of snow in the stubble approximately equal to the height of the vegetation, and (c) a sharp decrease in depth (from ~29 cm to 17 cm) at the advancing front (~180 m). Because the two fields were relatively flat and the wind(s) that caused transport were fairly uniform in speed and direction, the distance snow accumulated into the field was fairly constant throughout its length (~1.6 km).

Snow Management Practices and Snowcover Accumulation

The interaction between snow accumulation, terrain variables and vegetative cover has been intensely studied by researchers interested in snow control and water resources. For example, Kuz'min (1960), Adams and Findlay (1966), McKay
and Findlay (1971), Steppuhn and Dyck (1974) and others have developed techniques for determining and mapping the average areal depth or water equivalent of a snowcover based on landscape features. Much research of direct application to agriculture has been undertaken into different practices of trapping wind-transported snow by: (a) growing tall, woody (caragana, ash, maple, etc.) or non-woody (sudan grass, tall wheatgrass, uncut strips of grain) windbreaks adjacent to or within cultivated fields; (b) using different stubble management practices, e.g. different heights of stubble in a field and tall companion crops; (c) erecting snow fences or other mechanical barriers; (d) snowplowing and (e) modifying the micro relief of the soil surface by mechanical or other methods.

Steppuhn (1981) provides an excellent summary of these practices including an extensive list of literature on the subjects. The evidence showing an increase in the depth of accumulated snow with a snow management practice is indisputable; however, the effects of increased depth on snowmelt infiltration, soil water augmentation and crop yield is unclear. Often an increase in snow depth does not accurately reflect the corresponding change in the water equivalent of a snowcover, which is also directly related to snow density. Densities are highly variable and governed by the physical properties of the snowfall and the degree of packing of the snowcover. Typical average values for a Prairie snowcover in mid February fall in the ranges of: 175 to 235 kg/m³ on uniform stubble and 225 to 325 kg/m³ on fallow.

For the Prairies, because of the type of crops grown and the nature of the farming operation, stubble management is the most viable snow management practice. The most popular methods include tall stubble, alternate height stubble, hi-low stubble and leave strips.

**Tall Stubble** - the term "tall" stubble is used in a "relative" sense to infer that the crop is cut at the highest height possible during the harvesting
operation thus leaving a field of "high" stubble. Normally this practice is used when the crop is straight-combined. The actual height of a "tall" stubble is a function of the crop variety, plant density and crop height but usually will fall in the range from 30 to 60 cm.

Alternate-Height Stubble - this practice involves harvesting the crop to leave bands of stubble of alternate height within a field (low and high). The width of each band is normally the width of the swather. By adjusting the swather-height on each round of a field a series of bands of "low" (15-30 cm) and "tall" stubble (30-60 cm) are formed.

Hi-Low Stubble - this practice, also referred to as deflector strips, involves leaving narrow strips of tall stubble in a field. These strips, which are usually 40 to 60 cm wide, are made with a swather or combine header attachment called a deflector. Several deflector units have been developed; a common type is the 'V'-shaped deflector consisting of a V-shaped divider having lifter fingers on either side which are fastened to the bottom of the guards of the cutter head of the swather. As the swather travels through the crop, the deflector separates the crop and forces the stems to bend sideways. The heads of the grain are lifted vertically by the lifter fingers and cut by the knife leaving a strip having the shape of an inverted 'V' which is generally 25-35 cm higher than the adjacent stubble. The use of single or double deflectors is common.

Leave Strips - in this practice, 30 to 40-cm wide strips of crop, spaced 1, 2 or 3 swather/combine widths apart are left unharvested to act as barriers to trap snow. The width of a swather usually is in the range from 4.6 to 7.6 m. With a 30-cm wide strip placed on a 15-m spacing, approximately 2% of the area of a field is left unharvested.

A particular advantage in cutting a field to leave stubble at different
heights is that the vegetative surface formed is aerodynamically rougher than that of a uniform stubble; consequently, its snow trapping efficiency is higher. The practice would be favoured where crop conditions, principally density and height, are insufficient to provide a "tall" dense stubble and on highly-exposed topographic facets e.g., the tops of ridges and knolls.

Figures 2 and 3 are typical snowcover accumulation patterns found in fields harvested with "alternate-height" and "hi-low" practices. The data in Fig. 2 were obtained in March of 1983 at a site where snowcover, wind and other conditions favoured accumulation and it can be observed that the snowcover filled the vegetation. The average density of the snow in the low stubble was 207 kg/m³ and in the tall stubble, 248 kg/m³; the higher density in the tall stubble due to greater packing by wind. Taking an average snowcover depth in the low stubble of 20 cm, and 40 cm in the high stubble, the difference in snow water equivalent on the two strips would be ~57.8 mm which represents an average increase over the field attributable to the tall stubble of ~28.9 mm. The data in Fig. 3 were collected in February, 1983 and show larger accumulations in a field with deflector strips than in an adjacent field of "tall" stubble. In the figure note the change in the accumulation pattern in the strips caused by reducing both the width and spacing of the strips by a factor of about two. The accumulation on the wide spacing exhibits an undulating pattern as a result of scour or erosion of snow from between the strips. Conversely, on the area with the strips placed on the narrow spacing the depth of snowcover is more uniform and deeper; the average increase in depth being approximately 5 cm. Further work is needed to define the interaction between snowcover accumulation, the physical properties (spacings, density, height) of strips and upwind fetch conditions in order to establish design criteria for this stubble management practice.
Snowcover Water Equivalent - Infiltration Interaction

The basic premise underlying the use of any snow management practice for increasing soil moisture is that an increase in snow water, the result of an increase in depth, density or both of these snowcover properties, will result in an increase in snowmelt infiltration. On flat areas when the entry of meltwater to a soil is not limited the association between these two variables may be close to linear. The relationship can be expected to depart significantly from this trend on sloping terrain; when a late-lying snow (which can be related to a deep snowcover) incurs large evaporation losses because of increases in the net radiation flux, due to an increase in solar radiation and a decrease in albedo, and to the flux of advective energy from adjacent areas of bare ground; when a snowcover melts rapidly and encourages surface runoff, and when the entry to and the downward movement of the meltwater in the soil is restricted, for example as may result from refreezing of meltwater on the soil surface or within the profile.

Infiltration to frozen soils involves the complex phenomenon of coupled heat and mass transfer through porous media. The process is affected by many factors including: the hydrophysical and thermal properties of the soil; the soil moisture and temperature regimes; the rate of release of water from the snowcover and the energy content of the infiltrating water. In the absence of major structural deformations in a soil profile, e.g. cracks or other macropores, the major hydrophysical property of a frozen soil which governs its ability to absorb and transmit water is its moisture content. The number and distribution of ice-filled pores reduce the hydraulic conductivity through the blockage of pores and decrease the energy gradient by increasing tortuosity and lengthening the flowpaths. In addition, because the soil temperature is less than $0^\circ\text{C}$ meltwater may refreeze within the soil causing a decrease in the infil-
tration rate or a stoppage of flow. It is generally accepted that the movement of water through capillary pores (as differentiated from large non capillary pores) is only possible when the soil temperature is at its freezing point, but not before (Steenhuis et al., 1977).

An inverse relationship between infiltration and frozen soil moisture has been demonstrated or postulated by many investigators (Willis et al., 1961; Kuzik and Bezmenov, 1963; Gillies, 1968; Shipak, 1969; Romanov et al., 1974; Motovilov, 1979; Granger and Dyck, 1980 and Kane, 1980). Recently, Granger et al. (1984) reported two characteristics of snowmelt infiltration to frozen medium to fine-textured Prairie soils, that were not heavily cracked and did not contain an ice lense on the surface or at shallow depth, which are important to the problem of soil moisture recharge by snowmelt. These were: (a) the average depth meltwater penetrated a soil during the period of snowmelt was 26 cm (standard deviation = 10 cm), independent of vegetative cover (fallow, grass or stubble), and (b) the amount of snowmelt infiltration was inversely related to the average moisture content of the frozen soil layer, 0-30 cm, at the time of melt. These findings suggest that the capacity of frozen soil to infiltrate snowmelt is limited to the ice-free (air-filled) porosity of a shallow depth of soil and puts in question the concept that an increased snowcover accumulation above a certain limit of snow water equivalent will produce significant increases in soil water augmentation. It is suggested that surface runoff and evaporation losses could increase in greater proportion than infiltration and that for maximum benefit and most efficient use of the snow water resource, in terms of water utilization and management, the amount of snowcover accumulated on a field should be closely associated with the fall soil moisture condition.

MATERIALS AND METHODS

Over the past five years, 1978-83 inclusive, a comprehensive study of snowmelt
infiltration to frozen soils was undertaken at ninety sites within the brown and dark brown soil zones of Saskatchewan. A complete description of the locations of the sites and measurement procedures and methods is given in Granger et al. (1984); a summary of these details is given below. The sites included glacial and lacustrine soils ranging in texture from sandy loam to heavy clay under landuse practices common to the region (fallow, grass and stubble). Measurements of accumulated precipitation (snow and rain) and soil moisture changes were made at varying intervals throughout the period from freeze-up in the fall to the end of snowmelt. Estimates of the water equivalent of snowfall were obtained from readings made using a standard MSC Nipher gauge and the snowcover water equivalent was evaluated from direct measurements of depth and density. Soil moisture changes were calculated from changes in the wet density of a soil measured with a twin probe gamma density meter assuming a density of water of 1000 kg/m³. Readings on successive dates give the change in soil density (or soil moisture) in the interval provided no major structural changes (e.g. cracks) occurred within the soil profile between the access tubes used for the radiation source and detector. Complete details of the twin probe density meter and its use in soil density and soil moisture measurement are reported in numerous works (for example see Troxler, undated; Smith et al., 1967; Ligon, 1969; Ryhiner and Pankow, 1969; Reginato and Jackson, 1971 and Jame and Norum, 1980). The data collected provided profiles of soil moisture changes at 2-cm increments to a depth of 1.6 m with a measurement error of approximately 2.5 mm. The change in moisture calculated from readings taken just prior to melt and immediately following the disappearance of the snowcover was taken as the snowmelt infiltration. Note, all sites allowed unrestricted drainage of surface water.

RESULTS AND DISCUSSION
Re-examination of the field data and the results reported by Granger et al.
(1984) suggest that for practical purposes the interrelationship between snow-melt infiltration (INF), snowcover water equivalent (SWE) and the premelt moisture content of the soil layer, 0-30 cm ($\theta_p$) can be defined by the equation:

$$\text{INF} = 5(1-\theta_p)\text{SWE}^{0.584},$$  \hspace{1cm} (1)

in which INF and SWE are in mm and $\theta_p$ is the degree of pore saturation cm$^3$/cm$^3$. Note, the equation is valid for medium to fine-textured soils which are not cracked and the entry of water at the surface is not impeded. Figure 4 shows the family of curves described by the equation.

Equation 1 can be used as the base for formulating a method of estimating the SWE, and corresponding height of stubble, to be used with a given soil moisture condition. It can be observed in Fig. 4 that the rate of increase in infiltration per unit increase in snowcover water equivalent decreases with SWE. Note, this trend is also exemplified by the increase in departure of a given curve from the 45° line describing the condition, INF = SWE. Figure 5 shows the slope ($d$(INF)/$d$(SWE) of Eq. 1) plotted with SWE for different values of $\theta_p$. It is evident that $d$(INF)/$d$(SWE) tends toward a reasonably constant value; the SWE-value ($SWE_c$) where this trend occurs varies with $\theta_p$. The higher $\theta_p$, the lower $SWE_c$, and vice versa. For $\theta_p$ in the range 0.20-0.90, $SWE_c$ appears to fall between 5 mm and 100 mm. The practical aspect of the asymptotical characteristic of the curves is that it can be used to establish an upper limit in the amount of snow water which should be accumulated on a soil in a given premelt moisture condition. Above this limit, the rate of increase in losses greatly exceeds the gains in infiltration. Note, although the finding puts in question the practicality of applying snow management practices to increase the snowcover water equivalent on uncracked frozen soils under all field conditions it must be recognized a management practice will tend to insure a reasonable catch of snow.
It is difficult to specify an optimum value for $SWE_c$ for a given premelt moisture condition. This value depends on many factors: the interaction of snowmelt infiltration and crop yield, especially the incremental increases in yield per unit increase in infiltration; the interactions between direct runoff and erosion and drainage problems; crop conditions at the time of harvest and others. No single value would satisfy all cases. Only general guidelines and criteria can be presented to assist the selection. Table 1 was prepared for this purpose. It lists the recommended snow water equivalent (RSWE) and corresponding height of stubble ($D$), which when filled by a snowcover having a density equal to 250 kg/m$^3$ would provide the RSWE, for different soil moisture levels and infiltration efficiencies; i.e. the relative amount of RSWE that would infiltrate (equal to the ratio $\frac{INF}{RSWE}$). To illustrate the application of these data assume the case where it is desirable to have 70% (or more) of the snowcover water infiltrate a soil having a premelt moisture content of 30% of saturation. Entering Table 1 with $\theta_p = 0.30$ and $x = 0.70$, the recommended value for $D$ is $\approx 19$ cm. It is obvious from the data that for a given $\theta_p$, $D$ increases as $\frac{INF}{SWE}$ decreases. Also, as the infiltration efficiency decreases the incremental increase in the amount of infiltration per unit increase in snowcover water equivalent also decreases; for example, values of $\frac{d(INF)}{d(SWE)}$ corresponding to $\frac{INF}{SWE}$ - ratios of 1.0, 0.9, 0.8, 0.7, 0.6 and 0.5 are 0.58, 0.53, 0.47, 0.41, 0.35 and 0.29 respectively.

The horizontal lines in Table 1 define minimum values of RSWE and $D$ and correspond to a stubble height of 10 cm; practicing farmers suggest that rarely would a crop be harvested at a lower height unless this was unavoidable. The values for $D$ in the table can be adjusted for a different snow density ($p$) by direct calculation using the RSWE listed in the Table; e.g. $D = \frac{RSWE}{p} \times 250$. Because these data were derived from measurements made at sites on relatively-
flat topography, one may wish to consider increasing the values of D listed in
the Table to account for both the differences in infiltration time and exposure
conditions on mid- and upper-slope topographic facets.

A limitation to the use of the above relationships and procedures is they
require an estimate of the premelt moisture content $\theta_p$. Gray et al. (1983)
reported that changes in the moisture regime of a soil may occur over winter
because of moisture transfer as a vapor across the soil/air or soil/snow inter-
faces, the infiltration of water from mid-winter melt or rain events and the
migration of water in response to the freezing action. Usually, losses (de-
creases in the soil moisture content measured at the time of freeze-up) are
common from the 0-30 cm soil layer whereas a 1-m soil depth may show either a
gain or little change in its moisture profile, depending on soil moisture con-
ditions. For practical purposes however the soil moisture content of the 0-30 cm
layer in the fall ($\theta_f$) can be used to index the moisture content at the time of
melt ($\theta_p$). Figure 6 shows the relationships between these parameters for fallow
(Fig. 6a) and stubble (Fig. 6b). The "best-fit" regression equations calculated
from the data were:

Fallow: $\theta_p = -5.08 + 1.050 \theta_f$, and
Stubble: $\theta_p = 0.294 + 0.957 \theta_f$,

in which $\theta_p$ and $\theta_f$ are expressed as a percent moisture by volume. Each expres-
sion has a correlation coefficient of approximately 0.9 with a standard devia-
tion from regression of approximately 3.33% by volume. In review of Figs. 6a
and 6b and Eqs. 2a and 2b it is evident that the overwinter soil moisture losses
from the sites located in fallow are greater than those under stubble. This is
attributed to differences in snowcover; in fact, it is likely that some of the
fallow sites used in the analyses were not snowcovered during the entire winter
period. For practical applications $\theta_p$ can be taken equal to $\theta_f$ for stubble.
SUMMARY

For the Prairies there is ample evidence to support the strong association between the height of a vegetative barrier and the depth of snowcover under adequate snowfall fetch and wind conditions. However the assumption that the amount of snowmelt infiltration can be related directly to snowcover depth is tenuous. The dominant factors governing snowmelt infiltration to an uncracked frozen soil in which entry at the surface is not restricted are the moisture (ice) content and the number of large non-capillary pores of the shallow soil layer at the surface (0-30 cm) at the time of melt. For those soils not containing a high content of air-filled macropores at the time of melt, a condition common to the fine-grained glacial and lacustrine soils comprising a large part of the area under the production of cereal grains in the region, infiltration is limited. This fact puts in question the assumption that the benefits to be derived from snow management practices for soil water augmentation are unlimited. It is possible that increased snowcover accumulation could have the negative effect of causing runoff, erosion and drainage problems. In effect, in terms of water augmentation, there is a limit in the amount of snow water that should be accumulated on a field above which additional accumulations would provide very little benefit. Because the "limiting" value of snow water equivalent is directly related to the soil moisture content at the time of melt it is suggested that a crop should be harvested at a height based on the "projected" fall moisture content at the time of freeze-up. As a general guide it is recommended that for the "broad" soil moisture classes: "very dry" - near the wilting point ($\theta_p \approx 0.2 \rightarrow 0.35$); "medium" - between the wilting point and field capacity ($\theta_p \approx 0.35 \rightarrow 0.45$) and "moist" - near field capacity ($\theta_p \approx 0.45 \rightarrow 0.60$) the stubble should provide a snowcover depth in the range of 24 → 32 cm, 15 → 22 cm and 10 → 12 cm respectively.
The fact that snowmelt infiltration to a frozen soil which does not contain a large number of non-capillary or macropores is limited stresses the need for using mechanical operations, such as subsoiling, deep cultivation or other methods, in tandem with snow management practices in order to obtain the maximum benefit of the snow water resource for crop production.

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REFERENCES


Table 1. Recommended snowcover water equivalent (RSWE) and corresponding stubble height (D), which when filled with a snowcover having a density of 250 kg/m³ will give the RSWE, for different premelt soil moisture conditions (θ_p) and infiltration efficiencies (x).

<table>
<thead>
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<th>θ_p</th>
<th>x = 1.0</th>
<th>x = 0.9</th>
<th>x = 0.8</th>
<th>x = 0.7</th>
<th>x = 0.6</th>
<th>x = 0.5</th>
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<td>D (cm)</td>
<td>RSWE (mm)</td>
<td>D (cm)</td>
<td>RSWE (mm)</td>
<td>D (cm)</td>
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</table>

a) x = infiltration efficiency, i.e. ratio snowmelt infiltration: snowcover water equivalent.
Figure 1. Snowcover accumulation pattern on adjacent fallow and stubble fields, Richlea, Sask., 1983.
Figure 2. Snowcover accumulation pattern on a field cut with "alternate-height" stubble management practice, Eston, Sask., 1983.
Figure 3. Snowcover accumulation patterns on a field cut with "hi-low" stubble management practice at Saskatoon, Sask., 1983. W = width of the deflector strip; S = distance between strips.
Figure 4. Relation between infiltration (\(INF\)), snowcover water equivalent (SWE) and the premelt moisture content of the soil layer, 0-30 cm, \((\theta_p)\) for frozen, uncracked Prairie soils.

\[ INF = 5(1-Bp) \cdot SWE^{0.584} \]
Figure 5. Variation in the slope, \( d(\text{INF})/d(\text{SWE}) \) of Eq. 1 plotted with the snowcover water equivalent (SWE) for different premelt soil moisture conditions \((\theta_p)\).
Figure 6. Relationship between "premelt" (θ_p) and "fall" soil moisture contents of the soil layer 0-30 cm: (a) fallow and (b) stubble.