Corn and Soybean Production in Western Canada: Climate and Heat Unit Risk

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New Meaning for “North American Grain Exchange”
Canola ↓
Central Great Plains
Northern Great Plains
Soybeans-Corn ↑

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Great Plains Producers Could Profit from Spring Canola Crops

By Ann Perry
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Computer modeling by scientists at the U.S. Department of Agriculture (USDA) suggests that spring canola has the potential to become a profitable bioenergy crop for farmers in the semi-arid Central Great Plains.

The research by Agricultural Research Service (ARS) agronomist David Nielsen and others could provide producers with alternatives for stretched water supplies and increasing crop production. ARS is USDA’s chief intramural scientific research agency, and this work supports the USDA priority of developing new sources of bioenergy.

Nielsen, who works at the ARS Central Great Plains Research Station in Akron, Colo., worked with colleagues to combine existing plant growth computer models and generate spring canola production simulations. They ran their results from the combined model with 15 years of regional weather data, four different soil water levels at planting time, and other site-specific information to generate spring canola yield estimates for nine locations in Nebraska, Colorado and Kansas.

Results from their crop simulations suggested the highest yields would be produced in the north-central area near Champion, Neb., and the lowest yields would be produced in the south-central area near Walsh, Colo. When 75 percent of the soil water was available for crop use at planting, the model indicated six of the sites had more than a 70 percent probability of producing a canola seed yield of at least 900 pounds per acre.
Recent changes in prairie climate
Recent changes in agroclimatic risk
Predictions for future prairie climate
Future corn and soybean production risk
Air Temperature in Southern Canada has increased
- Minimum temperature has increased at more than twice the rate of the maximum
- Most of the increase has occurred in the most recent decades

Mean annual maximum and minimum air temperature in comparison to the 1961-1990 mean in southern Canada (Vincent et al. 2012, J Geophys Res 117: D18110).
Maximum Air Temperature has increased across Western Canada (1950 to 2010)
- Most significant increase during winter and spring, variable in summer and fall

Minimum Air Temperature has increased across Western Canada (1950 to 2010)
- Especially during winter and spring, somewhat in summer. Variable in fall

Long Term average evaporation in Western Canada has decreased (1961-2000)

Down arrows – decreasing trend; circles – no significant trend at p = 0.10. (Burn and Hesch, 2007, J Hydrol 336: 61)
Long Term Average Precipitation in Western Canada
- most of the annual precipitation is received as rainfall with the highest monthly amounts in June, July and August

Source: Environment Canada 1971-2000 Climate Normals (climate.weather.gc.ca)
Long Term Average Precipitation in Western Canada
- 20 to 35% of average precipitation is received as snow

Mean Annual Snowfall (% of Total Prec)
1971-2000 Average

Source: Environment Canada 1971-2000 Climate Normals (climate.weather.gc.ca)
Rainfall has increased across Western Canada (1950 to 2009)
- Especially in spring, somewhat in the fall and variable in summer

Snowfall has generally decreased across Western Canada (1950 to 2009) - especially in winter, generally in spring, variable in fall.

Climatic Limitations for Crop Production on the Northern Great Plains

- Short frost-free period
- Short thermal time (i.e. lack of heat units)
- Non-optimal soil moisture conditions
Most areas receive 100+ frost-free days, on average.

1 year in 10, most of the prairies receive less than 100 FFD

Frost-Free Period has been Increasing Significant Inter-annual Variation

The rate of change in the frost-free period is not the same everywhere.

Rate of change (d y⁻¹) in the frost-free period (using a 0°C benchmark) from 1940 to 1997 (Cutforth et al. 2004, Can. J. Plant Sci. 84: 1085–1091).
Temperature is the most important weather condition affecting plant development.

CHU mimics plant response to temperature

Crop (Corn) Heat Unit

http://www.omafra.gov.on.ca/english/crops/facts/93-119.htm#c4
Cumulative Corn Heat Units from May 15 to first fall frost of -2.2°C or lower on the northern Great Plains based on weather station data for 1971 to 2006.


Canadian prairies have higher risk for limited CHU accumulation compared to the Northern USA.
Annual accumulation of 2000+ CHU in most areas.

Average CHU accumulated during a growing season.
1 year in 4, over half the prairies is under 2000 CHU.

Annual CHU accumulation has generally increased.
Brandon CHU Time Series (1920-2000)

\[ y = 1.0312x + 321.55 \]
Brandon CHU Time Series
(1920-2007)

\[ y = 1.1799x + 31.92 \]
Trends in long-term annual CHU accumulation have changed little with weather of the past 10 years.

<table>
<thead>
<tr>
<th>Weather Station</th>
<th>Period of Record</th>
<th>Slope Up To 2000</th>
<th>2010</th>
<th>Annual CHU - Change in Long-Term Trend</th>
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<tr>
<td>Brandon</td>
<td>1920-2007</td>
<td>1.0312</td>
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<td>Scott</td>
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<td>Medicine Hat</td>
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<td>-1.8939</td>
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</tbody>
</table>
2013 CHU accumulation

Prairie Region

CHU
1535
1735
1935
2135
2335
2535
2735
2935
3135
3335

Created by: WIN
Weather Innovations Consulting LP
Created for: weatherfarm
2013 CHU-slightly below to slightly above average
Crop water demand during the growth period of corn at 50% risk.
Estimated corn evapotranspiration and yield loss per stress day during various stages of growth

Evapotranspiration (inches per day) and % Yield Loss per Day derived from Rhoads and Bennett (1990) and Shaw (1988).
Outlook is for a 1 to 4°C temperature increase (greater winter than summer) by 2045-2065.

Precipitation outlook - slight increase (winter), small decrease to small increase (summer) by 2045-2065.

Extreme Precipitation

Latest Intergovernmental Panel on Climate Change Draft Report

- “There is medium confidence that, in some regions, increases in heavy precipitation will occur despite projected decreases in total precipitation in those regions. Based on a range of emissions scenarios... a 1-in-20 year annual maximum daily precipitation amount is likely to become a 1-in-5 to 1-in-15 year event by the end of the 21st century in many regions”

- “There is medium confidence that droughts will intensify in the 21st century in some seasons and areas, due to reduced precipitation and/or increased evapotranspiration. This applies to regions including southern Europe and the Mediterranean region, central Europe, central North America, Central America and Mexico, northeast Brazil, and southern Africa.”

- “There is medium confidence (based on physical reasoning) that projected increases in heavy rainfall would contribute to increases in local flooding in some catchments or regions”
Summary

• Frost-free period is likely to continue increasing in length, especially early season
• Heat units are likely to continue to increase
(For both of the above, significant variability year-to-year, variation between locations)

• Precipitation outlook is uncertain
• Potential for both increased drought and increased flood

Bottom Line
• Soybean and corn production outlook is generally positive from a heat unit perspective but this may be overshadowed by increasing occurrence of extreme precipitation events.