# BREEDING HYBRIDS IN RAPESEED AND MUSTARD

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## ABSTRACT

With the development of Cytoplasmic male sterile (CMS) lines and their maintainer and restorer sources in both rapeseed (B. napus) and mustard (B. juncea), the possibility of exploiting the hybrid vigour for oil yield productivity seems almost a reality in the very near future. The initial problems of pollen fertility restoration of male sterile cytoplasm in B. juncea has been overcome through recurrent selection for profuseness of pollen production and bringing together the restorer genes from nigra (RN) and campestris (RC) sources in the juncea background as reported previously by Anand et al. (1985). The male sterile juncea cytoplasm which was transferred through recurrent backcrossing with respective pollen parent in ten promising lines of B. napus (A lines) has provided two natural sources of pollen fertility restoration in B. napus and are currently been used as donor parents (R-lines) for pollen fertility transfer. A number of hybrids in both rapeseed and mustard are being tested for their oil yield productivity against the standard varieties. Studies of the recent past have suggested that it may be possible to double the seed yield in both rapeseed and mustard, once suitable hybrid combinations are identified. Heterosis for oil and protein content upto 10 and 25 per cent respectively has also been observed in the $F_1$ crosses. It is likely that in the near future 'Hybrid Rape and Mustard' based on CMS system would provide a necessary breakthrough in the stagnating yields of these crops.

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Studies on heterosis have led to substantial gains for yield and other economic characters in both self and cross pollinated crops. In oleiferous Brassica, although exploitation of heterosis for oil yield productivity has not reached at commercial level but efforts are being made all over the world to realise the heterozygous advantage of the $F_1$ hybrids (Shiga, 1976; Anonymous, 1983; Anand and Mishra, 1984). The present study was undertaken with a view to transfer the male sterile

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cytoplasm of B. juncea (Anand and Rawat, 1978) into different species of Brassica particularly B. napus L. and B. carinata Braun, and to study extent of heterosis for the major economic attributes of the cultivated digenomic species of Brassica.

Cytoplasm transfer

The programme on the substitution of B.napus and B. carinata nuclear genomes in the male sterile cytoplasm of B. juncea was initiated in 1979 at the Institute of Agronomy and Plant Breeding University of Gottingen, West Germany during the course of senior fellowship of Alexander Van Humboldt Foundation. Initially, only two early lines in each of the two species were chosen as pollen parents, however, later in India a number of new lines were incorporated in the programme as interspecific crosses involving CMS-B. juncea as mother parent showed greater succession in per cent pod and seed setting. Recurrent backcrossing with respective pollen parent, followed by selection of the improved genotypes was undertaken in each backcross generation. Thus, CMS cytoplasm has been transferred in ten promising lines of B. napus and in three lines of B. carinata constituting A lines for the hybrid seed programme. CMS cytoplasm is also being transferred in twenty promising genotypes (lines) in each of B. napus and B. carinata to use them as future A lines.

Attempts were also made to transfer the CMS cytoplasm in the background of numerous other species which includes B. oleracea ssp. alboglabra, botrytis and acephala (all c genomic species with n=9), B. campestris ssp. chinensis, parachinensis, pekinensis, nipposinica,

Oleifera var. dichotoma (brown sarson), var. trilocularis (yellow sarson), var. toria (all A genomic species with n=10), Raphanus sativus (n=9) and Sinapis arvensis (n=9). However, due to distant hybridisation involving irregular pairing of chromosomes resulted in the formation of unbalanced gametes leading to both male and female sterility in the majority of interspecies crosses.

Identification of restorers

While transferring the cytoplasm in B. napus and B. carinate background, a large number of crosses between CMS sources (viz. CMS B. nap and CMS B. car. in the initial stages) and a number of germplasm lines of B. napus and B. carinata (68 in the former and 28 in the latter species) have resulted in the identification of partial to complete pollen fertility restoration lines. Two of these B. napus lines have shown complete pollen fertility restoration in its crosses and are currently been utilised as donor parents (R lines) for restoration. In case of B. carinata, although restoration was observed for a large majority of lines, it was partial with per cent viability of pollen ranging between 24-60 per cent. The flower and anther size in B. napus was normal with pollen viability ranging between 86 to 96 per cent. Studies are being intensified to transfer the restorer genes from these two lines to suitable pollen parents (future R-lines) that showed high heterosis for oil yield productivity with the CMS source (A lines).

Heterosis in Brassicas

In order to formulate a successful hybrid programme to exploit heterosis for seed and oil yield productivity in the various cultivated digenomic Brassica, it is essential to estimate the extent of heterosis

of the crosses, the combining ability of the parents involving the crosses and the nature of gene action for the major economic attributes. The present study describes briefly the results obtained on these aspects in the various Brassicas.

## I. B. juncea (L.) Czern (Indian mustard)

### Heterosis:

Studies on heterosis were carried out utilising different breeding material in various biometrical mating designs involving Diallel, Line x Tester and biparental crosses. The diverse material used in these crossing designs included improved Indian x Indian, Indian x Exotic and Indian x Synthesised amphidiploids of B. juncea. Considerable heterosis was observed for all the nine characters viz. early flowering (24.8%), maturity (30.2%), number of siliquae per plant (78.6%), seeds per siliqua (32.4%), 1000-seed weight (56.8%), seed yield ( 200%), oil content (9.6%), oil yield per plant (47.8%) and protein content (24.6%). The range of commercial heterosis for seed yield and oil content in these crosses is presented in Table-1.

### Combining ability/Nature of gene action:

Among the lines involved in the crossing, Varuna, Pusa Bold and RH-30 were found to be the best combiners for the majority of characters. General combining ability (gca) effects of parents were not reflected in the corresponding sca effects of crosses for the majority of characters. For seed yield, the frequency of desirable crosses was more in high x low gca parent crosses than in high x high or low x low crosses indicating the importance of diversity in heterotic

effects. The combining ability variance and gca:sca ratio indicated the importance of non-additive gene action for seed yield and oil content. For the remaining characters both additive and/or non-additive gene action were observed.

## II. B. napus L. (Swede rape or rapeseed)

**Heterosis:**

Estimates of heterosis were calculated for 18 characters contributing to seed yield, oil content and protein content using different biometrical designs including diallel, Line x tester and Triallel crosses. The material for the crosses included both exotic introductions and artificially synthesised stable amphidiploids of B. napus. Considerable amount of heterosis was observed for all the characters. Heterosis for seed yield ranged from 4.75 to 217.92%, for oil content from 0.51 to 25.91%, for oil yield from 0.65 to 216.24% and for protein content from 0.27 to 20.23% (Table-1). Among various heterotic crosses, three crosses showed significant heterosis for all the four economic characters taken together. There was no consistent relationship between the diversity of parents and heterosis for seed yield expressed by their hybrids.

**Combining ability/Nature of gene action:**

Based on g.c.a. effects, four lines (AG-29376, BO-54, Na-38 and Na-12) were found best combiners for the majority of characters studied. The per se performance of the line was found to be a good indicator of the performance of the crosses involving the line. Almost all the best crosses included in their parentage at least one line with high gca effect.

The combining ability analysis revealed significant estimates of both additive and non-additive gene action for almost all the characters. The manifold g.c.a./s.c.a. ratio suggested preponderance of additive gene action for all the characters.

III. B. carinata Braun (Ethiopian mustard)

Studies on heterosis were carried out in the diallel and Line x tester crosses involving 44 exotic lines of B. carinata for nine characters contributing to seed yield and oil content. Heterosis for seed yield ranged upto 234.6% and for oil content upto 12.4% (Table-1).

Some of promising selections of B. carinata gave upto 93.39% oil yield superiority over the best control B. juncea under rainfed conditions, thus suggesting the potential of this species under dryland agriculture.

Studies on combining ability and nature of gene action are underway.

## References

Anand, I.J. and D.S. Rawat (1978). Exploiting cytoplasmic male sterility for heterosis breeding in Indian mustard (B. juncea (L) Czern.). Proc. Int. Conf. Cytogenetics and Crop Improvement, Varanasi, India.

Anand, I.J. and P.K. Mishra (1984). Exploitation of hybrid vigour on commercial scale rapeseed-mustard. Proc. Annual Rabi Oilseeds Workshop, Jaipur, India.

Anand, I.J., P.K. Mishra and D.S. Rawat, 1985. Mechanism of male sterility in Brassica juncea I. Manifestation of sterility and fertility restoration. Cruciferae Newsletter 10: 44-46.

Anonymous (1983). Proceedings of hybrid oilseed Brassica Workshop. Paris, France.

Shiga, T. (1976). Studies on heterosis breeding using cytoplasmic male sterility in rapeseed B. napus L.Bull. Nat. Inst. Agric. Sci. (Series D), 27: 1-85.

Table 1: Per cent heterosis observed in $F_1$ crosses of Brassica spp.

| Crosses | Yield | | Oil content | |
|---|---|---|---|---|
| | C.H. | B.H. | C.H. | B.H. |
| Brassica juncea | | | | |
| Indian x Indian | 70.5 | 48.4 | 9.6 | 7.7 |
| Indian x Exotic | 309.0 | 217.0 | 0.3 | 0.3 |
| Indian x Syn. B.J. | 206.2 | 186.8 | 8.5 | 6.6 |
| Brassica napus | | | | |
| Natural x Natural | 3.4 | 128.4 | 0.8 | 10.27 |
| Natural x Synthesised | 156.6 | 156.6 | 7.2 | 7.2 |
| Synthesised x Synthesised | 169.7 | 169.7 | 3.2 | 11.1 |
| Brassica carinata | | | | |
| BCR-HC-2 x BCR-K-2 | 234.6 | 234.6 | 12.4 | 12.4 |

C.H. = Heterosis over commercial cultivar
B.H. = Heterosis over better parent