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APPLICATION OF RECESSIVE SELF-INCOMPATIBILITY TO PRODUCTION OF HYBRID RAPESEED

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Self-incompatibility is normally dominant to self-compatibility in forage rape, Brassica napus (Mackay, 1976; 1977), but in oilseed rape Olsson (1960) reported segregation for self-incompatible plants from selfing self-compatible plants. Marketing of seed to farmers from double-cross hybrids, produced from lines with dominant self-incompatibility, would give low yielding crops, because the self-incompatible plants would be also largely cross-incompatible with each other. Self-incompatible plants are also undesirable in a farmer's crop as they are dependent on dry weather for adequate cross-fertilisation by wind and in addition the production of several kilograms of selfed seed annually by hand-pollination of flower buds from the inbred lines is both laborious and expensive. Two recent developments may overcome these problems.

RECESSIVE SELF-INCOMPATIBILITY

A self-incompatible, homozygous diploid line, obtained by colchicining a naturally occurring haploid (Thompson, 1975) in a zero erucic acid winter variety, gave self-compatible F_1 hybrids when crossed by self-compatible plants. Self-incompatible plants, cross-incompatible with the original line, were recovered in the F_2 and F_3 generations from these crosses and hence this character could be transferred into zero erucic, low glucosinolate lines.

OVERCOMING SELF-INCOMPATIBILITY WITH CARBON DIOXIDE

Nakanishi and Hinata (1975) obtained selfed seed from self-incompatible cabbages by putting a plant in an atmosphere containing 4 to 5 per cent carbon dioxine for five hours after selfing flowers. This method was used successfully by Taylor (1977) to produce selfed seed from clones of marrow-stem kale, B.oleracea, homozygous for different incompatibility S alleles, in a polythene chamber, 2 x 1 x 2 metres high, in a glasshouse, while the self-incompatible rape line averaged 23 selfed seeds per fruit with carbon dioxine, compared with 1.1 seeds per fruit for the control plant.

In an attempt to produce larger quantities of seed, 240 plants of the self-incompatible rape line were planted in the ground and covered by a 9 metre long by 4.3 metre wide polythene tunnel. Ventilation was provided by nylon mesh screens or doors at both ends of the tunnel; these were replaced by polythene covered screens or doors for carbon dioxine treatment, which was done twice a week for four weeks during the flowering period. About 8 kilograms of dry ice (solid carbon dioxide) pellets, each 2 by 1 cm, were put in plastic seed trays, stood 50 cm from the ground on wooden trays, down the central path in the tunnel. The heavier than air carbon dioxide was circulated by a 22.5 cm diameter fan overnight. A concentration of 3 to 4 per cent carbon dioxide was reached in two to three hours and maintained for at least four to five hours. Flowers were pollinated by blow flies, which lived for two to three weeks in the tunnel. Seed setting was good while the flies were alive and four kilograms of selfed seed was obtained.

YIELDS OF SELF-COMPATIBLE F_1 HYBRIDS

The highest yielding of four zero erucic acid hybrids, produced by hand pollination of the self-incompatible line, gave 17 per cent more oil than Primor in one trial, the hybrid yielding 30 per cent more than the higher yielding parent. Choné (1976) reported that preliminary results from INRA Rennes, suggested that hybrids, from cytoplasmic male sterile material, might yield from 40 to 80 per cent more than current varieties.

METHODS FOR APPLYING RECESSIVE SELF-INCOMPATIBILITY TO HYBRID PRODUCTION

1. Self-compatible F_1-hybrids

If an F_1 hybrid yielded 20 per cent more than any marketed variety, it might be profitable to produce a self-compatible F_1-hybrid for commercial use. If 36 metre long polythene tunnels can be ventilated adequately, each could produce 20 kg of selfed seed by the carbon dioxide method and 50 tunnels would give a tonne of seed. This quantity of seed would sow 200 hectares in blocks alternating with a self-compatible pollinator to give 300 tonnes of self-compatible F_1 hybrid seed, to drill about 50,000 hectares.

2. Self-compatible three-way hybrids

With a second recessive, self-incompatible line, cross-compatible with the original line, seed of a self-compatible three-way cross hybrid could be marketed (Diagram 1). With the high seed multiplication rate in this crop and the low weight of seed required for sowing, this method appears to be economically feasible. Only small quantities of selfed seed would be needed from the two self-incompatible lines. Such a second recessive self-incompatible line has not been found yet in oilseed rape, but an annual, recessive self-incompatible, artificial *B.napus* line, synthesised by the Scottish Plant Breeding Station, is cross-compatible with the original line.

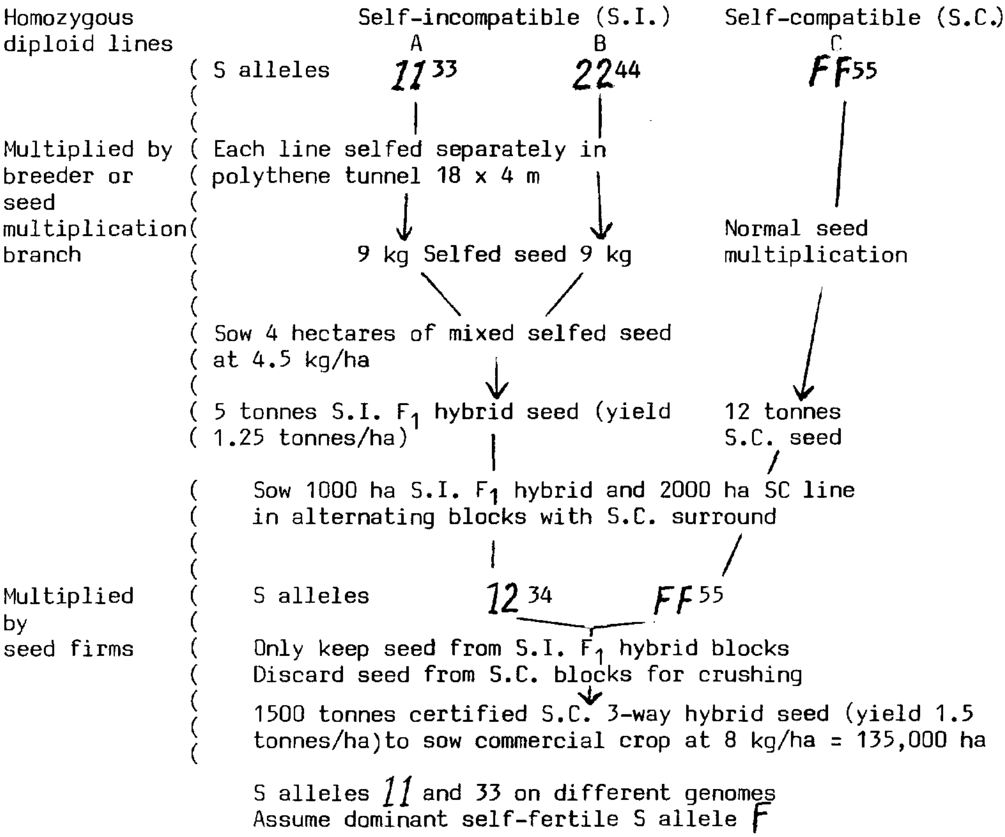
As wind pollination can be very effective in *B.napus* (Olsson, 1955), the seed yields from field crops in diagram 1 may be underestimated. The self-incompatible F_1 hybrid blocks, provided they are adequately cross-fertilised, should be wide enough to allow seed to be harvested easily from them without contamination by seed from the self-compatible blocks. In a 1977 trial, plots of the self-incompatible line, 5 metres long by 1.5 metres wide, gave 90 per cent of the yield of Primor, although very little seed was set during the first three cold, wet weeks of flowering. Obviously, the self-compatible pollinator line must also be a good pollen producer.

A problem in working with recessive self-incompatibility may be that, as in *B.oleracea*, lines active only for S alleles low in the dominance series, may be less self-incompatible (Thompson and Taylor, 1966) and more selfing may occur at higher temperatures ($>20^{o}C$) and towards the end of flowering (Johnson, 1971). The original self-incompatible rape line averaged only 80 per cent hybrid seed when seeded with alternating self-compatible high erucic acid plants in a nylon cage without insects. The percentage of hybrids was determined by analysis of single seeds for erucic acid content. For three-way cross production, 10 to 15 per cent of selfs with the self-incompatible F_1 hybrid seed can be tolerated, because they will not cross with the F_1 hybrids but with the self-compatible pollinator line.

A second difficulty might be mutual weakening between the four different

DIAGRAM 1

POSSIBLE PRODUCTION OF SELF-COMPATIBLE THREE-WAY HYBRID



recessive S alleles in the self-incompatible F_1-hybrid, for three-way cross production, to give a fairly self-compatible F_1 hybrid, although both constituent lines were self-incompatible. This was found in B.oleracea (Thompson, 1972); the F_1 hybrid between the two cross-compatible, self-incompatible rape lines has not yet been tested.

INHERITANCE OF RECESSIVE SELF-INCOMPATIBILITY

In one cross between the self-incompatible and a self-compatible line, one dominant major gene determined self-compatibility. Its action was identified a day or two after self-pollination by darkening of the stigma followed by a full seed set. The stigmas of a quarter of the F_2 generation plants (46 out of 184) did not darken on selfing. The gene could be either a self-fertile S allele or a self-compatibility gene linked fairly closely to the S allele locus as none of the 46 F_2 generation plants which did not darken stigmas on selfing, were cross-compatible with the original self-incompatible line. In another cross, in addition to this major gene, segregation occurred for degree of self-incompatibility, which ranged from strongly self-incompatible to almost completely self-compatible in an F_3 generation line, whose stigmas did not darken on selfing.

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