SELECTION FOR HIGH-YIELDING SPRING TURNIP RAPE LINES WITH HIGHER LINOLEIC/α-LINOLENIC ACID RATIO

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INTRODUCTION

A breeding programme designed to produce spring turnip rape varieties (Brassica campestris L.) better adapted to Finnish climatic conditions and with an improved fatty acid composition has been carried out since 1978. Zero erucic acid lines with good agronomic characteristics and an average linoleic acid (LA) content of 25-26% have been produced through individual plant selection under open-pollinated conditions in the field (Hovinen and Laakso 1987). Breeding works are also directed at decreasing the content of α-linolenic acid (α-LLA) and increasing that of palmitic acid (Jönsson and Persson 1983; Rakow et al. 1987). Rapeseed oils with such properties are technically desirable in the margarine industry.

Selections based on the highest LA/α-LLA ratio in parental seeds have considerably increased the variability of α-LLA, and an individual plant yield with an α-LLA content of as low as 7% was found in our turnip rape material (Hovinen and Laakso 1987). Selections for lower α-LLA content have since been included in the breeding trial.

The results of fatty acid breeding during 1987-90 and yield trials are presented in this study. In addition, preliminary results for high palmitic acid selections are also reported.

MATERIALS AND METHODS

Single plant selections, pair-crosses in the field, and the fatty acid analyses were performed as described earlier (Hovinen and Laakso 1987). About 10-15 free pollinated plants, which were vegetatively vigorous and disease-free, were selected each year from every pair-cross multiplication plot. The results of fatty acid analysis of the seed yield of single plants created the statistical basis for evaluating the progress of the breeding work. The highest LA/α-LLA ratio has been kept as the main criterion. After glucosinolate tests the plants with the desired fatty acid combination and low glucosinolate level were selected for new pair crosses. Two spring turnip rape populations (type 00) of Canadian origin have been used as controls.

New lines were produced through free, pan-mixed pollination between plants inside pair-cross multiplication plots. The material for yield trials was sown each year using seeds harvested from multiplications. High yielding lines with the desirable fatty acid composition and best agronomic properties have been submitted for yield trials in subsequent years. Field trials with three replications were carried out in the fashion generally recommended in Finland, including standard varieties (Emma, Kova and Valtti). The net plot size was $8m^2$. Nitrogen fertilization was given at a dose of 120kg/ha.

In 1986, a high palmitic acid breeding line Sv 8437520 was crossed with several dwarf-type mutant lines, as well as with high LA lines (≈28%, Hja 99493 and 99498). Selection for higher

palmitic acid content was performed on the yields of the F2 plants. New lines were composed by bulking morphologically similar, high palmitic acid F3-plants. In 1990, a new single plant selection was made from multiplication plots of high palmitic acid lines.

RESULTS AND DISCUSSION

Linoleic and α-Linolenic Acid Selection

Individual plant seeds with an LA content of more than 27% and an LA/α-LLA ratio higher than 2.6 have been the primary basis of the selection. Other high LA (>27%) breeding materials regardless of their α-LLA levels, have also been used as parental seeds. Further pair crossings have been made between individuals containing less than 10% α-LLA.

The results of the selection experiments are presented in Table 1. Selection for a high LA/α-LLA ratio (a) or high LA content (b) has resulted in a mean LA content of 27% in the selected lines (M14-90, a total of 17 lines, 251 plants). When the levels are compared with those of the M11-generation, an increase in LA of 1%-unit (a) and a decrease in α-LLA content of 2%-units (c) have been achieved. Table 1 also shows that plant yields with less than 9% α-LLA are continously found.

Table 1. Linoleic (LA) and α-linolenic acid (α-LLA) content in selected and control lines in successive generations. Selection of parents based on highest LA/α-LLA ratio (a), highest LA (b) or lowest α-LLA content (c).

	SELECTED LINES					CONTROL LINES		
Genera-tion	N	LA (%) Range	Mean	α-LLA (%) Range	Mean	N	LA(%) Mean	α-LLA(%) Mean
M11-87a	53	21.6-31.3	26.1	10.5-15.6	12.7	65	22.4	13.2
b	87	19.6-30.3	25.1	10.2-15.9	13.0			
M12-88a	68	20.1-30.7	25.4	8.6-16.6	11.4	38	20.9	11.3
b	73	20.5-31.5	24.9	9.6-14.9	11.6			
c	119	18.7-33.2	24.9	8.4-13.9	11.1			
M13-89a	92	20.7-30.3	25.6	9.2-13.6	11.3	43	22.2	12.6
b	139	22.0-30.1	25.0	9.6-16.8	12.5			
c	63	21.2-31.0	24.9	8.7-14.2	11.1			
M14-90a	148	21.2-33.0	27.1	8.6-14.9	11.6	63	22.8	12.2
b	103	21.5-32.4	26.9	8.5-15.1	11.9			
c	75	20.7-29.5	25.1	8.4-13.3	10.8			

N = number of individual plants analysed

Yield Trials

A total of 38 breeding lines, three standard varieties and two control lines were submitted for yield trials in 1990. The 16 lines with the best combination of yield and LA content (also selected for trial-91) are presented in Fig.1.

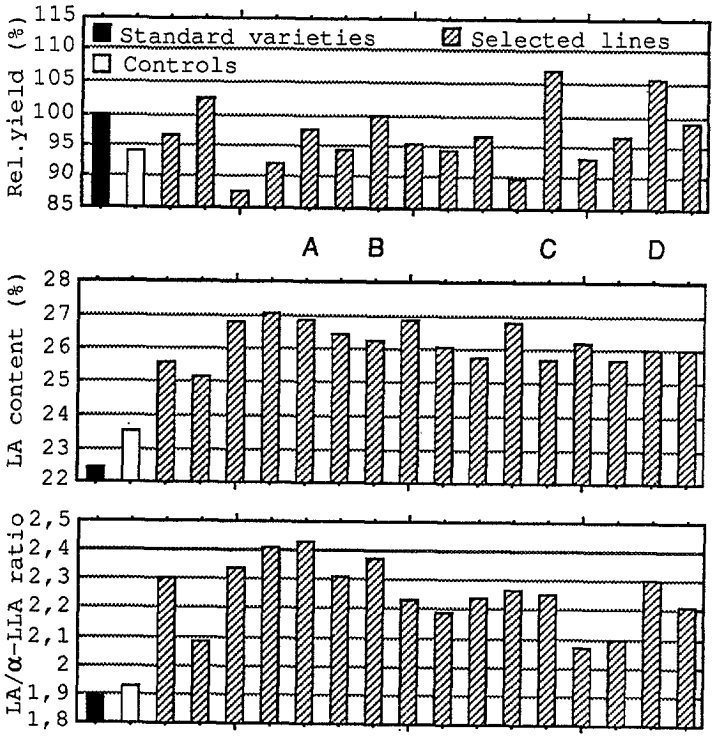

Fig. 1. Relative seed yield, linoleic acid content and linoleic/α-linolenic acid ratio of standard varieties, selected lines and controls in the 1990 field trial. The mean yield of the three standard varieties calculated as 100%.

The results show, that LA levels of 26-27% and an LA/α-LLA ratio of more than 2.3 can be combined with high-yielding lines. Selected lines A-D (Hja 91754, 91757, 91766, 91771)(Fig. 1) with a high LA content and yield fully comparable with that of the standard varieties commonly cultivated in Finland could be released on the market as varieties.

Long-term Effects of Selection

The LA/α-LLA ratio of the control lines has remained rather stable under field conditions, and has ranged from 1.7 to 1.9 during the 12 year period. The LA/α-LLA ratio and α-LLA content of the selected lines are compared with those of the controls in Fig. 2a-b. After elimination of the environmental effect (controls) the selection curves clearly show an increasing trend that indicates no reduction in response to selection (a). The slight fluctuations are most probably due to the differences in selection intensity in subsequent years. A further progess in the selection for lower α-LLA contents can be similarly expected (Fig. 2b). The α-LLA level can also be decreased by selection for high LA/α-LLA ratio, whereas LA selection alone seems to be ineffective (generations 2-8).

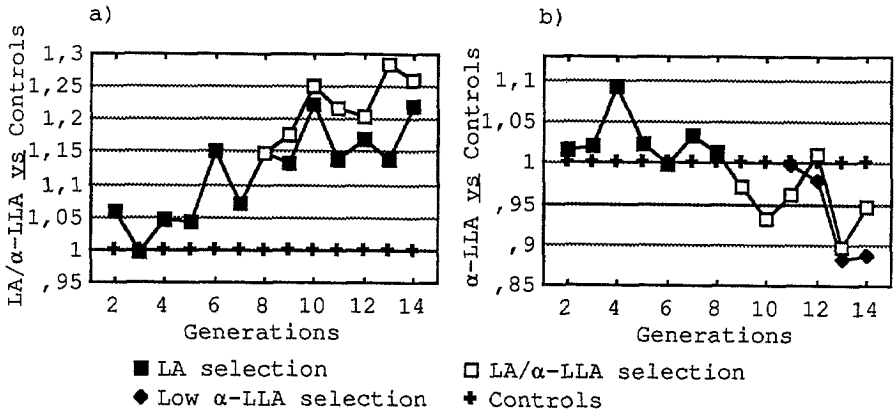

Fig. 2. Long-term effects of selection on linoleic/α-linolenic acid ratio (a) and α-linolenic acid content (b). Family means are plotted against control values.

Palmitic Acid Selection

A total of 26 high palmitic acid lines (each consisting of 6-8 plants) have been produced from crossings grown in the field (Fig. 3).

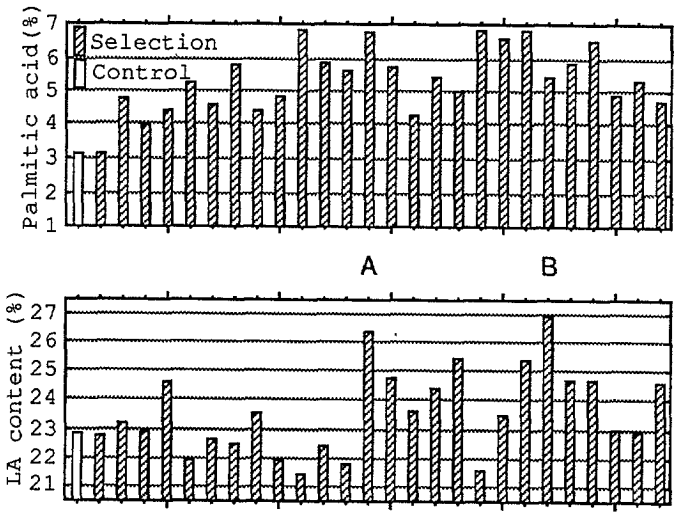

Fig. 3. Mean palmitic and linoleic acid content (%) in the selected and control lines in the 1990 trial.

Several lines with palmitic acid levels double (5-7%) in those of the controls were found. These preliminary results suggest that the selection for higher palmitic acid content is very effective. Progenies with an LA content of more than 26% were also obtained (Lines A-B, Hja 92095, 92106). However, problems may arise when combining a high palmitic acid with a low α-LLA content, since these compounds unexpectedly had a significant positive correlation with each other ($r = 0.42$; $p<0.001$; d.f. 177).

CONCLUSIONS

The results indicate that a combination of high yielding capacity, good agronomic properties and high linoleic acid level is possible in spring turnip rape material. Stable linoleic acid contents 4-5% higher than those in common varieties have been bred. Lines produced by long-term selection are commercially utilizable as varieties. Selection for high linoleic/α-linolenic acid ratio and low α-linolenic acid content can be continued, since there is still a response to selection.

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