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INFLUENCE OF TEMPERATURE AND SOIL ON SEED COMPOSITION

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I am not actively engaged in studying the effect of environment on plants. I am not a physiologist or a chemist but rather, a plant breeder concerned with understanding the effects of environment for the purpose of assessing results more accurately. Therefore, I am interested in examining environmental effects for the purpose of predicting how they will influence yields and seed composition.

It may be convenient to regard environmental factors which deviate from the optimum for a plant species as stress factors. Furthermore, we should not expect straight-line relationships for stress factors such as excessively high or low temperatures, but would rather expect fairly complex curves.

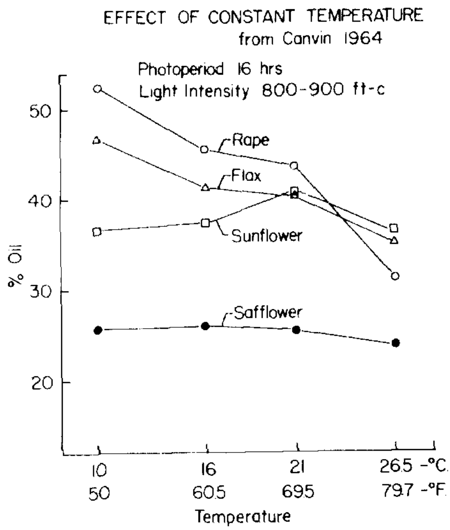
Several different stress factors appear to produce a group of similar effects (a syndrome). Therefore, I will attempt to divide stress factors into groups:

Stress factors may have a more or less direct effect on the energy available and/or nutrients mobilized for the synthesis of a particular product such as oil. For example, high temperatures, drought, and long days all hasten the maturity of rape and flax. Since the time from flowering to maturity is usually shortened, the similarity in the effects of these three stress factors appears to be that they all tend to reduce the photosynthate available for seed production.

Stress factors may influence seed composition through an effect on the development of the plant. Thus low temperatures and short days may exert an effect on rape and flax by delaying maturity and by causing a partial reversion from reproductive to vegetative growth.

Nutrient deficiencies or excesses may also influence specific aspects of biosynthesis. For example, the flowers on rape grown in sulfur deficient soils tend to be light yellow and may approach white under conditions of severe stress.

FIGURE I



A rather dramatic effect of high temperature resulting in low oil content illustrated in Figure I was taken from Canvin's paper[2]. High temperature appeared to have little effect on safflower and sunflower. These species are adapted to higher temperatures than flax and rape, therefore the higher temperatures used in these experiments probably did not represent a severe stress to these species. Several scientists have indicated that there is something peculiar about the magnitude of these effects on the oil content of rape and flax seed. I agree. A constant temperature during the 24-hour cycle could be expected to produce much more severe stress than the same temperature during the day combined with a lower night temperature. Although there seems to be a dearth of direct comparisons, there is a lot of evidence to indicate that the effect of relatively high day temperatures is substantially reduced by cooler nights[4,5,6]. It may also be of interest to note that Dybing[5] found that high temperatures during the night reduced oil content more than the same temperature during the day.

In addition to the effect on oil content, the effects of high temperature stress are usually accompanied by other changes which might be called a high temperature stress syndrome (2,4,5,6,10,12). These effects usually include:

- low oil content
- low linolenic and low erucic acid content
- low seed weight
- hastened maturity

Somewhat similar effects have been reported for the effect of drought[1] and low light intensity[6]. It looks as if high temperature, drought, and low light intensity all restrict the energy and/or nutrients available for the synthesis of oil and for the conversion of oleic to linoleic and linolenic, or to eicosenoic and erucic acid.

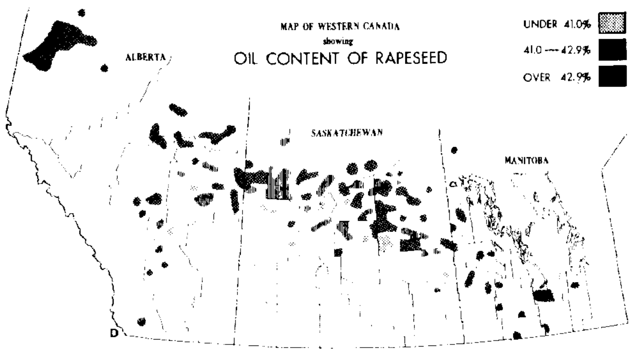
The reports of the effect of nitrogen on oil content may appear to be conflicting. To summarize these results as concisely as possible, I would like to mention that if nitrogen is applied at seeding time, vegetative growth is likely to be greatly stimulated and that there may or may not be luxury consumption of this element during the period when the seed is developing. If luxury consumption takes place when the seed is developing, the reactions from sugars to protein appear to be somewhat favored over those leading to oil. Thus, in this case we may obtain lower oil content in association with larger seed size.

Several investigators have indicated that short days and low temperatures delay the maturity of rape and flax, and often stimulate vegetative growth. Under these conditions flax and rape produce a number of late branches. It is rather surprising that such major changes in vegetative growth do not appear to be accompanied by consistent changes in seed composition. Short days appear to lead to low oil content without a consistent effect on iodine number while low temperature appears to promote high oil content and a high degree of unsaturation in flax[2,5,6,8,10,12].

The known effects of temperature and nitrogen on oil content help to explain the results that have been obtained from dates of seeding experiments in Canada[7]. The general tendency for a decrease in oil content which accompanies delayed seeding probably is caused by increasing temperatures during critical periods in seed development. The variability from different dates and different years probably reflects the variability of the soils and the continental climate in the Prairie Provinces.

The data from experiments involving controlled conditions indicate that the oil content of rapeseed from Northern areas should be higher than that from Southern areas. The oil contents of rapeseed grown near Minneapolis have been 2 to 5% oil lower than the oil contents for the same varieties grown near Winnipeg. The three year averages for oil content (1967-1969) for the Co-operative Rapeseed Tests in Western Canada for the Northern Black and Grey, Southern Black, and Brown Soil Zones were 43.4, 42.3, and 40.7 respectively. Thus, the effect of the range of temperatures found in Western Canada appears to have a relatively small effect on oil content of rapeseed.

FIGURE II



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Examination of a map of the oil content of carlots of commercial rapeseed(3) produced in 1969 (Figure II) discloses no apparent relationship between northerly and southerly areas and oil content. The oil content of the dominant variety (Echo) grown in the north is about 2% lower than the oil content of the dominant variety (Target) grown in southern areas. Thus, the varieties which are grown mask the effects of temperature on the oil content of commercial samples of rapeseed from Western Canada.

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