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Effect of Environmental Factors on the Composition of Canadian Canola and Flax.

Long term trends and qualitative evaluations (1)

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Abstract

Carefully controlled agronomic studies have generated much experimental data that have allowed the development of theories regarding the effect of environment on oilseeds quality. The practical effects of these theories were tested by examining the results from quality surveys of flax([1]) and canola conducted over the past 60 years by the Grain Research Laboratory. Oil contents were inversely correlated with protein content, yield and total production. For canola and flaxseed, years with cool wet harvests usually resulted in high levels of oil content and correspondingly lower protein, although severe conditions led to decreases in both oil and protein. Years with cool growing conditions gave oils with higher iodine values (unsaturation) flax seed but it was difficult to relate weather patterns in canola to changes in saturated fatty acids due to the massive shift in species during recent years.

Introduction

High temperatures during the growing period were shown to lead to a more rapid maturity with a lowering of the oil content and degree of unsaturation but an increase in protein . While a uniform high temperature throughout the growing period demonstrated this effect for flax and rapeseed, one study suggested that night time temperature may play an important role in deposition of oil in flax. Low temperatures during the growing period, conversely, have been found to result in delayed maturity, more vegetative growth, higher oil content and lower protein content. Marquard , based on phytotron studies, has suggested that a change of 1ºC was equivalent to a change of 1% to 1.5% oil for the brassica seeds in his study.

Other environmental factors that may play a role in establishing oil and protein content include moisture stress , low sulfur , high nitrogenand increased photoperiod , all of which have been shown to reduce oil content and conversely increase protein content.

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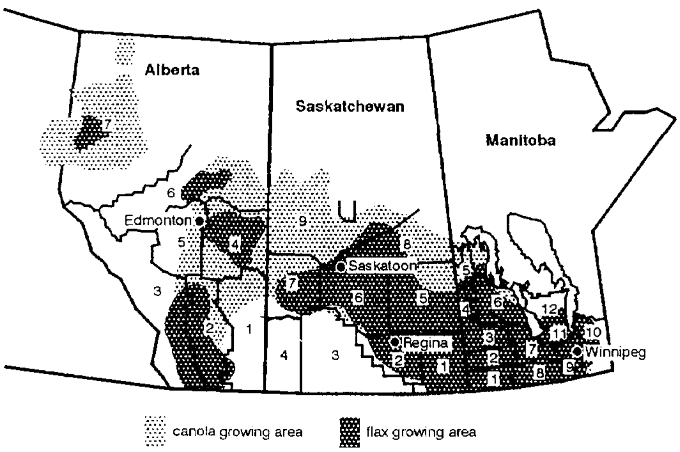
2 Flax, in North America, is the term used to designate oilseed *Linum usitatissimum* L.. Linseed is used for this designation in Europe

The objective of the study was to determine to what extent quality data results from Grain Research Laboratory surveys could be related to weather information. This part of the work relates changes in annual average quality data with qualitative observations on the weather, especially at harvest time. A second part will provide initial quantitative relationships between weather data in the form of monthly temperature and rainfall and quality. Further work might lead to a prediction model for quality based on environmental factors such as temperature and rainfall similar to that proposed for oil quality in sunflowers grown in Australia



Materials and Methods

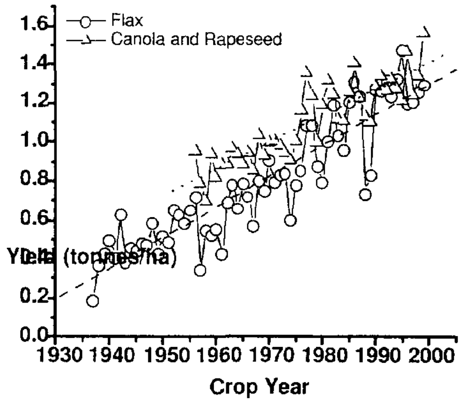
In Western Canada, canola is grown over a wide area with the greatest concentration of production traditionally occurring in the northerly portions of western prairies (Figure 1). Recently there has been an increase in production of canola the southern prairies and this trend seems likely to continue. Flax is grown more predominantly in the southern prairies with the greatest concentration being in the southeastern portion of the growing area.

Quality data used in this study were derived from harvest surveys for western Canadian canola and rapeseed carried out between 1956 and 1994 and from flaxseed for the period of 1938 to 1998.

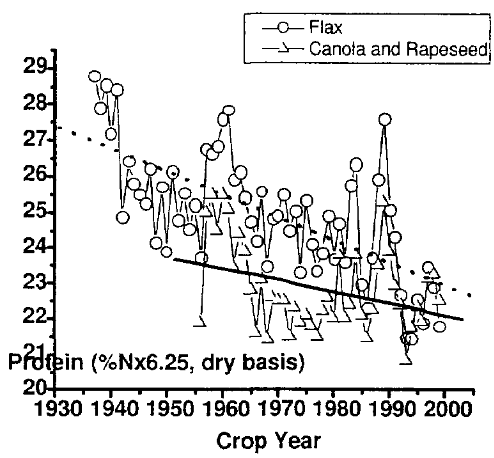
Methodology used in analysis of samples has changed somewhat over the past 50 years . For example, Kjeldahl testing with mercury-based catalyst was used from 1950 to 1972. From 1972 to 1990, the mercury catalyst was replaced with titanium based catalysts. Since 1991, nitrogen has been determined by combustion. Similarly, oil content determination has varied in the number of grinds and the length of time of extraction. Data used in this study was corrected to account for the small but significant differences between the different analytical techniques used over the years.

General observations on annual weather patterns relevant to harvested grain were derived from individual crop bulletins for the years involved and from a database maintained by the director of the Grain Research Laboratory (Keith H. Tipples, personal communication).

Results and Discussion

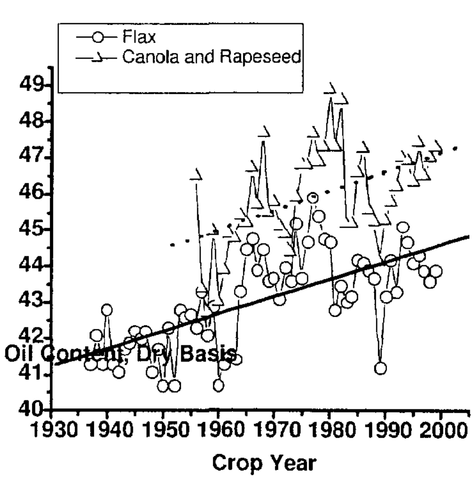


Between 1938 and 1998, mean annual oil contents for flaxseed increased from about 41% to 45% while protein contents decreased from 27% to about 22%. At the same time, average yield increased from less than 0.5 tonnes per hectare to nearly 1.5 tonnes per hectare (Figure 2). Similarly for rapeseed and canola, since 1956, oil content has increased by about 2.5 percentage points while protein has decreased by a similar amount. Yield has shown an increase from 0.8 tonnes per hectare to nearly 1.5 tonnes per hectare. Much of the change in oil, protein and yield for both flax and canola is probably due to improved varieties but it is also likely that



improvements in agronomic techniques have also played a role, particularly in the yield increases.

A major objective of this study was to examine the reasons for variation of quality factors above and below the trendlines shown in Figure 2. These variations are much larger than might be expected due to analytical variance including sampling and are primarily due to a combination of a number of environmental factors. The trendlines themselves present an interesting picture since they show almost parallel increases in yield and oil content for both flax seed and canola despite the almost complete segregation of the breeding programs for each. The more rapid decline in protein content in flax seed might be attributed to the lack of emphasis on this characteristic in breeding programs.



Temperature and moisture may be expected to have a significant effect on quality as indicated in the studies cited in the introduction. To a certain extent, this may be associated with growing period where planting date especially has been shown to influence the oil and protein content of harvested seed. Excess stress, for example in the form of hail or severe frost, has been shown to give a reduction in both oil and protein content.

For canola, there are significant differences in quality between the *B. napus* and *B. rapa* species. *B. napus* varieties have more protein, and until recently had more oil than the earlier maturing *B. rapa*. Some of the year to year variation may be due to changes in the proportions of these seed types grown across the prairies (Figure 3).

Temperature and moisture might also be expected to play a significant role in determining the final composition of canola and flax seed as indicated in the studies cited above. To a certain extent this may also be associated with the growing period where planting date, especially, has been shown to influence the oil and protein content of harvested seed. Other factors such as frost damage have been shown to cause a severe reduction in oil and protein content by interrupting the maturity of the plant . Location, particularly latitude also effects composition as it plays a major role in the photoperiod experienced by the plant. The oilseed growing area in Western Canada extends over nearly 10 degrees of latitude resulting in a wide range in temperature, photoperiod and maturity.

There are also four major soil types in the Canadian prairies and research has shown that these may also play a role in determining the final composition of seeds. In addition, weed seed contamination has been shown to affect oil content, not only because of the direct effect of admixture but also through competition in the field which has been shown to reduce oil content .

Using the qualitative summaries of the overall weather patterns in Western Canada (Table 1) comments relating to drought, hot weather, cool and rainy harvests and frosts were plotted against quality factors (Figure 4).

Chlorophyll in Canola. Overall levels of chlorophyll in canola were highest in years where there was a severe frost or cool wet weather during harvest. Frost damage has been shown to result in high levels of chlorophyll in seed similarly, cool weather in the maturation period has also been asociated with high levels of chlorophyll . The pattern in chlorophyll was also noted in the top grade (No. 1 Canada) canola but was lessened or sometimes negated as the grading process limits the amount of chlorophyll through the limitation on distinctly green seeds. For example, in 1982 where there was a severe frost, the overall level of chlorophyll was high but the level in the top grade was relatively low as the frost damaged seed, containing most of the chlorophyll, was not selected for that grade. Low chlorophyll levels were typical for years with heat stress or drought.

Iodine Value in Flax. Iodine values in flax were highest in years with cool summers and cool maturation periods. This relationship between degree of saturation and temperature has been well established in small plot trials and it is interesting to see it born out in surveys of the commercial crop .

Oil and Protein. Oil and protein were inversely related as was previously shown. Oil content was higher in years with cool wet maturation periods, especially for canola. Severe heat and drought, such as in 1960 and 1988, produced significant decreases in oil content and increases in protein content. Although frost damage has been shown to decrease oil content in seed where the maturation process has been interrupted , overall oil content levels were sometimes high in years with frost damage. Possibly the general cool wet weather associated with the frost effects more of the seed than the more localized frost damage.

Saturated fatty acids. It has been shown in plot trials that saturated fatty acids in canola will increase in years with high temperatures . The change in species composition of the canola crop, especially over the past 10 years, (Figure 3) has overridden any change on saturated fatty acids which might be due to environment.This study has shown that trends established in small plot trials on the effect of environment on canola and flaxseed can be translated to overall effects on a large cropping area using qualitative weather statements in relation to quality trends. It will be interesting to study the relationship between quantitative weather data and the quality of the commercial Canadian crop to see if some predictive models can be developed.

References

Appelqvist L.-Å. Lipids in *cruciferae*: II. Fatty acid composition of *Brassica napus* seed as affected by nitrogen, phosphorus, potassium and sulfur nutrition of the Plants. *Physiologia Plant.* **1968**, *21*, 455-465.

Canvin, D.T. The Effect of Temperature on the oil content and fatty acid composition of the oils from several oil seed crops. *Can. J. Bot.* **1965**, *43*, 63-69.

Daun, J.K.; Clear, K.M.; Mills, J.T. Effect of frost damage on the quality of canola (*B. napus*). *J. Amer. Oil Chem. Soc.* **1985**, *62*, 715-719.

Daun, J.K.; DeClercq, D.R. *Sixty Years of Canadian Flaxseed Quality Surveys at the Grain Research Laboratory.* Flax Institute of the United States; 192-200.

Dybing, C.D.; Zimmerman, D.C. Temperature effects on flax (*Linum usitatissimum* L.) growth, seed production, and oil quality in controlled environments. *Crop Sci.* **1965**, *5*, 184-187.

Fiby, J. Prükum kvality oleje repkovêho semene. *Rostlinna Výroba* **1972**, *18*, 579-591.

Friesen, G.H. Effect of weed interference on yield and quality of flax seed oil. *Can. J. Plant Sci.* **1986**, *66*, 1037-1040.

Gendy, A.; Marquard R. Studies on the Effect of Nitrogen Fertilization and Growth Regulators on Seed-Yield and Some Quality Criteria of Oilseed-Rape (*Brassica napus* L.). *Fat. Sci. Technol.* **1989**, 353-357.

Harris, H.C.; McWilliam, J.R.; Bofinger, V.J. Prediction of oil quality of sunflower from temperature probabilities in eastern Australia. *Austral. J. Agric. Res.* **1980**, *31*, 477-488.

Mailer, R.J. Effects of Applied Sulfur on Glucosinolate and Oil Concentrations in the Seeds of Rape (*Brassica napus* L) and Turnip Rape (*Brassica rapa* L Var *Silvestris* (Lam) Briggs). *Austral. J. Exper. Agric.* **1989**, *40*, 617-624.

Mailer, R.J.; Pratley, J.E. Field studies of moisture availability effects on glucosinolate and oil concentration in the seed of rape, (*Brassica napus* L) and Turnip Rape (*Brassica rapa* L Var *silvestris* (Lam) Briggs). *Can. J. Plant Sci.* **1990**, *70*, 399-407.

Marquard, R. The influence of temperature and photoperiod on fat content, fatty acid composition and tocopherols of rapeseed (*Brassia napus*) and mustard species (*Sinapis alba, Brassica juncea*, and *Brassica nigra*). *Agrochimica* **1985**, *29*, 145-153.

Marquard, R.; Schuster, W. Veränderungen von Sameninhaltsstoffen verschiedener Rapssorten unter kontrollierten Bedingungen. *Fette Seifen Anstrich.* **1981**, *83*, 99-105.

Sosulski, F.W.; Gore, R.F. The effect of photoperiod and temperature on the characteristics of flaxseed oil. *Can. J. Plant Sci.* **1964**, *44*, 381-382.

Stefansson, B. R. Influence of temperature and soil on seed composition. In *Proceedings of the International Conference on the Science, Technology and Marketing of Rapeseed and Rapessed Products*; Rapeseed Association of Canada: Ottawa, 70; 86-91.

Ward, K.A.; Scarth R.; Daun, J.K.; McVetty, P.B.E. Effects of genotype and environment on seed chlorophyll degradation during ripening in four cultivars of oilseed rape (*Brassica napus*). *Can. J. Plant Sci..* **1992.**

Table 1. Qualitative Weather Summaries for Western Canadian Growing Season. From Canadian Grain Commission Crop Bulletins and Dr. K.H. Tipples, personal communication.

1960 Near Drought Conditions -hot dry- Good weather for harvest

1961 Severe drought conditions

1962 Mixed Weather - wet and early frost in Manitoba, Dry in Alta. Frost damage in rapeseed

1963 wet seeding in Manitoba (late), hot dry later esp. in Peace

1964 early frost and wet harvest

1965 Later seeding, good growing conditions, wet harvest, early frost effected napus

1966 Excessive moisture in Red River Valley, good harvest weather

1967 Severe and prolonged drought, relieved in August

1968 Cool and wet growing conditions, poor harvest weather - frost and wet

1969 Cool spring, good summer, wet harvest in Northern areas much immature rapeseed

1970 Late seeding due to cool, wet spring, hot dry summer

1971 Warm April, wet May, good rainfall, hot July Aug., generally good conditions

1972 Cool early season, dry in early year, relieved in July, warm July and August, Frost in Early September

1973 Average moisture, seasonable temperatures, dry in south, frost in mid August, cool wet harvest

1974 Cool spring, hot dry summer (drought), wet harvest

1975 Cool wet spring, hot July, cool wet harvest, Mid-August frost

1976 Early seeding, dry spring, wet northern regions, dry south, dry harvest

1977 Dry winter and spring, Dry, normal to below normal temperature, Wet harvest - weathering

1978 Generally good moisture, hot dry, frost early and mid August, wet harvest

1979 Slow maturation in Man. and Sask., good in Alta

1980 Fairly normal with later harvest

1981 Early harvest, good conditions

1982 Widespread killing frost, Aug. 26

1983 Average to good, hot dry, early harvest

1984 Good moisture, mid-season drought, good harvest

1985 Early drought, wet delayed harvest

1986 Excellent growing conditions, cool wet harvest, early local frost

1987 Dry, early harvest

1988 Severe Drought

1989 Severe Drought, high temperatures

1990 Dry hot August

1991 Dry Hot July and August

1992 Early Frost

1993 Extremely Cool Summer

1994 Good Growing conditions

1995 Delayed seeding, variable weather, cool harvest

1996 Good Growing conditions

1997 Later seeding, heat stress in summer, good harvest

1998 Early seeding dry weather

1999 Late seeding due to cool, wet spring, cool moist harvest

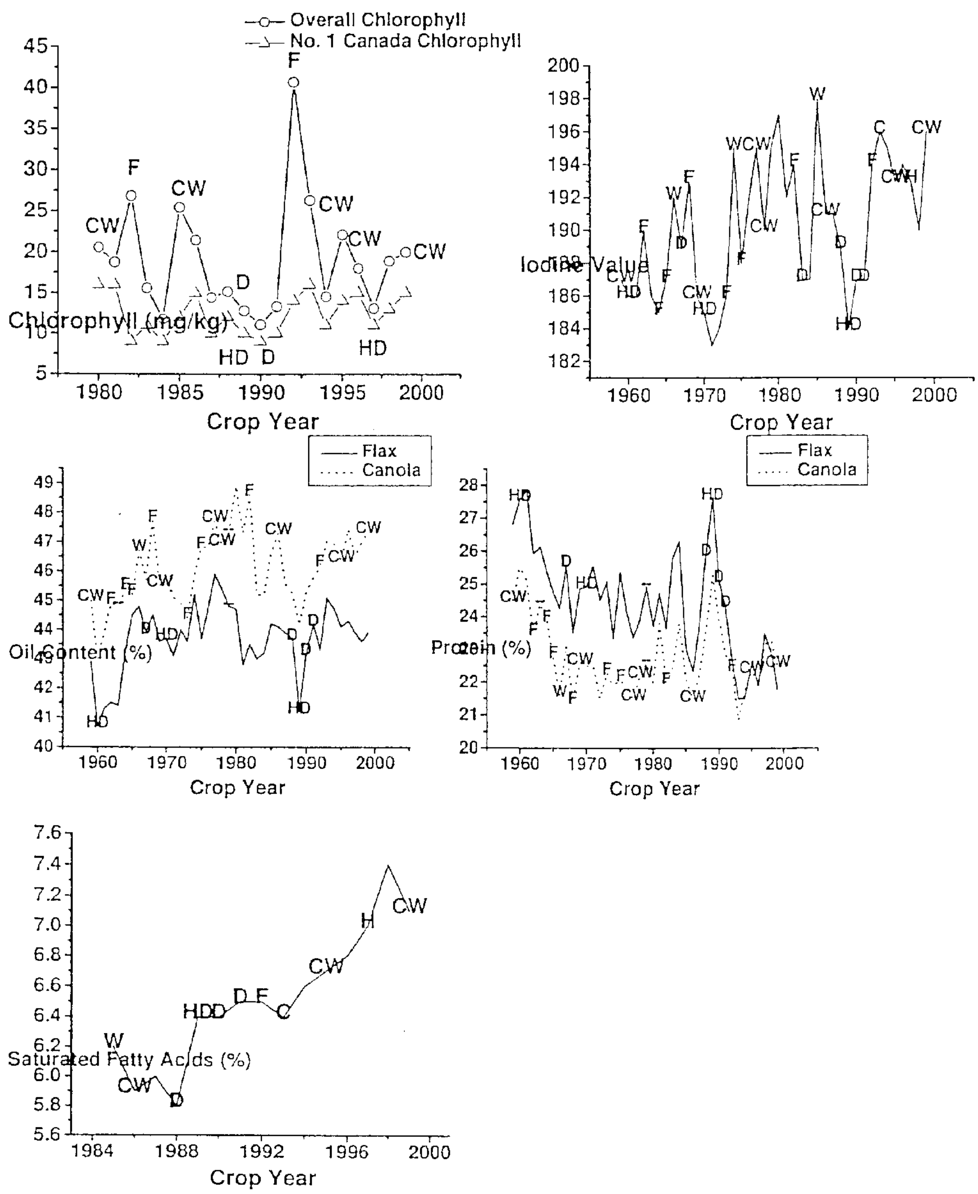


Figure 4. Relationship between weather and quality factors for chlorophyll (canola only), iodine value (flax seed only), oil, protein and saturated fatty acids (canola only). W = wet, C = cool, H = Heat, D = Drought, F = Frost.