THE EFFECT OF CLIMATE ON THE YIELD AND GROWTH OF CANOLA IN WESTERN CANADA

W.F. Nuttall, R.K. Downey and J.P. Raney
Agric. & Agri-Food Canada

Project Funded by Saskatchewan Agriculture and Food &
Saskatchewan Canola Development Commission

Abstract

The effect of temperature and precipitation on the yield and quality of Tobin canola has been determined by a statistical method known as regression analyses. The equations obtained from this analyses were used to show how an increase in maximum temperature in the growing season reduced yield, increased protein, decreased oil content and decreased time to maturity. The equations, also, showed that increased rainfall increased yield, decreased protein, and increased time to maturity. Lower minimum temperatures were associated with higher chlorophyll content of seed. The information could be used by farmers and researchers as an index of suitability of either Polish (Brassica rapa L.) or Argentine (Brassica napus L.) cultivars for production areas in the Province.

Introduction

Previous research has shown that temperature and precipitation have a dramatic effect on seed yield of Brassica napus L. cultivars (Nuttall et al 1992)*. Weather is important not only for yield, but for quality of seed. There was little or no research on the detailed effect of weather variables on yield of Brassica rapa L. cultivars. There was little or no research on the detailed effect of temperature and precipitation on quality of canola seed. Therefore, the objectives of this project included an investigation of temperature and precipitation effects on yield of Brassica rapa L., protein and oil content. The effect of temperature on days to maturity and chlorophyll content of seed would be related by regression analyses.

*Nuttall, W.F., A.P. Moulin, and L.J. Townley-Smith. 1992 Nitrogen, phosphorus, precipitation and temperature effects on yield of canola. Agron. J. 84:765:768.

Methods and Experimental Design

The Co-operative canola/rapeseed cultivar experiments conducted throughout the Prairie Provinces were the database for determining the yield and quality and other agronomic characteristics of canola cultivars in relation to weather variables of temperature and precipitation. Temperature and precipitation records were taken from Atmospheric Environment stations located near or at the experimental sites. Brassica rapa L. cultivars were selected, in particular, Tobin and Parkland to determine if there were differences in yield of these cultivars among sites located in western Canada.

A statistical analysis was performed to determine interactions between cultivars, sites and years affecting yield and quality of seed across western Canada from 1991 to 1993.

Mathematical models calculated by regression analyses were developed from temperature and precipitation data and yield and quality of canola information. The models were used to determine the relationship of maturity (Brassica napus L.), cultivar Westar, to temperature and precipitation. The mathematical models were used to calculate results placed in two-way tables with precipitation and temperature as co-ordinates.

Results

The statistical analyses indicated that there was a significant interaction among sites on cultivar yields. In other words, the ranking of yield could change among cultivars'for different sites (Table 1). Over the two years, 1991 and 1992, the yield of Tobin canola (Brassica rapa L.) was related (by quadratic equation) to average maximum temperatures for June and July (Table 2) and only to June rainfall. Thus the results from this period showed little effect of growing season rainfall on yield, except in June. The data over the period from 1991 to 1993 were fitted to a more complex model. This model was developed to relate yield (Table 3) to maximum temperature and precipitation over intervals of 15 days or one-half months. The model was developed in this way because monthly intervals of weather data did not account for much of the yield variation with this species. The results in Table 3 indicate very little effect of precipitation on yield. Because there were ten variables (temperature x precipitation x 5 one-half monthly intervals), any combination of these variables could affect yield. The results in Table 3 give a simple relationship of three temperature and four precipitation ranges over the period from June 1 to August 15. Over the period from 1991 to 1993, frost appeared to have affected the model with Westar canola (Brassica napus L.), therefore, the effect of temperature and precipitation on yield of this cultivar, are shown in Table 4 (taken from the Final Report, Saskatchewan Canola Development Commission, January, 1993), for the period from 1989 to 1991.

The relationship between protein content of Tobin canola and weather variables of temperature and precipitation are shown in Table 5. Only the June 1 to June 15 average maximum temperatures accounted for much of the protein increase with increased temperature during this period over the years 1991 to 1993.

Increased precipitation in the latter part of June and July, also, accounted for much of the protein decrease among sites over this period.

Oil content of Tobin canola was decreased with increasing maximum temperatures of June (Table 6), but there was little effect of precipitation, June 1 to June 15.

The effect of temperature alone, did not account for much of the variation in maturity of Westar canola. Therefore, precipitation was included in the model and a very good relationship to maturity was obtained as shown in Table 7. Excessive chlorophyll in the seed and therefore, the oil of canola is a problem in many crop years. Low temperatures during the growing season have been associated with higher chlorophyll contents in the seed of canola. A regression model, indicated that low minimurn temperatures throughout June, July, and September accounted for higher chlorophyll contents in seed. However, for August, higher minimum temperatures were associated with higher chlorophyll contents. In Table 8, the highest chlorophyll content was obtained with the lowest seasonal minimum temperature and the lowest chlorophyll content was associated with highest minimum temperature. However, this relationship was not consistent and this inconsistency could partially be explained because higher minimum temperatures in August were associated with higher chlorophyll content.

Discussion

Because cultivars may respond differently among sites, the number and distribution of test sites for canola should be chosen to represent the areas were farmers are likely to grow the crop. The interaction among sites and the differences in sites among years makes the problem of selecting the proper number and distribution of test sites difficult. The use of weather models to indicate the potential yield of a crop under the conditions of Land Resource Areas, as mapped by the Soil Survey units, could be used to give some indication of the number of test sites required. The sites would be selected to cover several Land Resource Areas dependent on yield.

The relevance of temperature and precipitation to yield of crops has only been related mathematically in recent years. We know that with increased rainfall that yield is usually increased and sometimes with excessive rainfall is decreased. 'Also, we know that high temperatures may reduce yield and that very low temperatures may have the same effect. Until meterologists and agrometerologists made specific studies with the use of high speed computers, no progress, was made in developing yield and weather models. The use of half monthly intervals within the growing season in this study to determine the specific effect of precipitation and temperature (maximum) among sites and years, proved effective in accounting for variation in yield, oil and protein of Tobin canola. Other, factors such as very low temperatures where there may be frost damage could have affected the models, particular-y, with Westar (Brassica napus L.). The development of models to accommodate all conditions, including frost damage, may be limited by the amount of data available. The maturity of canola cultivars, particularly, later maturing (Brassic napus L.) was not only affected by temperature, but by precipitation as well. Most often only temperature is used in models relating to maturity. The use of this model will be very useful in determining the range of maturity of canola at specific sites or in Land Resource Areas.

Conclusions

The weather variables, temperature and precipitation can now be used to estimate yield for both species of canola, Brassica napus L. and Brassica rapa L. Temperature and precipitation, also, can be used to estimate the protein and oil content of Tobin canola. The maturity of Westar can now be estimated with the use of both temperature and precipitation. A model is available that confirms that low minimum temperatures throughout the growing season increases the chlorophyll content of Brassica napus L. canola cultivars.

The information is of benefit to the canola industry, and the procedures could be used by breeders in selecting new cultivars. Because several million acres of canola are seeded each year in western Canada, any improvement in yield, quality or maturity would result in significant economic return to the industry. Based on weather records, the selection of the most suitable species of canola by farmers based on yield and maturity for their production area of the Province would result in greater economic return.

Table 1. The relationship between cultivar yield and three different sites over the period 199 1 to 1993, illustrating cultivar x site interaction

Site	Cultivar	Rank	Yield (t/ha)
Loon Lake	Tobin	2	1.481
	Parkland	1	1.505
Melfort	Tobin	2	2.294
	Parkland	1	2.344
Saskatoon	Tobin	1	2.710
	Parkland	2	2.617

Table 2. The relationship between yield of Tobin canola and average maximum temperatures for June-July and June rainfall, 1991 and 1992

		June Precipitation (mm)		
June max T.	July max T.	40	60	160
in °C		------yield in t/ha------		
17	23	--	0.276	--
19	23	1.794	2.097	1.583
21	23	2.723	3.025	2.512
21	26	1.526	1.828	1.314
25	23	1.905	2.208	1.694
25	26	0.708	1.010	0.500

Table 3. The relationship between yield of Tobin canola and average maximum temperature and total precipitation over the period from June to August 15,199 1 to 1993

	Precipitation (mm)			
Max T.°C	40	100	150	200
	------yield in t/ha_____			
22	2.620	2.609	2.580	2.534
24	2.104	2.094	2.065	2.019
26	1.364	1.352	1.324	1.278

Table 4. Effect of temperature and precipitation on yield of Westar canola, 1989 - 1991

	------June-July-August Precipitation (mm)------				
Max. Temp. °C*	80	160	240	320	400
	------yield in t/ha------				
20	2.52	2.77	3.03	3.29	3.54
22	1.68	1.94	2.19	2.45	2.71
24	1.28	1.53	1.79	2.05	2.30
26	1.27	1.52	1.78	2.04	2.30

*Mean of maximum temperatures for July and August.

Table 5. The relationship of protein content of Tobin canola and June 1 to June 15 average maximum temperature and June 16 to June 30 and July 16 to July 3 1, precipitation (1991 & 1993)

	Precipitation (mm)			
Max. Temp. °C	50	100	150	200
	-------protein %------			
22	42.5	41.5	40.7	39.8
24	43.8	42.9	42.0	41.2
26	46.3	45.4	44.5	43.7

Table 6. The relationship between oil content of Tobin canola and June average maximum temperature and June 1 to June 15 precipitation (1991 to 1993)

	Precipitation (mm)			
Max. Temp. °C	50	100	150	200
	------- oil % ------			
22	43.6	43.3	42.9	42.3
24	40.6	40.3	39.9	39.3
26	34.1	33.8	33.4	32.8

Table 7. The relationship between average temperature from June to August and total precipitation for June, July and August and maturity of Westar canola, 1991 to 1993

Max. Temp. °C	Precipitation (mm) 20	120	180
	------maturity (days from seeding)------		
18	94	103	107
20	97	106	110
22	97	105	109
24	91	100	104
26	84	92	96

Table 8. Minimum temperatures averaged over June to September and chlorophyll content of Westar canola, 1992

Chlorophyll content (ppm)	Minimum Temperature (°C)
6.6	
11.4	6.97
21.0	7.09
27.0	6.53
31.4	6.22
34.6	9.53
138.4	6.85