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ERUCIC ACID HEREDITY IN RAPESEED

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According to investigations by Downey and Craig (1964) and Harvey and Downey (1964) the fatty acid composition in summer rape is conditioned by the genotype of the seed and the erucic acid content is controlled by two additive genes without dominance. Kondra and Stefansson (1965) found that the synthesis of both eicosenoic and erucic acid is controlled by the same genes and that these have additive effect with regard to the erucic acid content but dominant effect with regard to the eicosenoic acid content. According to Dorrel and Downey (1964) the erucic acid content in summer turnip rape is controlled by one gene.

Erucic acid is found in both turnip rape and cabbage. Since rape is an allotetraploid hybrid derived from these two species, the erucic acid content in rape is controlled by at least two genes. Harvey and Downey (1964) showed that in summer rape the allele at each of the two loci in heterozygous condition increases the content by 9-10%. In the summer rape material that Stefansson and Hougen (1964) used for their investigation each allele contributed only to a 7.5% increase in erucic acid content. Krzymanski and Downey (1969) found an allele present in Bronowski summer rape that yields only 3.5% erucic acid in heterozygous condition. According to Krzymanski (1970) levels up to 50% of erucic acid are controlled by three alleles, which contribute 0, 4 and 12.5% respectively.

However, even in recently published papers the erucic acid content in rape is reported to be controlled by two additively effective genes giving in heterozygous condition about 10% erucic acid. Such information about the genetics of erucic acid is valid for individual cases only and does not adequately account for the presence of stable erucic acid levels at about 10% in Bronowski summer rape or at about 60% in winter rape and in summer turnip rape. Nor has the question of possible partial dominance been satisfactorily answered, since it has been impossible to establish with any degree of certainty whether the monohybrid segregation in F_2 is 1:2:1 or 1:3 and the dihybrid segregation 1:4:6:4:1 or 1:4:11. The half-seed technique has in recent years been used to an increasing extent at the Swedish Seed Association in order to speed up the breeding work. With this technique repeated selection for low erucic acid content has been carried out in marketed varieties and promising breeding lines with normal erucic acid content and genes for low erucic acid content have been transferred with the back-cross method to high-yielding marketed varieties with a normal erucic acid content. By means of this technique more accurate data about the erucic acid heredity are now obtained (Jönsson 1977).

In Gulle summer rape, with an average erucic acid content of about 40%, a seed with content as low as 26% was found. The progeny from this seed showed heterozygosity for one locus, and homozygosity for one and two loci gave about 11 and 33% erucic acid, respectively. Seeds from these two levels yielded constant progenies in the following generations. Plants with 11% erucic acid were crossed with Zephyr, displaying only traces of erucic acid. The data from F_2 show a monohybrid segregation. Repeated selection with the half-seed technique in a breeding line of summer rape, Sv 69610, revealed two homozygosity levels of about 5% and

9% erucic acid. These levels, too, are controlled by alleles at one locus.

The Polish summer-rape variety Bronowski has an average erucic acid content of only about 11%. Plants from this variety with 9-12% erucic acid were crossed with material having less than 1% erucic acid. The F_1-data are divided in two distinct groups with about 4% and 9% erucic acid. The data from F_2 show a monohybrid segregation for the lower level but a dihybrid segregation for the higher level. This means that the erucic acid contents at the low level of 9-12%, present in Bronowski, are controlled by genes at two different loci and that alleles for the absence of erucic acid are present in this variety.

Even in winter rape different alleles for erucic-acid production occur. The least effective allele found produces about 3% and 9% erucic acid in heterozygous and homozygous condition, respectively. The corresponding values for the most effective allele are about 15% and 30%.

Thus, alleles controlling the production of very small amounts of erucic acid have been found in materials of various origin both in summer and winter rape. Particularly interesting is the allele giving erucic acid contents even below 2%. There is a risk of misclassification since the border line between the erucic acid levels, indicating the presence or absence of the allele in question, is obscure. However, such mistakes can be avoided, if the content of eicosenoic acid is considered. If the allele in question is present this content exceeds 8%. Most probably, this allele controls the synthesis from eicosenoic to erucic acid, while the allele, yielding low amounts of both eicosenoic and erucic acid, is controlling the synthetic step from oleic to eicosenoic acid. The synthesis from oleic eicosenoic erucic acid is according to Morice (1974) probably controlled by only one enzyme system as almost identical quotients erucic acid/eicosenoic + erucic acid and eicosenoic + erucic acid/oleic + eicosenoic + erucic acid are found in rape. However, quite different quotients also exist in some materials and it is therefore obvious that the two steps of elongation of the carbon chain from oleic to erucic acid are controlled by different enzymes.

The selection work with the use of the half-seed technique has revealed the presence of series of multiple alleles that control the production of erucic acid. A large number of homozygosity levels for erucic acid and eicosenoic acid have been discovered. Such levels between 5-10%, 10-35% and with more than 35% erucic acid are controlled by alleles at one, one or two and two loci, respectively.

The correlation between the contents of erucic and eicosenoic acid is positive at erucic acid levels up to 25% but negative at higher levels. The alleles exhibit additive effect for erucic acid at levels below 30% while partial dominance is common at higher levels. Those alleles, that control low amounts of erucic acid exhibit partial dominance with regard to eicosenoic acid content. Alleles that control a more effective erucic acid production, on the other hand, exhibit strong overdominance with regard to eicosenoic acid content.

The erucic acid content in turnip rape is controlled by one locus. The segregation in F_2-populations seems to follow a 3:1 pattern but if single seeds from inbred plants are analysed a 1:2:1 segregation and the presence of a series of multiple alleles is revealed (Jönsson, 1973, 1974).

The breeding program for low erucic acid content in turnip rape and rape is complicated by the presence of series of multiple alleles that control this fatty acid. Plants with two different alleles E_1E_2 in turnip rape and four alleles $E_1E_2E_3E_4$ in rape, controlling the synthesis of erucic and eicosenoic acid, are probably rather common in the populations. Crosses between such plants can give rise to segregations in the subsequent generations that may be difficult to interpret. The presence of multiple alleles augments the risk of misclassification when series of backcrosses are carried out with the use of the half-seed technique. A better safety may be obtained, if varieties with a high degree of homozygosity with regard to the erucic acid content can be used as backcross parents.

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