# INTERRELATIONSHIP BETWEEN FATTY ACID COMPOSITION AND OIL CONTENT IN NORMAL AND LOW ERUCIC ACID *BRASSICA JUNCEA*

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## Introduction

Early work on the interrelationship between erucic acid level and oil content in summer rape (*Brassica napus* L.) indicated that rape genotypes with different erucic acid levels produced seed with similar oil content (Downey and Craig, 1964). Klassen (1976) reported a positive correlation between erucic acid level and oil content in summer turnip rape (*B. campestris* L.). He stated that turnip rape strains with 20% erucic acid contained 1 to 3% more oil than their zero erucic acid counterparts. The summer rape (*B. napus*) cultivar Midas is cited as an example for the successful combination of low levels of erucic acid with high oil content through cross breeding. This paper describes the interrelationship between fatty acid composition and oil content in segregating generations of *B. juncea*, with subpopulations partitioned by erucic acid, derived from crosses between normal and low erucic acid lines.

## Materials and Methods

The parental material consisted of the normal 25% erucic acid cultivars Donskaja, Zaria and Vniimk 405 from the Soviet Union, which were characterized by very high oil contents, the Canadian normal 25% erucic acid cultivar Domo, a condiment Oriental mustard adapted to the Canadian prairies with a desirable low oil content and the low erucic acid, low oil content line ZEM.

The four normal erucic acid parents were crossed with ZEM and the four $F_1$'s backcrossed to their respective normal erucic acid parents to produce $BC_1$, and $BC_2$ populations heterozygous for the erucic acid gene. The production of the $BC_2$ populations required the identification of $BC_1$ plants, heterozygous for erucic acid for use as parent plants in the second backcross to the normal erucic acid cultivars using the half seed technique (Downey and Harvey, 1963). Segregating $F_2$, $BC_1F_2$, and $BC_2F_2$ populations were produced from their respective $F_1$, $BC_1$, and $BC_2$ plants by selfing. In the initial crosses the low erucic acid, low oil content line ZEM was used as the male, thus all segregating generations were in the cytoplasm of the normal erucic acid parents.

Field grown single plants were harvested from the three segregating generations of all four crosses and the erucic acid level of the seeds from each plant was determined by gas chromatography. From each population two composites were made, one consisting of seed low in erucic acid (< 3%), and the other consisting of seed high in erucic acid (15-25%). Numbers of plants included in the composites varied, but were kept as large as possible in order to represent the average genotype of the generation. Thus for example the low erucic acid composite of the $BC_2F_2$ generation from the

Donskaja x ZEM cross was composed of seeds from 80 individual plants selected from seven rows, each row being derived from selfed seed of a different $BC_2F_1$ plant.

Two three-replicate split-split plot trials were grown in 1986, one test at Saskatoon, Saskatchewan, and one at Lethbridge, Alberta. The main plots were the four different crosses, five sub plots consisted of the two parents and the three intermediate generations. The 3 m single row sub-sub plots consisted of the normal and low erucic acid composites of the intermediate generations.

Parents could not be separated into different erucic acid levels, therefore two rows of each were planted. Rows were harvested individually and a seed sample was taken from each row for oil content analysis.

Oil contents were determined using a Newport Mark IIIA wide line NMR analyser. A composite bulk seed sample from each parental line was analyzed for seed oil fatty acid composition by gas chromatography.

Analysis of the two tests as a split-split plot design using data from the segregating generations determined the main effects of fatty acid compositions on oil contents and analysis as a split plot design using the entire data set enabled the calculation of confidence limits for the parental oil content values.

## Results and Discussion

The seed oil content of the normal erucic acid subpopulations grown from the $F_2$, $BC_1F_2$, and $BC_2F_2$ generations was, on average, 1.61% and 0.82% higher than the seed oil content of the low erucic acid subpopulations at Saskatoon and Lethbridge, respectively (Table 1). The expected oil content of the low erucic acid subpopulations, based on their fatty acid composition, and the observed oil content and fatty acid composition of high erucic acid plants was predicted to be 2.52% and 2.30% lower for Saskatoon and Lethbridge, respectively. These values were estimated on the assumption that the same number of triglyceride molecules were synthesized in both the normal and low erucic acid subpopulations. The observed smaller differences in oil content between normal and low erucic acid subpopulations suggested that the low erucic acid plants synthesized more triglyceride molecules than the normal erucic acid plants, thus partially compensating for the lower average weight of their triglyceride molecule.

The relationship observed between fatty acid composition and oil content in normal and low erucic acid subpopulations in the four individual crosses (Table 2) was similar to that found for the mean of all four crosses. In all cases the reduction in oil content was less than that which would be expected from the difference in weight of triglyceride molecules of normal and low erucic acid plants. The Donskaja, Zaria and Vniimk 405 crosses with ZEM produced normal and low erucic acid subpopulations with oil contents between those of the normal and low erucic acid parents. The Domo x ZEM cross was different in that some normal erucic acid subpopulations ($BC_2F_2$ at Saskatoon and $F_2$ at Lethbridge) were higher in oil content than Domo, and some low erucic acid subpopulations were lower in oil content than ZEM ($F_2$, $BC_1F_2$ and $BC_2F_2$ at Saskatoon and $BC_2F_2$ at Lethbridge). The results from the Domo x ZEM cross demonstrated the low oil content accumulation capacity of Domo, a condiment cultivar, and also indicated that ZEM has a higher potential for oil synthesis than Domo.

The results of our crossing studies indicated that the amount of glycerol required for the synthesis of seed oil in B. juncea is not limiting and that the breeding of low erucic acid, high oil content mustard cultivars should be possible. Low erucic acid B. juncea breeding material developed at the Agriculture Canada Research Station, Saskatoon, has an oil content equal to that of the summer turnip rape (B. campestris) cultivar Tobin, and a yield greater than that of the summer rape (B. napus) cultivar Westar.

Table 1. Mean and standard error for oil content of parents and segregating generations, partitioned by erucic acid content and derived from four crosses between the normal erucic acid B. juncea cultivars Donskaja, Zaria, Vniimk 405, Domo and the low erucic acid line ZEM. Backcrosses were made with the respective normal erucic acid cultivars. The material was field tested in 1986 at Saskatoon, Saskatchewan and Lethbridge, Alberta, Canada.

| Material | Oil content of normal and low erucic acid subpopulations | | |
|---|---|---|---|
| | Normal | Low | Difference |
| **Saskatoon** | | | |
| Parents | | | |
| Normal erucic | 42.78±0.22 | (41.17)[1] | |
| ZEM | (39.64) | 38.03±0.22 | |
| Generations | | | |
| $F_2$ | 41.40±0.15 | 39.78±0.15 | 1.62 |
| $BC_1F_2$ | 41.38±0.15 | 40.06±0.15 | 1.32 |
| $BC_2F_2$ | 42.29±0.15 | 40.41±0.15 | 1.88 |
| Mean Difference | | | 1.61 |
| **Lethbridge** | | | |
| Parents | | | |
| Normal erucic | 38.63±0.33 | (37.81) | |
| ZEM | (35.87) | 35.05±0.33 | |
| Generations | | | |
| $F_2$ | 38.13±0.35 | 36.94±0.37 | 1.19 |
| $BC_1F_2$ | 37.77±0.33 | 37.35±0.35 | 0.42 |
| $BC_2F_2$ | 38.38±0.33 | 37.53±0.33 | 0.85 |
| Mean Difference | | | 0.82 |

[1]Estimated oil content for parents, in parentheses, were calculated from mean differences between normal and low erucic acid classes of segregating generations.

Table 2. Oil content of parents and segregating generations of the four crosses Donskaja X ZEM, Zaria X ZEM, Vniimk 405 X ZEM, and Domo X ZEM, with subpopulations partitioned by erucic acid content. Donskaja, Zaria, Vniimk 405, and Domo were used as backcross parents in their respective crosses with ZEM. The material was field tested in 1986 at Saskatoon, Saskatchewan and Lethbridge, Alberta, Canada.

| | Oil content of normal and low erucic acid subpopulations of four crosses | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Location | Donskaja x ZEM | | Zaria x ZEM | | Vniimk x ZEM | | Domo x ZEM | |
| Material | Normal | Low | Normal | Low | Normal | Low | Normal | Low |
| **Saskatoon** | | | | | | | | |
| Parents | | | | | | | | |
| Normal erucic | 45.23 | — | 45.05 | — | 43.62 | — | 38.33 | — |
| ZEM | — | 38.03 | — | 38.03 | — | 38.03 | — | 38.03 |
| Generations | | | | | | | | |
| $F_2$ | 43.30 | 41.33 | 42.97 | 41.27 | 41.27 | 39.13 | 38.07 | 37.37 |
| $BC_1F_2$ | 43.37 | 41.50 | 43.83 | 41.37 | 41.27 | 40.97 | 37.07 | 36.40 |
| $BC_2F_2$ | 44.03 | 41.50 | 43.47 | 41.60 | 42.37 | 40.56 | 39.30 | 37.97 |
| Mean Difference | 2.12 | | 2.01 | | 1.42 | | 0.90 | |
| **Lethbridge** | | | | | | | | |
| Parents | | | | | | | | |
| Normal erucic | 39.46 | — | 40.18 | — | 38.80 | — | 36.07 | — |
| ZEM | — | 35.05 | — | 35.05 | — | 35.05 | — | 35.05 |
| Generations | | | | | | | | |
| $F_2$ | 39.27 | 37.90 | 38.90 | 37.90 | 36.67 | 35.67 | 37.70 | 36.30 |
| $BC_1F_2$ | 38.40 | 38.03 | 38.37 | 36.77 | 38.03 | 38.33 | 36.30 | 36.30 |
| $BC_2F_2$ | 40.50 | 38.90 | 39.73 | 39.80 | 36.70 | 36.57 | 36.60 | 34.87 |
| Mean Difference | 1.11 | | 0.88 | | 0.27 | | 1.04 | |

| Standard Errors | Crosses | Generations | Crosses and Generations | Crosses and Erucic Acid Levels |
|---|---|---|---|---|
| Saskatoon | 0.53 | 0.49 | 0.31 | 0.49 |
| Lethbridge | 1.26 | 0.66 | 0.67 | 0.66 |

References

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