# RESPONSE TO SELECTION FOR FERTILITY IN F3-PROGENIES OF SIX WINTER RAPE CROSSES

Werner Odenbach
Institute for Applied Genetics, Free University Berlin, Berlin-Dahlem, Germany

## Introduction

Fertility plays a major part in breeding high yielding winter rape varieties. It is correlated to other yield characters as e. g. seed number and seed weight. Reduction processes are a well known phenomenon controlling seed yield. They are caused by a lack of assimilates which may affect the number of fully developed flowers or after anthesis hinder the growth of the pollen tubes. As a result the number of well developed seeds is reduced. Since assimilates play an important role, light conditions during fertilization and early seed development are linked to the number of seeds per silique (ALLEN and MORGAN 1975, TAYO 1974).

To take all this into account one can assume that the expression of fertility is a multifactorial trait showing continuous variation caused by genetic and non-genetic variances and by genotype-environment interactions (BESCHORNER 1986). It is very likely that checking the gain from selection in a two-way-selection experiment will improve our knowledge about the heritability of this trait.

## Material and Methods

In this study $F_3$ and $F_4$ progenies of six different winter rape crosses which we got at our disposal from three German breeding stations were planted in 1985 and 1986 in a greenhouse which we kept free of insects. In each cross 0-0-rape was combined with conventional or zero erucic rape. Fertility is defined as the quotient of the number of well developed seeds in relation to the number of ovules and it was used as the selection criterion in our experiments. Fertility was computed from the data of 10 siliques developed from selfed flowers of the main shoot. Competition for light between the main shoots of different plants can be excluded. $F_3$ plants were single seed descendants from selfed $F_2$ plants in crosses I, II, V and VI. In crosses III and IV the $F_2$ plants were not bagged. In both years we selected for high and low fertility with a selection intensity of about 10%. Each progeny of the selected plants consisted of 10 plants. Progeny means were calculated from about 100 siliques.

## Results and Discussion

### 1. Variation of fertility in the $F_3$ generations of six winter rape crosses

In 1985 about 100 $F_3$ plants from each cross were grown in the greenhouse. In relation to fertility remarkable differences could be observed between these crosses. None of the distributions is symmetrical. Their means move more or less towards higher fertility and also the extension of the tails of these distributions differ from one another (Table 1). The dissimilarities of these six crosses represent the divergencies in selfcompatibility between the lines used as cross parents. These parental lines were selected for yield and probably for high seed set under inbreeding conditions, but we have to take into account that to about one third rape is an outcrossing species. On the basis of the frequency distributions of the fertility classes we may therefore expect a higher response to selection for low fertility, e. g. for more selfincompatible genotypes in crosses I, II and IV. Selection for high fertility should reveal nearly the same results in crosses IV and V, maybe also in cross II, whereas a weaker gain can be expected from crosses III and VI.

Table 1 Frequency distribution of fertility classes in $F_3$ generation of six winter rape crosses

| fertility (%) | cross I | cross II | cross III | cross IV | cross V | cross VI |
|---|---|---|---|---|---|---|
| 10-15 | 0 | 0 | 0 | 1 | 1 | 0 |
| 15-20 | 1 | 0 | 0 | 1 | 0 | 0 |
| 20-25 | 1 | 1 | 0 | 0 | 0 | 0 |
| 25-30 | 1 | 0 | 0 | 1 | 0 | 0 |
| 30-35 | 2 | 2 | 0 | 0 | 0 | 0 |
| 35-40 | 0 | 2 | 0 | 1 | 0 | 0 |
| 40-45 | 5 | 0 | 0 | 2 | 0 | 0 |
| 45-50 | 3 | 4 | 2 | 1 | 0 | 0 |
| 50-55 | 8 | 3 | 1 | 0 | 0 | 0 |
| 55-60 | 17 | 2 | 1 | 1 | 0 | 0 |
| 60-65 | 18 | 3 | 2 | 0 | 0 | 0 |
| 65-70 | 20 | 5 | 3 | 1 | 2 | 10 |
| 70-75 | 14 | 6 | 10 | 1 | 0 | 18 |
| 75-80 | 7 | 13 | 12 | 5 | 3 | 29 |
| 80-85 | 3 | 13 | 42 | 5 | 18 | 28 |
| 85-90 | 0 | 19 | 24 | 24 | 18 | 11 |
| 90-95 | 0 | 19 | 3 | 38 | 44 | 1 |
| 95-100 | 0 | 8 | 0 | 18 | 4 | 0 |

## 2. Two-way-selection in $F_3$ and $F_4$ generations

After the first cycle with a selection intensity of 10% in both directions in each cross two groups of lines were formed, which differ significantly. In general there is a wider range of fertility amomg the downwards selected plants and their progenies than after upwards selection. The mean fertility of the selected groups of $F_3$ plants in each cross correspond very well to the expectation based on the frequency distributions (Table 1). But, this picture becomes vague, when we look at the means of the $F_4$ progenies of each selected group (Table 2).

Only in crosses I and II the range of the fertility means of the lines in the up- and downwards selected groups do not overlap. This partitioning was expected from the distribution of the fertility data in $F_3$. In all other crosses the variation of the line means for fertility in both classes do overlap. There are evident differences in the variation of fertility between the groups of selected plants and their progenies.

As already mentioned, fertility has to be interpreted as a quantitative trait. In $F_3$ a high level of heterozygosity can be assumed. This may explain the different expression of fertility in the $F_4$ progenies in comparison with their selected $F_3$ ancestors. But, there is more genetic variation in the downward selected lines than in those selected for high fertility. Comparing the data of crosses III and IV with the other ones the more pronounced deviation of the $F_4$ progeny means may be due to the open pollinated reproduction in the $F_2$ generation of these two crosses.

Table 3 demonstrates the data of plants with the best and the weakest expression of fertility in each group after the second cycle of selection. In all six crosses the response to selection is very similar. These results confirm our opinion, that a higher degree of heterozygosity of the selected $F_3$ plants of the crosses III and IV is responsible for the unexpected fertility means of their $F_4$ progenies. The range of fertility in both classes of selected $F_4$ plants in crosses I to IV is alike and relatively narrow. Only the low fertility groups of plants from the crosses V and VI show a considerable variation in fertility.

## 3. Regression of $F_4$ progenies to $F_3$ selected plants

In both generations the progenies diverged from their parents as a result of genetic segregation and of environmental effects. In general the progenies of extreme parents tended to regress towards the population mean. In all combinations except cross IV significant positive correlations could be observed between the selected $F_3$ plants and their $F_4$ progenies.

Table 2 Fertility means of $F_3$ plants and their $F_4$ progenies after the first cycle in the two-way-selection experiment (%)

| cross | selected for high fertility | | | | selected for low fertility | | | |
|---|---|---|---|---|---|---|---|---|
| | $F_3$ | | $F_4$ | | $F_3$ | | $F_4$ | |
| | n | $\bar{x} \pm s_{\bar{x}}$ | n | $\bar{x} \pm s_{\bar{x}}$ | n | $\bar{x} \pm s_{\bar{x}}$ | n | $\bar{x} \pm s_{\bar{x}}$ |
| I | 6 | 78.3 ± 0.9 | 58 | 70.2 ± 2.3 | 6 | 31.0 ± 4.1 | 60 | 31.5 ± 2.9 |
| II | 6 | 96.4 ± 0.3 | 56 | 72.4 ± 1.7 | 6 | 38.9 ± 4.6 | 57 | 24.8 ± 2.0 |
| III | 6 | 89.7 ± 0.7 | 60 | 67.0 ± 2.2 | 6 | 55.3 ± 3.2 | 54 | 4[illegible] 2.9 |
| IV | 6 | 98.2 ± 0.3 | 59 | 68.2 ± 2.7 | 6 | 30.5 ± 5.8 | 57 | [illegible].0 3.2 |
| V | 6 | 95.0 ± 0.2 | 60 | 75.6 ± 1.6 | 6 | 66.2 ±10.5 | 58 | [illegible]3.0 ± 3.1 |
| VI | 6 | 88.0 ± 0.8 | 56 | 72.5 ± 1.8 | 6 | 67.7 ± 0.7 | 57 | 58.1 ± 2.2 |

Table 3 Origin of $F_4$ plants with best and weakest expression of fertility in each selection group after the second cycle of selection

| cross | $F_3$ 1985 | | $F_4$ 1986 | | |
|---|---|---|---|---|---|
| | plant no. | $\bar{x}$ | progeny $\bar{x} \pm s_{\bar{x}}$ | plant no. | $\bar{x}$ |
| I | 96 | 80.5 | 72.1 ± 4.6 | 56 | 91.0 |
| | 34 | 76.5 | 71.9 ± 6.2 | 11 | 86.1 |
| | 15 | 42.9 | 34.5 ± 6.6 | 109 | 21.6 |
| | 95 | 18.4 | 20.2 ± 6.4 | 64 | 4.1 |
| II | 40 | 97.4 | 74.0 ± 5.6 | 179 | 92.4 |
| | 51 | 96.8 | 70.0 ± 4.9 | 154 | 82.9 |
| | 90 | 39.5 | 36.7 ± 4.2 | 203 | 14.7 |
| | 7 | 33.0 | 17.8 ± 4.8 | 199 | 6.4 |
| III | 75 | 88.7 | 65.4 ± 8.0 | 254 | 90.8 |
| | 42 | 90.6 | 79.4 ± 2.0 | 287 | 84.4 |
| | 71 | 49.0 | 49.5 ± 5.0 | 315 | 24.1 |
| | 24 | 63.0 | 32.3 ± 7.5 | 345 | 2.6 |
| IV | 50 | 97.9 | 59.3 ± 10.4 | 382 | 95.3 |
| | 21 | 98.9 | 72.8 ± 5.9 | 403 | 85.8 |
| | 63 | 28.3 | 46.3 ± 3.9 | 448 | 31.6 |
| | 17 | 16.8 | 63.9 ± 8.4 | 431 | 16.5 |
| V | 26 | 94.7 | 82.4 ± 2.9 | 506 | 92.1 |
| | 27 | 95.1 | 80.2 ± 2.9 | 515 | 88.8 |
| | 5 | 67.9 | 66.1 ± 3.9 | 559 | 50.7 |
| | 44 | 14.7 | 26.7 ± 5.1 | 548 | 10.0 |
| VI | 17 | 91.0 | 80.6 ± 2.1 | 655 | 89.3 |
| | 65 | 88.2 | 69.6 ± 3.5 | 635 | 83.9 |
| | 26 | 66.4 | 60.1 ± 3.1 | 676 | 44.6 |
| | 88 | 69.0 | 60.3 ± 8.7 | 710 | 9.6 |

Coefficients of regression varied from 0.81 in cross II to 0.49 in cross III. Higher values suggest larger genetical effects. After computing separately the upwards and downwards selected groups of lines no correlation could be found in the high fertility class. Only environmental effects seem to vary the expression of fertility in $F_3$ and $F_4$ generation. This means, that in this material the genetic plateau for high fertility was reached already after one cycle of selection.

In the low fertility class $F_3$ and $F_4$ values were correlated significantly with a coefficient of regression of 0.39. Both, genetical and environmental effects control the expression of fertility after selfing in this group of lines. Further selection should reveal selfincompatible genotypes, which is already demonstrated in Table 3, but should be confirmed after the analysis of the $F_5$ progenies.

Literature

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