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Stubble and Seeding Management to Improve Microclimate and Seed Yield of Canola

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Abstract

The benefit of standing stubble for wheat and pulse growth and yield is dependent upon the height of the stubble. Taller stubble traps more snow and creates a better microclimate for seedlings growth than short or cultivated stubble. Since information on the effect of stubble management on the in-crop microclimate of canola was lacking, a three year field study was conducted at Swift Current. Short (15cm) and tall stubble (30cm) effect on microclimate and seed yield were compared with that of cultivated stubble. The microclimate parameters included wind velocity, soil, air, and plant temperatures, solar radiation, and relative humidity. Microclimate observations indicated lower wind speed near the soil surface and lower soil temperatures in tall compared to cultivated stubble. Surprisingly, the stem temperature of canola seeded in tall stubble was higher than cultivated stubble. Biomass production and water use efficiency increased for tall standing stubble compared to cultivated stubble. Tall stubble increased mean seed yield by 9 and 19% compared to short and fall cultivated plots, respectively. The results indicated that a combination of improved microclimate was responsible for the yield increase.

Introduction

Standing stubble increases snow trapping compared to conventional fallow. The amount of snow trapped is directly proportional to stubble height. Therefore, the practice of using taller standing stubble compared to cultivated stubble can increase the water supply to the crops.

Tall standing stubble reduces wind speed, solar radiation reaching the soil surface and maintains soil temperature cooler than fallow (Cutforth and McConkey 1997). The altered energy balance reduced water lost by evaporation. The major changes in microclimate are noticed early in the growing season, when the crop canopies are small and cannot regulate evaporation loss on their own.

The microclimate also has direct effects on the crop (Cutforth and McConkey 1997). Compared to cultivated stubble, there are several reasons why evaporation of water from tall stubble treatments is reduced , two of which are reduced turbulent air mixing due to reduced wind velocity and reduced solar radiation. However, while evaporation is reduced, plant photosynthesis is not. Greater biomass accumulation in tall stubble compared to cultivated/fallow plots has been reported (Cutforth and McConkey 1997). Compared to cultivated stubble treatments, the cumulative result of all microclimatic alterations by tall stubble was to increase yield of wheat and pulses at Swift Current. No information is available on the benefit of tall stubble for canola. Therefore, a large scale field trial was planned with the following objectives: 1) To study the effect of stubble management on microclimate under a canola canopy, 2) To determine the stubble management effect on canola yield and water use efficiency.

Materials and Methods

A field study was conducted on a Swinton loam soil (Orthic Brown Chernozem) (Ayres et al. 1985) at the Agriculture and Agri-Food Canada, Semiarid Prairie Agricultural Research Centre (SPARC), Swift Current for three seasons (1998-1999, 1999-2000 and 2000-2001). The plot size was 15m x 45m. A Glyphosate tolerant Argentine canola cv. 'Arrow' was seeded with a Flexicoil 5000 Air seeder with Flexi-Coil "Stealth" knives (Flexi-Coil Ltd, Saskatoon, SK, S7K 3S5) at 23-cm row spacing. A seeding rate of 9.5 kg ha^{-1} was used to attain an acceptable stand of canola. Fertilizer rate was 84 kg N ha^{-1}, 22 kg P ha^{-1} and 22 kg S ha^{-1}, of which 78 kg N and all of S was broadcasted in the spring and the remaining N and all P was mid row banded at seeding. Post emergent Glyphosate applications kept the experimental area weed free.

Three stubble heights (Tall, $\geq$30 cm; Short, 15 cm; and cultivated) were established in the fall. Stubble treatments were imposed on wheat grown on fallow, which was harvested using a header equipped combine to leave stubble taller than 30. The fall cultivated plot was slowly (<5 km h^{-1}) worked with a tandem disc followed by harrow-packers. About one-half of the standing stubble was buried with the remaining residue lying flat on the soil surface. The short stubble (15 cm high) in fall was deployed by cutting the tall stubble with an haybine without windrowing.

The microclimate measurements were restricted to one replication in each year. Soil temperatures were measured with thermistors at 0.05, 0.10 and 0.30 m depths. Air temperatures were measured with double shielded and passively aerated copper-constantan thermocouples at 0.15, 0.50 and 1.00 m above ground. Wind velocity at 0.15, 0.50, 1.00 and 2.00 m above surface was measured with anemometers (Wind Sentry and Gill 3 Cup anemometers, RM Young Company, Traverse City, MI). Solar radiation above the canopy (only in one plot) and solar radiation reaching the soil surface (approximately 7cm above the ground) were measured using 1 m long tube solarimeters ("Monteith pattern" tube solarimeter, Delta-T Devices Ltd. Cambridge, UK). Temperature measurements were replicated at 3 to 4 locations within the plot. Wind velocity and solar radiation readings were made at only one place.

Before harvest, 1.82 m row lengths from each quarter were hand harvested to measure biomass production. Seed yields were measured with a full-size MF 550 combine (AGCO Corporation, 4205 River Green Parkway, Duluth, GA 30096) after windrowing; the middle swath in each plot (5.5m x 18m) was used for seed yield estimation. Water use efficiency was calculated as the amount of water used to produce a unit of seed.

Results and Discussion

Microclimate

Among the microclimatic parameters measured, soil temperature at 5 cm depth, wind velocity at 15 cm height and solar radiation at ground level were significantly influenced by stubble height. The previous results indicate that the above parameters may have the greatest effect on transpiration, evaporation and water use efficiency (Cutforth and McConkey 1997).

The horizontal wind speed at 2m had a significant role in modifying the effect of stubble management on wind speed near the soil surface (Fig.1). At low wind speed (<5 m s^{-1}), stubble management had no effect on wind profile. As the wind velocity increased to moderate levels (5 to 15 m s^{-1}), tall stubble reduced wind speed closure to soil surface more than cultivated or short stubble. At high wind speed (>15 m s^{-1}), the efficiency of tall stubble to reduce wind speed further improved and short stubble also had lower wind speed than cultivated plot. This suggests that the efficiency of standing stubble in reducing wind speed close to soil surface increases with stubble height and prevailing wind speed.

The temperature profiles indicated higher soil temperature under cultivated conditions compared to stubble conditions during the growing season (data not presented). However, when temperature range was compared, the cultivated plot had a wider range than stubble plots (Fig. 2). Again, comparing the temperature profile at different wind speeds indicated that when wind speed at 2m is low, the air temperature range at 15 cm height widened in the order of short>tall>cultivated stubble. The soil temperature also showed similar trends, although the magnitude was small. The effect of stubble management on soil or air temperature was maximum close to the soil surface. As the wind speed increased, the effect of stubble management on the temperature profile was reduced. This suggests that the effect of stubble management is only observed in the absence of convective energy.

Plant Temperature

Plant temperature was measured by inserting a small thermocouple into the stem of canola seedlings at the10-15 cm height. Plants in tall stubble were warmer than plants in cultivated plots (Fig. 3). The effect was more significant when the solar radiation levels were high. Under, cloudy conditions the effect was reduced significantly.

Effect on Crop Growth and Yield

Stubble management had a significant effect on the biomass production (Table 1). Comparing across 2 years, tall stubble plots tended to produce the most biomass, while the biomass from the short stubble treatments was intermediate to tall and cultivated stubble. Visual observations indicated that early growth of canola in tall stubble was better than in cultivated stubble, which supported the early development of wheat in a tall stubble of corn (Sharratt, 2002).

Similar to biomass, seed yield was greatly influenced by stubble management and seeding management. Pooled over two years, tall stubble treatment produced 9 and 19% higher seed yield compared to short and cultivated plots. Short stubble plots were statistically similar to tall stubble or cultivated plots. Thus, the improved microclimate under tall stubble enabled canola to use water more efficiently to produce higher yields compared to cultivated plots.

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References

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Table 1 Effect of stubble and seeding management on mean biomass production and seed yield of Argentine canola (cv. Arrow) during 1999 and 2000 at Swift Current.

Treatments	**Seeding**			
	Late Fall	**Early Spring**	**Late Spring**	**Mean**
		Biomass (kg ha^{-1})		
Tall Stubble	7995	6621	5314	6643a
Short (Fall)	7902	6639	5061	6634ab
Cultivated (Fall)	7661	5897	4735	6097b
Mean	7852a	6386b	5035c	
		Seed Yield (kg ha^{-1})		
Tall Stubble	2201	1823	1548	1857a
Short (Fall)	1952	1677	1480	1703ab
Cultivated (Fall)	1750	1537	1388	1558b
Mean	1968a	1679b	1472c	

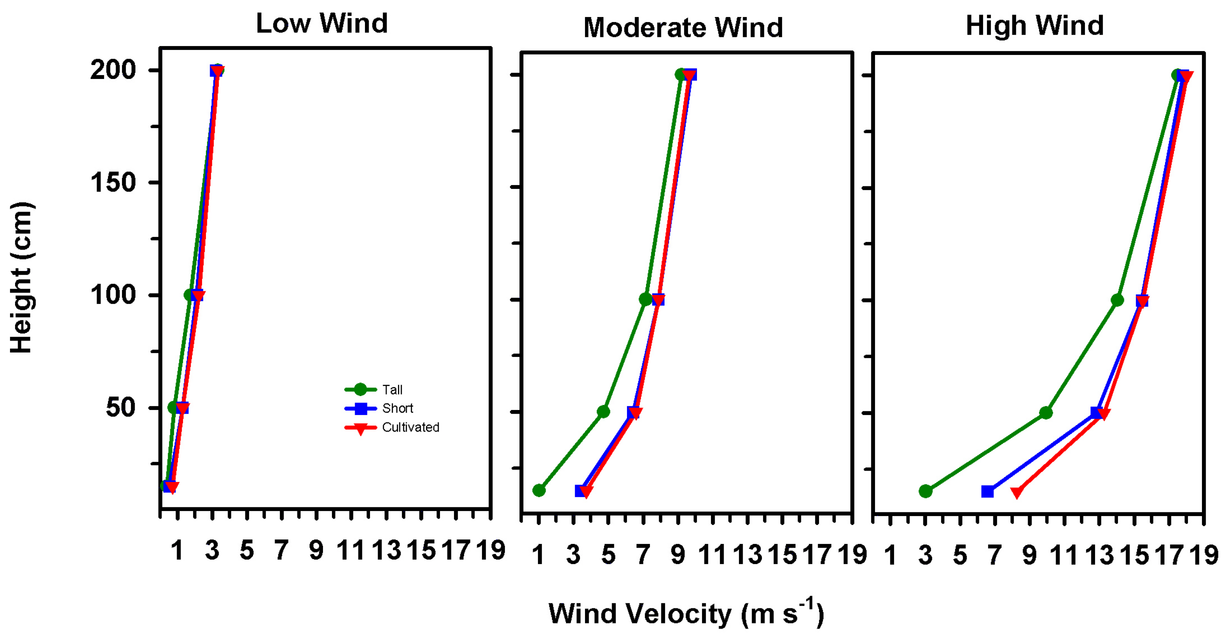

Fig. 1 Effect of stubble management on the wind profiles in the early stages of canola at low (<5 m s^{-1}), moderate (5-15 m s^{-1}) and high (>15 m s^{-1}) wind velocities measured 2 m above the soil surface at Swift Current in 2000.

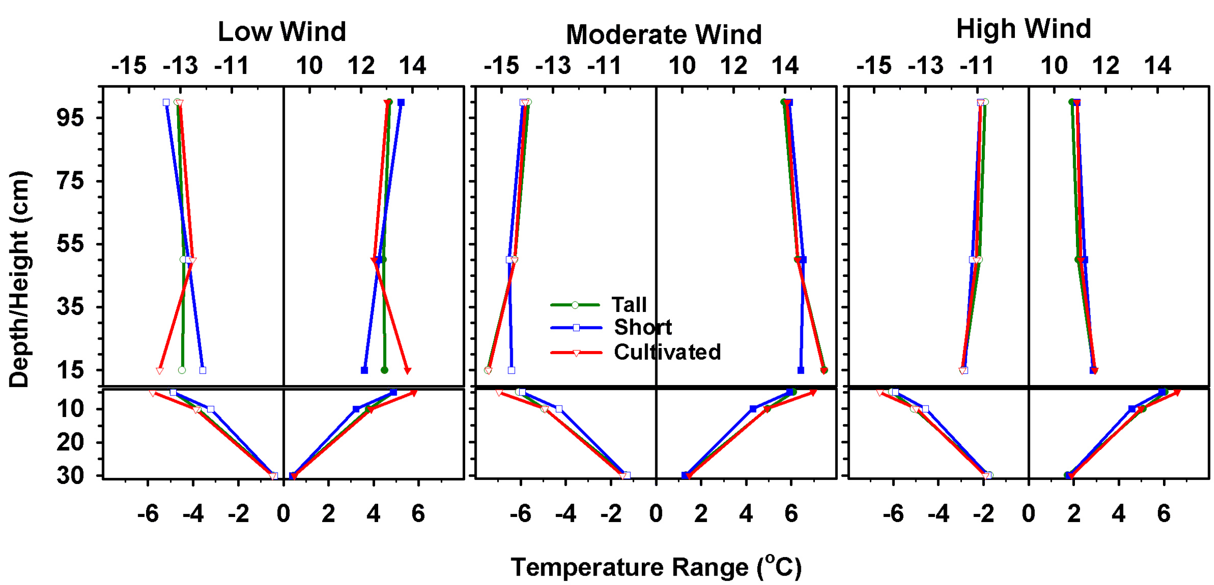

Fig. 2 Effect of stubble management on the soil and air temperature profiles in the early stages of canola at low (<5 m s^{-1}), moderate (5-15 m s^{-1}) and high (>15 m s^{-1}) wind velocities measured 2 m above the soil surface at Swift Current in 2000.

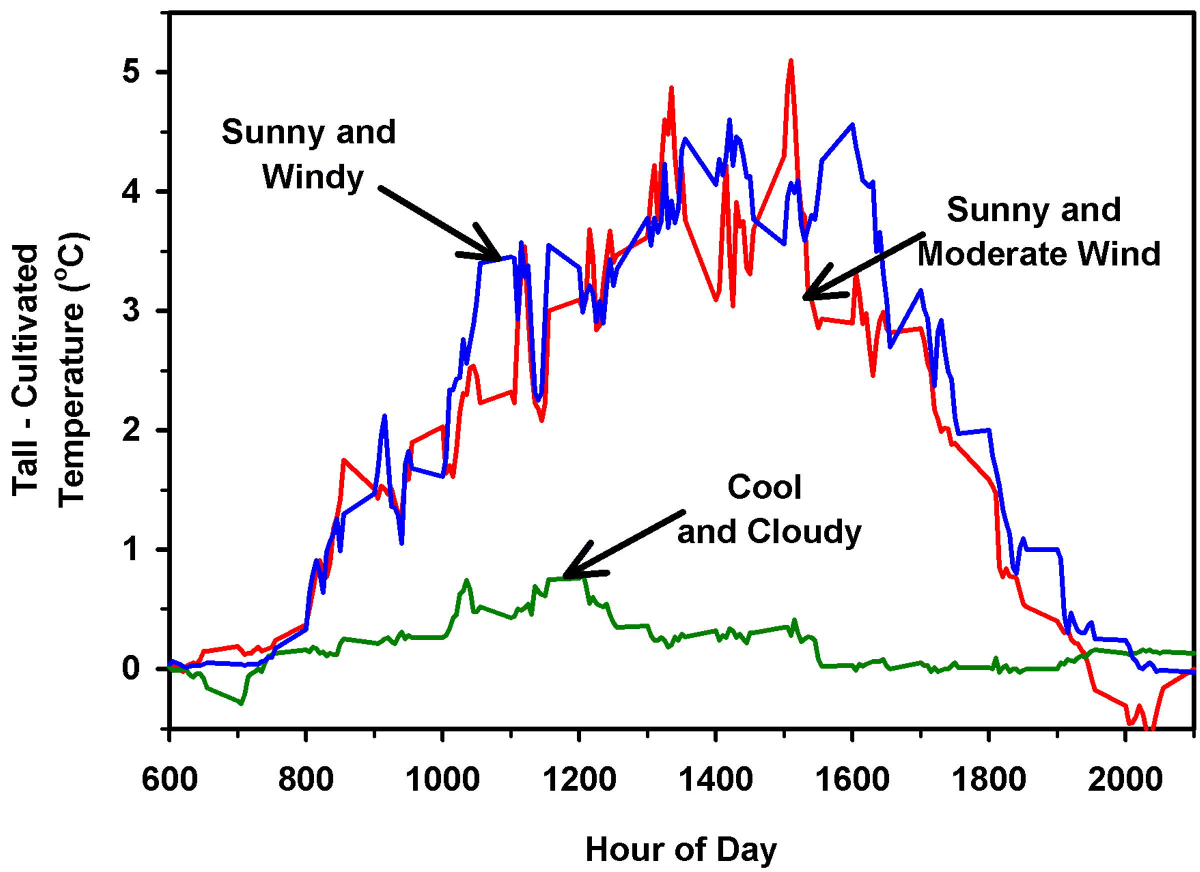

Fig 3. Effect of tall and cultivated plots on canola plant temperature on three contrasting days at Swift Current in 2001.