Extra-tall stubble and yield of wheat, canola and chickpea

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Introduction

From previous research in the semiarid region of the western Canadian prairies, we know that seeding wheat and pulse crops into tall stubble increased grain yield and water use efficiency by between 8 and 12% compared to wheat and pulses seeded into cultivated stubble (Aase and Siddoway 1980; Cutforth and McConkey 1977; Cutforth et al. 2002). We also found that growing season evapotranspiration (water use) was not affected by stubble height. When the seedlings were small, compared to cultivated stubble, tall stubble (30 cm (12 inch) high) altered the microclimate near the soil surface by reducing the daily average windspeed, soil temperature, and incoming solar radiation, and increasing the reflected solar radiation. Throughout much of the growing season, potential evapotranspiration at the soil surface, measured with minilysimeters, was significantly lower in the tall stubble (Caprio et al. 1985; Cutforth and McConkey 1977). Tall stubble, compared to cultivated stubble, increased the proportion of evapotranspiration that was transpired by the wheat and pulses.

Objective

Producers now have the technology to seed directly into stubble standing 45 cm (18 inches) or higher. In this study, compared to tall (30 cm), short (15 cm), and cultivated stubble, we will determine the effect of extra-tall (45+ cm) stubble on water use and yield of wheat, canola and chickpea.

Materials and Methods

This study 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. There were three treatments imposed on spring wheat stubble: tall, short, and cultivated. All treatments overwintered as tall stubble to equalize snow trapping and then the stubble treatments were applied in the spring before seeding. Stubble plots measured 40 by 40 m.

Spring wheat (cv. Eatonia), Argentine canola (cv. Arrow), and Kabuli chickpea (cv. Chico) were seeded with a Bourgault Air Coulter drill (Bourgault Industires Ltd., St. Brieux, SK. S0K 3V0) with 20 cm row spacing. Seeding dates were 25-27 April 2001 and 29-30 April 2002. Each crop was seeded in a sub-plot measuring 13 m x 40 m within each stubble treatment plot. The chickpeas were inoculated with appropriate peat-based inoculants applied to the seed, and were sprayed for disease control as required. Fertilizers were applied as per soil test recommendations. Herbicides were used for weed control as required.

Crops were harvested with a Massey Ferguson 550 combine (AGCO Corporation, 4205 River Green Parkway, Duluth, GA 30096).

Soil water to the 1.2 m (4 ft.) depth was measured gravimetrically just before seeding and after harvest. From these measurements, evapotranspiration (ET), or water use, was calculated:

ET = (soil water at seeding - soil water at harvest) + growing season precipitation. Water use efficiencies (WUE) were calculated:

WUE = Grain yield / ET.

Data from a series of split-plot experiments was combined across years and analyzed based on Split Plot Design with stubble height as main-plot effect, and crop as subplot effect using the General Linear Models (GLM) procedure of SAS (SAS Institute 1985). The year effect and interactions with year were analyzed as random effects. Within a given year, the split-plot design had three replications. The level of significance was $P<0.05$ unless otherwise stated.

Weather

Overall, 2001 was extremely dry and very warm-a severe drought year; the 2nd driest and 5th warmest year on record for Swift Current (Table 1). Precipitation was 52% of normal. Thus, 2001 was a very stressful year for crop growth and yield. Precipitation from January to April was very low resulting in an extremely dry soil profile by the end of April. Air temperatures during May and July were warmer than normal, especially during August. May and June received less than half their normal precipitation whereas precipitation during July was near normal mainly because of two significant rainfall events. August was extremely dry receiving only a trace of rain.

The dry weather continued throughout 2001 until the end of May 2002. The soil profile was extremely dry with the result that germination, emergence and subsequent crop growth during 2002 were almost completely dependent upon rainfall. Air temperatures during May and August were well below normal and slightly above normal for June and July. Whereas January through May were extremely dry, the rest of 2002 was wet, especially June through September which were very wet. June, August and September each received more than twice their normal rainfall, and the rainfall for July was also substantially above normal.

Results and Discussion

Note: *Because only two years of a four year study have been completed, these results reported here are preliminary.*

At Swift Current, 2001 was one of the driest years and 2002 one of the wetter years on record (since 1885) (Table 1). Therefore, the first two years of this study present a unique opportunity to study the effects of stubble height treatments on water use and yield of spring wheat, canola, and chickpea in a severe drought year and in a very wet year. When averaged across crops and stubble heights, compared to 2001, three times the water was used to produce twice the yield in 2002. As well, water use efficiency (WUE) was significantly higher in the drought year compared to the wet year (Table 2). Averaged across the years and stubble heights, water use was similar across crops although chickpea tended to use slightly more water than wheat or canola. The fall of 2002 was wet and cool, conditions that promoted continued vegetative growth of chickpea well into late fall until stopped by the first fall killing frost. Because of the extended growing season, chickpea used more water than wheat or canola. Wheat yield was much greater than canola or chickpea. The severe drought in 2001 that continued until May of 2002 reduced canola yields in both years. Chickpea yields were reduced in 2002 because of continued vegetative growth due to the very wet fall.

Averaged across crops and years, water use was independent of stubble height (Table 2). However, yields were highest for crops grown in the extra-tall stubble and were lowest for crops gwon in the cultivated stubble. Generally, compared to cultivated stubble, extra-tall stubble

increased yield by 21%. Yields for tall and short stubble were intermediate to the other two. Thus, generally, yields were dependent upon stubble height. Water use efficiency (WUE) also tended to increase with stubble height.

Comparing between crops and averaged across years, canola was most responsive to stubble height (Table 3). Although not significant, yield and WUE of of wheat and chickpea tended to increase with stubble height. Within a given crop, water use was independent of stubble height whereas yield and WUE tended to be highest from the extra-tall stubble.

From this preliminary study, yields and WUE in the semiarid prairie increased as stubble height increased to at least 45+ cm (18+ inches). Crop yield, especially for canola, was postively affected by extra-tall stubble. Water use was independent of stubble height, and therefore, the proportion of evapotranspiration (water use) transpired by the crop increased as stubble height increased.

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Table 1. Average monthly air temperatures and precipitation for the growing season (May through August) 1999 to 2002, as well as the long-term mean monthly mean air temperature and precipitation total.

Month	T_{max} (? C)			T_{min} (? C)			Precipitation (mm)		
	2001	2002	Mean?	2001	2002	Mean	2001	2002	Mean
April	11.9	5.7	11.0	-1.1	-5.7	-1.7	9.8	11.0	22.0
May	19.8	15.8	17.8	4.5	1.2	3.9	22.6	21.9	43.7
June	21.0	21.2	22.0	9.0	10.3	8.7	31.8	143.9	72.8
July	26.5	26.0	26.0	12.9	13.1	11.3	63.0	73.1	52.6
August	29.0	25.2	25.2	12.4	10.0	10.0	3.2	102.2	42.9
				Total (MJJA):			130.4	352.1	234.0

? Long-term mean (1885 to 2002)

Table 2. Water use, grain yield, and water use efficiency (WUE) as affected by year, stubble height, and crop type in the semiarid prairie at Swift Current.

Source	Water Use (mm)	Grain Yield (kg ha^{-1})	WUE (kg ha^{-1} mm^{-1})
Year			
2001	122 b	958 b	7.80 a
2002	367 a	1704 a	4.73 b
Stubble Height			
Extra-Tall	245 a	1492 a	7.40 a
Tall	244 a	1316 ab	6.22 a
Short	245 a	1276 ab	5.77 a
Cultivated	245 a	1228 b	5.82 a
Crop			
Spring wheat	234 a	1831 a	8.87 a
Argentine canola	232 a	1011 b	4.73 a
Kabuli chickpea	268 a	1126 b	5.21 a

Table 3. Water use, grain yield, and water use efficiency (WUE) of spring wheat, canola and chickpea as affected by year and stubble height.

Source	Water Use (mm)	Grain Yield (kg ha^{-1})	WUE (kg ha^{-1} mm^{-1})
Spring Wheat			
Year			
2001	123 b	1358 b	11.08 a
2002	346 a	2304 a	6.66 b
Stubble Height			
Extra-Tall	234 a	1995 a	10.16 a
Tall	234 a	1815 a	8.67 a
Short	235 a	1745 a	8.31 a
Cultivated	234 a	1768 a	8.32 a
Canola			
Year			
2001	121 b	668 b	5.53 a
2002	344 a	1354 a	3.94 b
Stubble Height			
Extra-Tall	234 a	1177 a	5.62 a
Tall	232 a	1062 ab	4.99 ab
Short	232 a	970 ab	4.34 ab
Cultivated	231 a	836 b	3.99 b
Kabuli Chickpea			
Year			
2001	124 b	849 b	6.80 a
2002	411 a	1430 a	3.48 b
Stubble Height			
Extra-Tall	268 a	1266 a	6.22 a
Tall	267 a	1070 a	4.99 a
Short	267 a	1114 a	4.67 a
Cultivated	269 a	1079 a	5.15 a