# BREEDING FOR SUMMER TURNIP RAPE VARIETIES (*Brassica campestris* L.) WITH IMPROVED FATTY ACID COMPOSITION

Simo Hovinen[1] and Into Laakso[2]

[1]Hankkija Plant Breeding Institute, SF-04300 Hyrylä

[2]School of Pharmacy, University of Helsinki, Helsinki, Finland

## INTRODUCTION

The primary aim in the breeding of rapeseed fatty acids is to bring about a considerable increase in the content of linoleic acid (18:2n-6). A decrease in the content of α-linolenic acid (18:3n-3) to as low as 3-4% is also desirable because, being an easily oxidized component, it is particularly problematic for the margarine industry, Downey /1975/, Röbbelen /1983/.

On the other hand, new evidence that α-linolenic acid acts as a precursor for eicosapentaenoic acid (20:5n-3, EPA) in humans, Sanders /1981/, Budowski /1984/, Lassere /1983/, and that rapeseed oil decreases total cholesterol and increases HDL cholesterol, McDonald /1983/, Savoie /1983/, is giving rapeseed fatty acids a new physiological importance. In Finland, particularly, a high cholesterol level is considered to be a result of an imbalance between the intake of saturated and polyunsaturated fatty acids, Vartiainen /1982/. In addition, the EPA content in human plasma lipids can be very low (≈1%), Seppänen /1985/.

A selection programme designed to produce summer turnip rape varieties with higher linoleic acid content, as well as good agronomic characteristics, has been under way since 1978. During the past eight years, lines with an average linoleic acid content of 25-26% have been produced through individual plant selection under open-pollinated field conditions without affecting the α-linolenic acid content. In the case of linoleic acid-selection alone, the correlation between these two fatty acids within parents and subsequent progenies has been found to correspond rather well with each other during the trial, Laakso /1986/.

Therefore, in order to obtain a further increase in the linoleic/α-linolenic acid ratio, simultaneous selection for the highest linoleic and lowest α-linolenic acid content was also applied parallely with linoleic acid-selection. The seed material from the selection lines, controls and some common summer turnip rape varieties was submitted for yield trials. The results for fatty acid selection, yield and agronomic characters are presented in this study.

## MATERIAL and METHODS

Two populations of Canadian origin, which were erucic acid-free and had a low glucosinolate content and about 70% yellow seed, have been used as the primary breeding material and also as controls. Healthy plants with the best vegetative growth have been taken for further breeding and fatty acid analysis. Yields of a pair of single plants were normally mixed in the proportion 50:50, the rest of the seed being saved. On a number of occasions 3-4 plants were used instead of pairs, Laakso /1986a/. Fatty acids have been determined as methyl esters by gas-liquid chromatography (GLC) using conventional or PTV (programmed temperature vaporizer) injection techniques, Laakso /1986/.

The yield trials were carried out in accordance with the standard technique used in the official trial system in Finland. The net plot size was $8m^2$, with three replications. Nitrogen fertilization was given at a dose of 120kg/ha. The plots were randomized on the field, and the results calculated according to the lattice experimental design. Crude fat was analyzed by the near infrared reflectance (NIR) technique, and the oil yield determined using an average moisture content of 9%, Laakso /1986a/.

## RESULTS and DISCUSSION

The reults of the selection experiments on the last four generations are presented in Table 1. The $M_{10}$-lines with an average linoleic/α-linolenic acid ratio of 2.3 were produced from parental material which had a corresponding ratio of more than 2.6. This type of selection also resulted, for the first time during the trial, in an α-linolenic acid content which was significantly lower ($M_9$ and $M_{10}$ materials) than that in the control lines. In addition, an individual plant yield with a rather low α-linolenic acid content (6.8%) was also found /Table 1/.

The linoleic/α-linolenic acid ratio of the selection lines were compared with the corresponding control values /Fig.1/. Despite the fact that simultaneous selection has so far been applied to two generations only, the results clearly indicate that the ratio can be increased by taking a low α-linolenic acid content into account in linoleic acid-selections /Fig.1/.

The selected material, consisting of 51 lines (exept $M_{10}$ progenies), were tested in yield trials in 1986. The results for the 27 lines with the best combined characters are presented in Tables 2-3. Keeping the oil yield as the main criterion, seven lines with a linoleic acid content of 25% or more are fully comparable to the common varieties Emma and Valtti /Table 2/. In addition, the lines Hja 97711, 97816, 97822 and 97832 have also proved to be among the highest yielding material in earlier trials, Laakso /1986a/. The lines Hja 97816, 99484 and 99485 had clearly the best yield in this trial. Furthermore, the two last-mentioned lines had a high crude fat content (41-42%) and an excellent lodging resistance (28-30%). No clearcut differences were observed in stem height ($\bar{x}$=65cm), growing time ($\bar{x}$=91 days) or thousand seed weight ($\bar{x}$=3.20g) between the selection lines and the other material (Tables 2-3).

## CONCLUSIONS

The linoleic/α-linolenic acid ratio can be increased by simultaneous selection for these compounds. It was ossible, for the first time during the long-term field trial, to produce lines with an average α-linolenic acid content that was lower than the controls. In yield trials, several erucic acid-free and good-yielding lines with a linoleic acid content of 25-26% were selected. Other properties of the selection lines, especially growing time and lodging, would not restrict their overall suitability for cultivation.

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Table 1.

Statistical data for linoleic and α-linolenic acid content in the selected and control lines in successive generations.

| SELECTED LINES | | | | | | CONTROL LINES | | |
|---|---|---|---|---|---|---|---|---|
| Generation | N[a] | 18:2n-6 (%) | | 18:3n-3 (%) | | N[a] | 18:2n-6 | 18:3n-3 |
| | | Range | $\bar{x}$[e] | Range | $\bar{x}$[e] | | $\bar{x}$ | $\bar{x}$ |
| $M_7$-83F[b] | 408 | 19.9-30.4 | 24.5*** | 9.3-15.9 | 12.3** | 70 | 22.2 | 11.9 |
| $M_8$-84F[b] | 151 | 21.2-34.1 | 26.7*** | 10.9-17.1 | 13.7 | 34 | 23.0 | 13.5 |
| $M_9$-85FI[c] | 260 | 19.2-34.0 | 26.2*** | 9.4-14.8 | 11.7* | 35 | 22.9 | 12.1 |
| II[d] | 105 | 20.0-31.9 | 26.0*** | 9.1-15.4 | 12.1 | | | |
| $M_{10}$86FI[c] | 180 | 19.0-31.8 | 25.0*** | 6.8-14.0 | 11.0** | 98 | 21.4 | 11.8 |
| II[d] | 77 | 20.5-30.9 | 25.6*** | 9.1-13.6 | 11.6 | | | |

[a] number of individual plants analyzed

[b] ref. 3

selection of parents based on { [c] highest linoleic/α-linolenic ratio; [d] higher linoleic acid content only }

[e] Student's t-test: *** $p<0.001$; ** $p<0.01$; * $p<0.05$

Figure 1.

Linoleic/α-linolenic acid ratio of selected lines expressed as the deviation from that of the control lines.

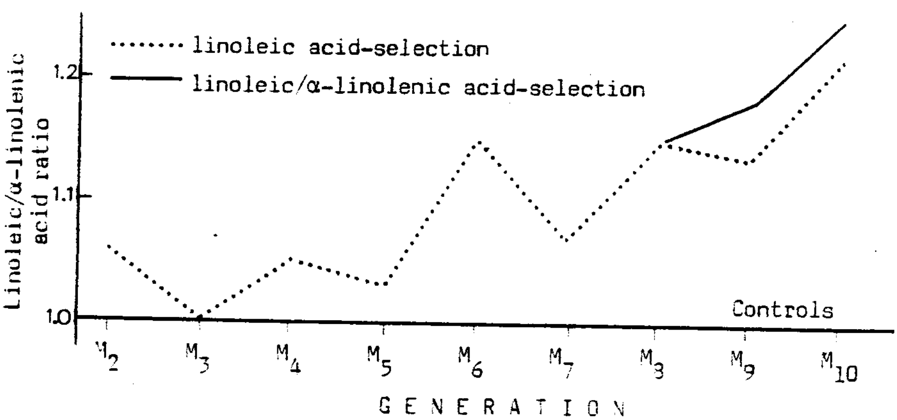

Table 2.
Quality characters of some turnip rape varieties, control and linoleic acid-selected lines in the yield trial in 1986 (N=3).

| Material | Fatty acids (%) 18:2n-6 | 18:3n-3 | 22:1n-9 | Crude protein (%) | Crude fat (%) | Seed yield (rel.) | Oil yield (rel.) |
|---|---|---|---|---|---|---|---|
| Emma | 21.2 | 12.4 | - | 21.2 | 39.6 | 100 | 100 |
| Valtti | 23.2 | 13.5 | - | 21.3 | 40.8 | 102 | 106 |
| Controls | 22.1 | 13.2 | 1.2 | 20.3 | 42.1 | 94 | 100 |
| Selection | | | | | | | |
| Hja 97711 | 25.1 | 12.6 | - | 21.1 | 41.2 | 100 | 105 |
| 97816 | 23.8 | 11.9 | - | 20.5 | 41.3 | 110 | 115 |
| 97822 | 24.2 | 12.6 | - | 20.9 | 41.6 | 98 | 103 |
| 97832 | 24.1 | 13.8 | - | 21.2 | 40.4 | 103 | 105 |
| 98852 | 24.4 | 12.4 | - | 20.5 | 40.7 | 100 | 102 |
| 98855 | 25.4 | 12.1 | - | 20.6 | 41.6 | 87 | 92 |
| 99856 | 25.1 | 12.8 | - | 21.0 | 40.2 | 97 | 98 |
| 99461 | 25.4 | 12.2 | - | 21.0 | 41.4 | 89 | 93 |
| 99463 | 24.9 | 12.8 | - | 21.6 | 39.6 | 105 | 105 |
| 99464 | 26.6 | 12.6 | - | 20.5 | 40.6 | 98 | 100 |
| 99465 | 24.7 | 12.3 | - | 21.1 | 40.4 | 96 | 98 |
| 99466 | 26.4 | 12.2 | - | 21.0 | 40.6 | 95 | 97 |
| 99469 | 24.1 | 12.9 | 1.1 | 21.2 | 40.5 | 101 | 103 |
| 99470 | 25.3 | 13.0 | - | 21.7 | 40.2 | 99 | 101 |
| 99472 | 26.5 | 13.2 | - | 21.9 | 40.7 | 99 | 102 |
| 99473 | 25.6 | 13.4 | - | 21.1 | 40.4 | 95 | 97 |
| 99476 | 24.4 | 13.5 | - | 21.4 | 39.8 | 104 | 104 |
| 99477 | 24.8 | 13.9 | - | 20.5 | 40.6 | 101 | 104 |
| 99479 | 25.0 | 13.3 | - | 21.3 | 40.2 | 98 | 100 |
| 99481 | 24.0 | 12.9 | - | 22.0 | 39.3 | 103 | 102 |
| 99484 | 21.8 | 12.1 | - | 21.0 | 41.0 | 114 | 118 |
| 99485 | 23.9 | 11.8 | - | 21.0 | 42.0 | 109 | 116 |
| 99489 | 23.4 | 12.3 | 1.1 | 22.1 | 39.4 | 104 | 104 |
| 99495 | 25.5 | 12.7 | - | 21.6 | 40.8 | 105 | 108 |
| 99497 | 24.8 | 13.2 | - | 21.9 | 40.1 | 106 | 107 |
| 99501 | 25.5 | 13.1 | - | 21.5 | 41.0 | 99 | 102 |
| 99503 | 24.1 | 13.4 | - | 20.6 | 41.7 | 102 | 107 |

Table 3.
Agronomic properties and thousand seed weight of summer turnip rape material in the 1986 trial.

| Material | Stem height (cm) | Lodging (%) | Growing time (days) | 1000-seed weight (g) |
|---|---|---|---|---|
| Emma | 68 | 37 | 91 | 2.91 |
| Valtti | 65 | 34 | 95 | 3.21 |
| Controls | 62 | 37 | 91 | 3.16 |
| Selection | | | | |
| Hja 97711 | 62 | 40 | 90 | 3.00 |
| 97816 | 65 | 40 | 91 | 3.28 |
| 97822 | 62 | 38 | 91 | 3.08 |
| 97832 | 63 | 41 | 91 | 3.23 |
| 98852 | 59 | 38 | 91 | 3.45 |
| 98855 | 66 | 35 | 92 | 3.20 |
| 98856 | 64 | 34 | 94 | 3.43 |
| 99461 | 63 | 38 | 92 | 3.15 |
| 99463 | 64 | 33 | 91 | 3.32 |
| 99464 | 64 | 32 | 91 | 3.49 |
| 99465 | 68 | 31 | 91 | 3.15 |
| 99466 | 62 | 29 | 90 | 3.28 |
| 99469 | 67 | 32 | 91 | 2.79 |
| 99470 | 67 | 40 | 92 | 3.28 |
| 99472 | 61 | 40 | 90 | 3.17 |
| 99473 | 69 | 44 | 94 | 3.09 |
| 99476 | 67 | 38 | 91 | 3.08 |
| 99477 | 62 | 33 | 91 | 3.25 |
| 99479 | 69 | 34 | 93 | 3.41 |
| 99481 | 64 | 32 | 91 | 2.86 |
| 99484 | 64 | 28 | 91 | 3.15 |
| 99485 | 67 | 30 | 94 | 3.14 |
| 99489 | 66 | 44 | 92 | 3.41 |
| 99495 | 63 | 48 | 90 | 3.37 |
| 99497 | 67 | 35 | 91 | 2.95 |
| 99501 | 65 | 33 | 92 | 3.23 |
| 99503 | 63 | 44 | 91 | 3.13 |
| $\bar{x}$ | 65 | 36 | 91 | 3.20 |