Effect of Stubble Microclimate on Canola Yield

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Abstract

A field study using farm scale seeding and harvesting equipments was conducted to assess the effect of stubble management on the microclimate, water use and seed yield of canola at Swift Current on Swinton Silt Loam. The differences in wind velocity, soil temperature and solar radiation reaching soil surface indicate significant modification of microclimate by tall stubble compared to cultivated plots. Stubble management did not influence biomass production and water use. But tall stubble significantly increased seed yield and water use efficiency over other stubble treatments. Seeding dates interacted with stubble treatments. The results suggest that, early or fall seeding may be better to exploit the potential of tall stubble. Thus tall stubble has a great potential in the heat and water stressed semiarid prairie.
Keywords: Stubble Height, Microclimate, Canola, Fall Seeding, Yield

Introduction

The growing season on the Canadian prairie is short and crops are subjected to increasing temperature stress and precipitation deficit during the season. The deficit between water supply and the potential evapotranspiration increases through the growing season in this region. The crop productivity is directly proportional to the amount of water transpired. The transpiration can be increased either by increasing water supply or by reducing evaporation. Therefore any practice that improves water available for transpiration either by conserving or by reducing evaporation, increases crop yield.

Standing stubble increases snow trapping compared to fallow field (Lafond et al., 1992). The amount of snow trapped is directly proportional to the stubble height (Aase and Siddooway, 1980; McConkey et al., 1997; Steppuhn, 1994). Therefore, the practice of using taller standing stubble increases water supply to the crops.

Tall standing stubble reduces wind speed, solar radiation reaching 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 effect on the crop (Aase and Siddoway, 1980; Cutforth and McConkey, 1997). There are indications that reduced turbulent air mixing due to reduced wind velocity and reduced solar radiation by tall standing stubble are enough to reduce evaporation, but not enough to reduce plant photosynthesis. On the other hand, greater biomass accumulation in tall stubble compared to cultivated/fallow plots has been reported (Aase and Siddoway, 1980; Cutforth and McConkey, 1997). The cumulative result of all responses to tall stubble was increased yield in wheat and pulses at Swift Current over cultivated plots. However, the response to stubble microclimate depended on crops. No information is available on the benefit of tall stubble for canola. Therefore, a large scale field trial was planned with 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.
3. To determine the effect of seeding date on canola response to stubble management.

Materials and Methods

The experiment was conducted on a Swinton loam soil (Orthic Brown Chernozem) at the Agriculture and Agri-Food Canada, Semiarid Prairie Agricultural Research Centre (SPARC), Swift Current during 1998-1999 season. Six stubble treatments, tall stubble (>30cm), tall stubble with 34 kg ha^{-1} extra N (Black soil zone fertilizer rate), short stubble in fall (15 cm), short stubble in spring, spring cultivated and fall cultivated were laid out in large plots. Three seeding dates, late fall (Nov 6, 1998), early spring (April 24, 1999) and late spring (May 19, 1999) were super imposed on each main plots. The main and subplot sizes were 45m X 45m and 15m X 45m, respectively. Argentine canola cv. Arrow was seeded with Flexicoil 5000 Air seeder. Seed rate of 9.5 kg ha^{-1} was used to get an acceptable stand of both fall and spring seeded crops. The base fertilizer rate was 84 kg N ha^{-1} , 22 kg P ha^{-1} and 22 kg S ha^{-1} with 78 kg N and all S broadcast in spring. Plots were kept weed free with Round up.

The microclimate measurements were restricted to the late spring seeded plots of tall, short stubble (spring) and cultivated (spring) plots in the first replication. The microclimate observations included soil temperature 5cm below soil surface, air temperature and wind velocity 15cm above surface, solar radiation above canopy and solar radiation reaching soil surface (approximately 7cm above ground). Temperatures were measured with 3 to 4 thermocouples or thermistors spread out in the large plot. Wind velocity and solar radiation readings were made at only one place. Soil moisture was measured gravimetrically before seeding and after harvest. Plant dry matter accumulation at harvest was assessed by taking two 1 m^2 samples from opposite sides of the plot. Combine yields from middle swath in each plot (5.5m X 18m) were used for seed yield estimation.

Results and Discussion

The results are for the first year of this 3 year project and, therefore should be considered preliminary.

Microclimate

Seasonal and diurnal trends in soil temperature, wind velocity and solar radiation are presented in Fig. 1 and 2. Less solar radiation reached soil surface in the tall stubble compared to the cultivated plots. The difference was less in the beginning of the season, increased during vegetative growth period, and then decreased with canopy closure. Comparing the solar radiation reaching the ground with incoming solar radiation indicates that early in the season most of the radiation was reaching soil surface in the cultivated plots, while a small portion of it was intercepted by the tall stubble. Similar observations were made by

Aase and Siddoway (1980) and Cutforth and McConkey (1997). As the season advanced both cultivated and tall stubble treatments intercepted more radiation. However, the difference widened with season. The plant growth in tall stubble is reported to be faster than fallow, which broadened differences in radiation interception during vegetative growth (Aase and Siddoway, 1980; Cutforth and McConkey, 1997). The tall stubble reduced wind speed effectively than cultivated plot (Fig. 1 and 2). However, the differences narrowed with crop growth and development. Diurnal trends in weather parameters were observed early in the season. For example, the differences in radiation interception and wind velocity were higher during the middle of the day, when they would have maximum effect on evaporation.

The microclimate effect was reflected in soil temperature close to the surface. For example, soil temperature 5cm below the soil surface was always lower in the tall stubble than the cultivated treatment, but the difference was very small (0.18-1.51 oC) and was mostly observed on warmer days (Fig. 1). The diurnal trend observed earlier in the season indicated wider differences during the middle of the day, which indicates greater soil warming in the cultivated soil compared to the standing stubble. The results indicate that stubble management influence on microclimate is more pronounced in the beginning of the season.

Effect on Crop Growth and Yield

In general crop establishment with fall seeding was better in standing stubble than in cultivated plot. Tall stubble plots, pooled over seeding dates, increased seed yield significantly over cultivated plots by 29 per cent (Table 1). Extra fertilizer did not increase seed yield significantly. Although mean yield differences between tall and short stubble were about 16 %, stubble height did not influence yield significantly. Similarly yield differences between short fall and short spring, which indicate the difference due to snow trapping, was about 8 % and were not significantly different. Thus both improved microclimate and the improved moisture conservation were cumulatively responsible for the higher yield potential of tall stubble compared to cultivated treatment. The advantage of tall stubble decreased with delayed seeding. Fall seeding seems to take full advantage of tall stubble.

Table 1. Canola yield (kg ha^{-1})in response to stubble management under three seeding dates.

Treatments	Seeding Dates			
	Late Fall	Early Spring	Late Spring	Mean
Tall	2741	2177	1877	2265a
Tall+Fert*	2677	2452	1950	2360a
Short Fall	2195	1795	1760	1917ab
Short Spring	2400	1948	1840	2063a
Cultivated Spring		1812	1696	1754b
Cultivated Fall	1835	1713	1833	1794b
Mean	2370a	1983b	1826b	

* Tall+Fert: Tall stubble with additional 34 kg N ha^{-1}.

Biomass production and water use were not significantly influenced by stubble treatments. However, tall stubble was producing about 1.7 kg ha^{-1} more seed yield per millimeter of water used. The tall stubble treatment provided better microclimate for canola by sheltering them from wind and radiation. The tall stubble also reduces evaporation from total evapotranspiration (Cutforth and McConkey, 1997). Thus direct effect on the crop and reducing fraction of evaporation from total water use in tall stubble compared to cultivated might have contributed for the increase in water use efficiency.

Table 2. Effect of stubble management on biomass production, water use and water use efficiency.

Treatments	Biomass	Water Use	WUE
Tall	6671a	356a	6.4ab
Tall+Fert*	7226a	339a	7.0a
Short Fall	6772a	339a	5.7bc
Short Spring	6814a	358a	5.8bc
Cultivated Spring	6007a	354a	5.0c
Cultivated Fall	6459a	365a	4.9c

Summary

The one year field study conducted with field scale equipments reveals that the tall stubble modified the microclimate within the canola canopy, resulting in increased water use efficiency and seed yield. Better microclimate and higher snow trapping contributed for the increase in seed yield. Total biomass production and water use did not accompany seed yield. Water use efficiency increased mainly due to the increase in seed yield. However, seeding dates seem to interact with stubble management. Reasons for better yield in tall stubble need to be elucidated, especially from a soil moisture and temperature stress perspective.

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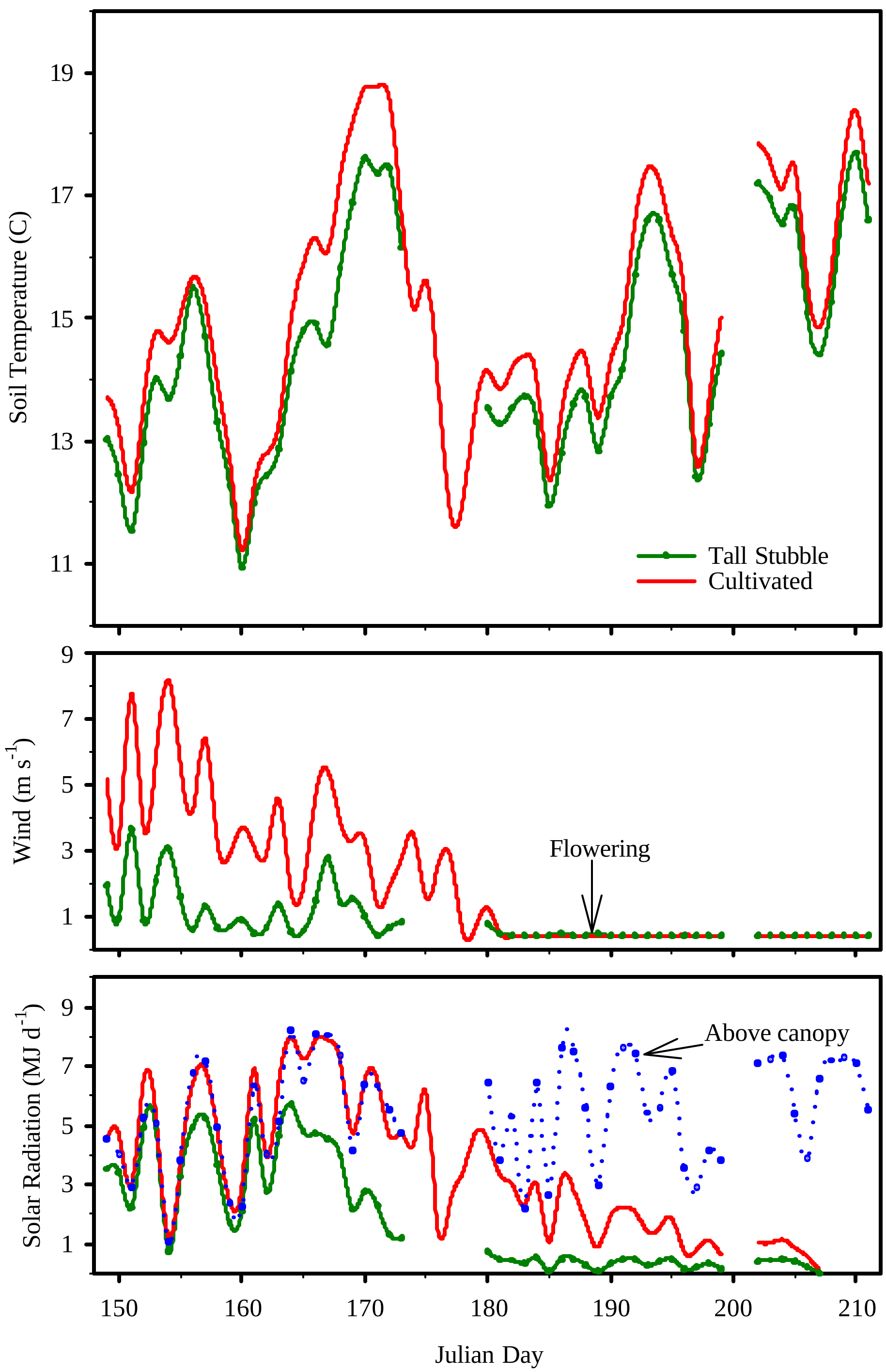

Fig. 1. Seasonal trends in soil temperature at 5cm depth, wind velocity at 15cm from the surface and solar radiation at 7cm from surface at Swift Current in 1999.

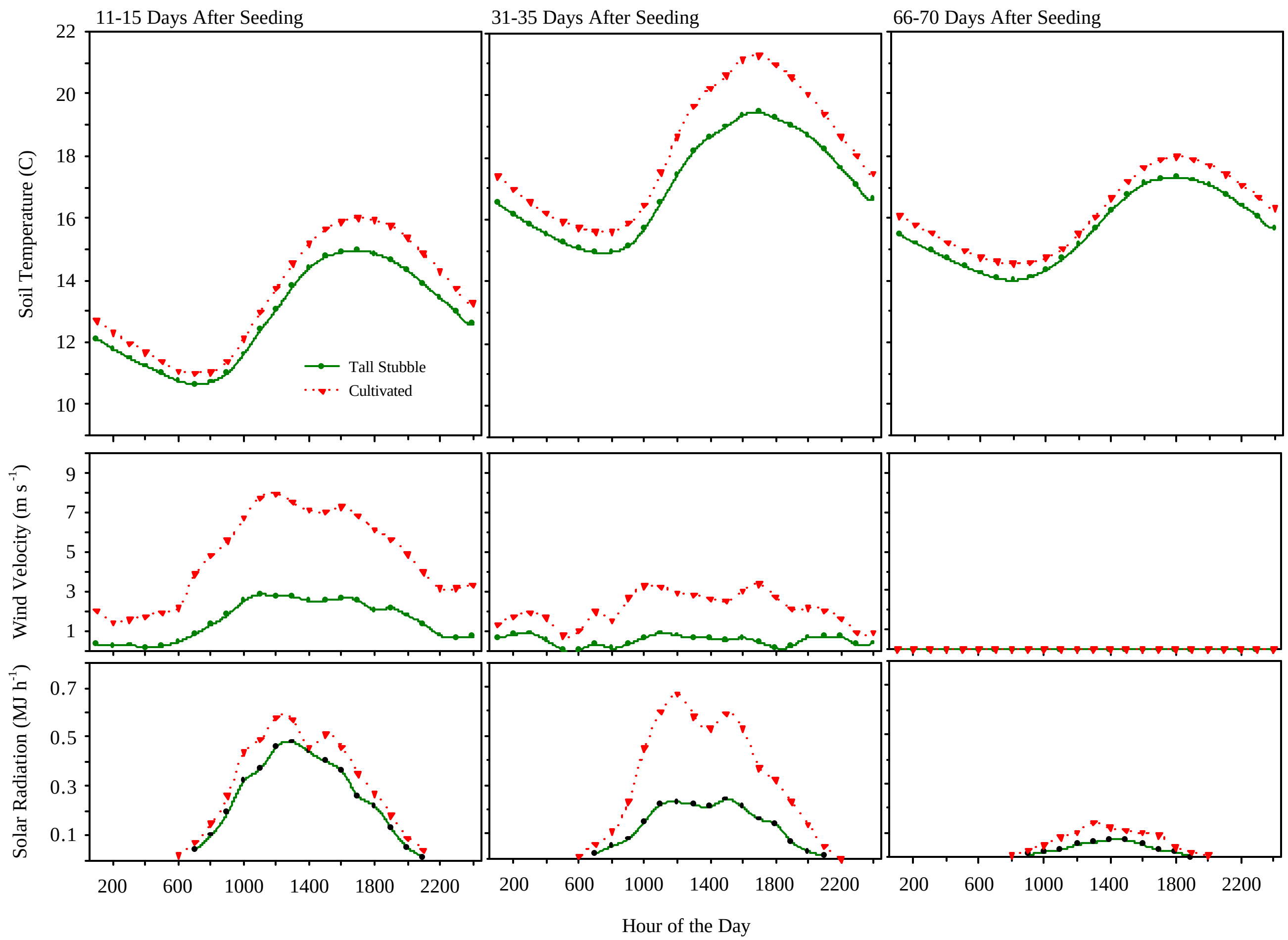

Fig.2. Diurnal trends in soil temperature at 5cm depth, wind velocity at 15cm from the surface and solar radiation at 7cm from the surface at Swift Current in 1999.