SELECTION OF HIGH LINOLEIC ACID CONTENT IN SUMMER TURNIP RAPE

(*Brassica campestris* L.)

II. Variation in linoleic acid content in successive generations

By I. Laakso[1], R. Hiltunen[1] and S. Hovinen[2]

[1]School of Pharmacy, University of Helsinki, SF-00170 Helsinki 17, Finland

[2]Hankkija Plant Breeding Institute, Hyrylä, Finland

INTRODUCTION

During the last few years, increasing attention has been paid to the development of new rapeseed varieties which are better adapted to Finnish climatic conditions. The content of erucic acid (22:1ω9) in the seeding material should not exceed 0.5 percent. In addition, a low glucosinolate content is also required. An increase in the linoleic acid (18:2ω6) would be beneficial from the nutritional point of view.

A selection programme designed to produce cultivars with higher linoleic acid level, as well as good agronomic characteristics, has been under way since 1978. The trial has already reached the sixth generation and involves pair crossings and individual selections. The selection of progeny for further crossings has been made on the basis of the results of fatty acid analyses performed by gas liquid chromatography (GLC).

The variation of fatty acids in an irradiated crossing material was described in the first part of this study (Laakso et al., 1982). After preliminary selections, a highly significant increase in the linoleic acid content was found in some of the progenies in the M_2 generation.

The variation in the linoleic acid content of selected and controlled lines over six generation was investigated in this part of the study. In addition, the effects of selection during the trial are described, and the information obtained from offspring about the parents is also discussed.

MATERIAL AND METHODS

Breeding experiments

The two individuals with the highest linoleic acid content were selected from each of the 24 families of the M_2 generation for growing in the greenhouse in winter 1980. 4 pair crossings were made between individuals originating from the same M_2 progeny. Seeds of individuals from the original populations were sown as controls (7622-80G; 7629-80G). These represented the average linoleic acid level. The seed produced as a result of pair crossed individuals (M_3-80G), as well those of the controls, were subjected to fatty acid analysis.

Mixed seed of pair-crossed individuals were sown as spaced isolations in the field in summer 1980, totalling 63 plots and 7 control plots. Pollination between the individuals within the plots was unrestricted. From each progeny (M_4-80F) 5 individuals with the best vegetative growth were selected. The plots were then harvested and the yields analyzed. 21 progenies were taken for further crossings on the basis of the results, and the fatty acid composition was analyzed on 5 individuals from each progeny.

Further selection was made on 32 individuals and 16 pairs were assortatively formed according to their order of magnitude, i.e. the first crossing was made between the two plants with the highest linoleic acid content. Progenies (M_5-81F) and controls were grown in the field in summer 1981. The fatty acid composition was determined on 261 individuals. 48 individuals were selected as the parents for the sixth generation and 15 lines were assortatively formed by mixing the seed of 3-4 plants. The fatty acid composition of the progenies (M_6-82F) and controls grown in the field was determined (a total of 512 analyses).

Gas liquid chromatography

The analyses of the present investigation were carried out using gas liquid chromatography (GLC). The fatty acids were determined as methyl ester derivatives produced by transesterification according to the method described earlier (Hiltunen et al., 1979).

High reproducibility of the analyses is of great importance during long-term trials, especially if only slight changes in the population mean are expected - as is the case after selection experiments. The split sampling technique, which is the method most commonly used in GLC, has found to be quite unreliable for some compounds, such as palmitic and erucic acids (Hiltunen et al., 1982). The proportion of the sampling error caused by the split method out of the total variation in the fatty acids of the M_1 and M_2 generations (N=486) was on average 0.6 percent.

The sampling error for linoleic acid accounted for about 1.8 percent of the variation within one particular rapeseed variety (N=30)(Laakso et al., 1983). The PTV sampling technique has recently been found to be a suitable method for determining minor fatty acids in rapeseed oil, having a precision equal to that obtained by the on-column method (Laakso et al., 1983a).

The statistical significance of the differences between the means of selected and control lines was determined by the Studentś t-test and the equality of variances by the F-test (Snedecor and Cochran, 1967). The heritability was estimated from the regression of offspring on parents (Falconer, 1981).

RESULTS AND DISCUSSION

Table 1. Statistical significance of the differences in the linoleic acid content between selected and control lines in successive generations (according to the t-test and the F-test).

	Selected lines				Control lines			
Generation	N	Mean[a]	Variance[b]	CV(%)	N	Mean	Variance	CV(%)
M_1-79G	250	26.61	4.93	8.3		-		
M_2-79F	236	24.28***	3.84**	8.0	80	22.58	2.13	6.5
M_3-80G	158	26.46	5.05	8.5	14	26.05	3.87	7.6
M_4-80F	100	24.34***	3.87*	8.1	28	21.32	2.11	6.8
M_5-81F	206	26.74***	2.93	6.4	55	25.07	3.15	7.1
M_6-82F	390	25.29***	3.23	7.1	122	21.99	2.71	7.5

[a]Student´s t-test

[b]F-test ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

A highly significant increase in linoleic acid content was obtained for selected lines grown in the field (M_2, M_4-M_6)(Table 1). On the other hand, the fact that in the greenhouse generation (M_3) no differences were found indicates that there is a strong environmental effect; the variation in the linoleic acid of the control lines is almost twice that in the M_2 generation. The significant differences detected by the F-test possible indicate that a large amount of variation has been transferred from the M_1 to the M_2 generation and from the M_3 to the M_4 generation as a result of selection performancies or that environmental effect are involved.

The coefficients of variation and the variances in the selected and control lines are presented in Fig. 1. It is expected that the variance of a quantitative characteristic under one-way selection will decrease (Falconer, 1981). In the present breeding experiment, however, no such trend could be found until the two last generations (M_5-M_6). If the mean and variances are highly dependent on each other, then the coefficient of variation also decreases under selection (Fig. 1).

The mean values of linoleic acid content of the selected lines are plotted against the control values in Fig. 2. It can be seen that the gain through selection, after elimination of the environment, is mainly achieved in the last three generations (M_4-M_6). As far as different generations are concerned, however, the linoleic acid level is strongly affected by environmental conditions during the growing period.

The genetic gain through selection primarily depends on the additive genetic variance. The heritability, which is the ratio of additive genetic variance to phenotypic variance (V_a/V_p), was estimated from the regression of offspring on mid-parent values (Falconer, 1981). The selection of parents does not affect the regression of offspring on parents, but it reduces the precision (Robertson, 1977). The results of regression analysis are presented in Table 2.

Table 2. The slope of offspring mid-parent regression for linoleic acid content.

	Mean of parents	Mean of offspring		Regression coefficient (b)	Error of estimate (S_b)
M_2-79F	26.52	M_3-80G	26.46	0.14	0.17
M_5-81F	28.91	M_6-82F	25.29	0.12	0.16

Despite of the low mean of the M_6 progeny, it is higher with a highly significant degree compared to that of the respective control lines. The regression coefficient (b) shows only a slight dependence between parents and offspring (Table 2).

CONCLUSIONS

The variation of selected lines was decreased compared to controls during the breeding programme over six generations. It was found that it is possible to increase the linoleic acid level by a few percent units through continued selection. However, a strong environmental effect was observed for controlled and selected lines grown in the greenhouse. The results obtained from the analysis of offspring mid-parent regression showed a very low heritability for linoleic acid.

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Fig. 1. Coefficients of variation and variances for linoleic acid content in successive generations.

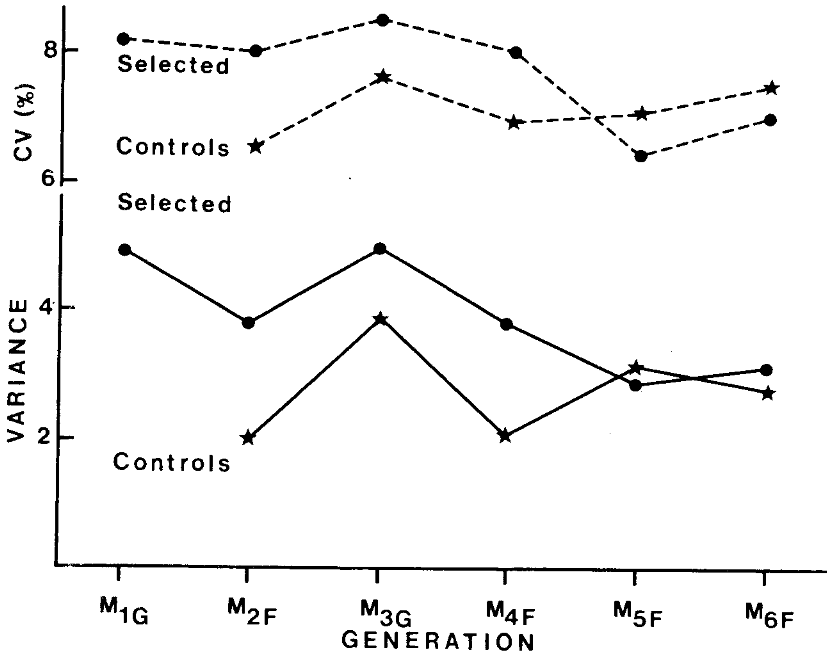

Fig. 2. Mean of linoleic acid content in selected lines expressed as the deviation from the mean of two control lines.