The utilization of genetic male sterility in *Brassica napus* in Shanghai, China

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One means of obtaining high-yielding rapeseed hybrids is to utilize genetic male sterile (GMS) and fertility restoring plants. This paper describes the identification, utilization and commercial experience with such a GMS hybrid system.

Isolation of genetic male sterile plants

Genetic male sterile plants were found in various old Chinese varieties at a frequency of 0.01%, and at a frequency of about 1-2% in inbreds from some new varieties. However, intervarietal and interspecific crosses yielded a higher frequency of such plants (Table 1).

Table 1. Sources of *B. napus* genetic male sterile (GMS) material in China

Breeding method	GMS name	Variety source	Source institution	Year found
Spont. mutation	Suan 7A	Suan You 7	Yi-Zuan Agric.Res.Inst.	1972
	Xiao Hua A	Sao Yi Qin	Shanghai Acad.Agric.Sci.	1976
Hybrid	Yi 3A	Yi You X Lu Zhou 5	Yi-Bin Agric.Res.Inst.	1972
Segreg.	Zh 9A	Japan X 72-119	Shanghai Acad.Agric.Sci.	1977
	Yu San A	Shang Li X Han Zhong Ai*	Shanghai Acad.Agric.Sci.	1977
Inbred	Hua You 6A	Hua You 6	Shanghai Acad.Agric.Sci.	1977

*a *B. campestris* variety.

GMS plants from these sources and later breeding studies were crossed to fertile sibs in 215 combinations. Of these, 94.4% segregated for the GMS characteristic, yielding 1 to 50% GMS plants. None of the combinations gave 100% MS plants. However, the results suggested that it should be possible to develop lines which would give a ratio of GMS to fertile plants of approximately 1:1. The fact that fertility was completely restored in 5.6% of the crosses also indicated that fertility restorer genes were available in the population.

Development of double purpose lines

Since crosses between GMS and fertile sib plants result in both GMS and fertile progeny, the sib-line serves as both a maintainer and a GMS source. Thus, such lines are termed "double-purpose" lines. To develop agronomically suitable double-purpose lines which yield 40 to 50% GMS plants, seed from sib-mated GMS and fertile plants were sown in isolation blocks and seed harvested from identified GMS plants. Progeny from such plants were evaluated for their agronomic performance and the proportion of GMS plants produced. Stable lines were identified after three to four cycles of selection.

To further improve the agronomic performance of such lines, GMS plants were backcrossed three times to "No. 23", a high-yielding, non-fertility restoring variety. This program resulted in the production of an agronomically acceptable double-purpose line which yielded 45 to 50% GMS plants.

The inheritance of the GMS character in this material is still not completely worked out. It is believed that sterility results from the heterozygotic condition of one gene pair, i.e., Aa, with the homozygous dominant being completely fertile, and the homozygous recessive lethal.

It is also postulated that a second dominant gene must be involved in restoring fertility, and that a low frequency of the recessive restorer allele could account for the occurrence of GMS plants in ratios approximating 1 in 4, 16 or 64 plants when hybrid plants are inbred.

Identification of restorer lines

In theory, any variety can be used as the restorer parent, provided no GMS plants occur in the inbred progeny of such a cross. Nine varieties among the many tested were found to restore the fertility of GMS hybrids to at least the 95% level. Five of these restoring varieties originated from Japan; three were Chinese and one was from Europe.

In combining ability tests of these nine restorers with strain No. 23A, F_1 yields were 20.7 to 53.5% above the best standard commercial variety. Restorer variety No. 4190 was found to have the best combining ability, and was tested in combination with No. 23A under experimental and commercial field production.

GMS flower characteristics

Anthers of GMS flowers have short filaments, are needle-shaped, contain aborted pollen and have a white, blighted appearance (Fig. 1A and 1B). The buds are thin (Fig. 1C) and the number of seeds per pod are fewer than in male fertile plants of the same line (Fig. 1D). GMS and fertile plants of the same line can only be distinguished in the field by examining the floral parts. Therefore, in maintaining the double-purpose line and in the production of commercial hybrid seed, GMS plants must be identified. This is done by examining the buds shape prior to flowering.

Experimental and commercial use of GMS hybrids

Three years of trials with double-purpose line No. 23A indicate that GMS plants will yield approximately 886 kg/ha. Since 7.5 kg of seed is sufficient to sow a 1 ha seedling bed and the resulting seedlings will transplant to 5 ha, the propagation coefficient exceeds 1:500.

To produce the commercial F_1 seed, one row of restorer is planted to every two rows containing the GMS plants. Since only half the plants in these rows are GMS, these rows are planted at twice the normal density. The fertile plants in the GMS rows are removed at the bud stage.

F_1 hybrids of 23A X 4190 were extensively tested in experimental and full-scale field trials in 1980 through 1982 (Table 2). Yields recorded were significantly higher than the standard varieties. Yield increases ranged from 20.7 to 45.6%. Actual oil content of the hybrid seed was also higher than the standard varieties in every trial, with an average moisture-free oil content of 42.7%. F_1 plants had, on average, 17.4% more pods, 9.8% more seeds per pod and 3.1% heavier seed than the standard variety (Fig. 1E).

From 1980 to 1982 the hybrid has been grown at Shanghai on over 70 ha, giving an average yield increase of 24.7%. In 1983 hybrid production has been extended to 700 ha in the Shanghai region.

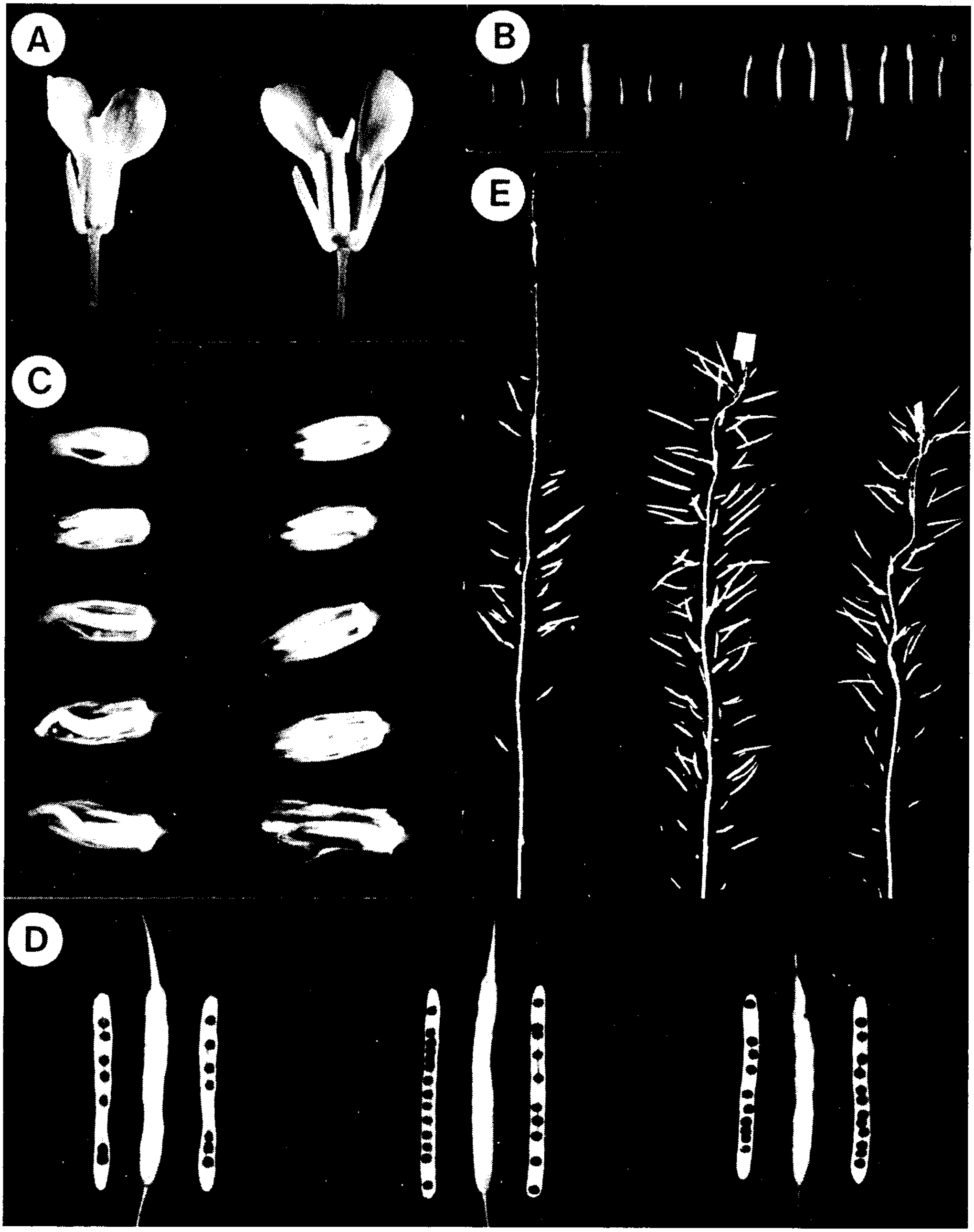

Fig. 1A and 1B, left GMS flower, normal fertile, right; 1C, left GMS buds, fertile buds, right; 1D, left to right GMS, F_1 and restorer pods; 1E, left to right GMS, F_1 and restorer racemes.

Despite the success of this hybrid program, the present A23 X 4190 hybrid requires improved resistance to lodging and the mosaic virus diseases. The efficiency of this GMS hybrid system would be greatly increased if a seedling marker could be found in a double-purpose line that is linked to either the fertile or GMS characteristic.

Table 2. Yield performance of GMS hybrid No. 23A X No. 4190 in plot and field-scale testing compared to best standard variety, 1980-82

Testing method	Test year	Test design	Yield kg/ha	% yield advantage over standard var.
Experimental plots	1980	1 location,non-rep.	2186	+ 36.8
	1981	1 location, 3 reps.	2413	+ 30.2
	1982	1 location, 3 reps.	2257	+ 45.6
Regional trials	1981	9 loc., 4 reps.	2222	+ 34.9
	1982	6 loc., 4 reps.	2230	+ 34.1
Field scale trials	1980	1 location	2423	+ 33.9
	1981	7 locations	2056	+ 24.6
	1982	3 locations	2275	+ 20.7

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