MALE STERILITY IN YELLOW *SARSON*

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IN commercial plantings of yellow *sarson* (*Brassica campestris* var. yellow *sarson*) a few plants were detected during 1960–61, in which the size of the petals was significantly reduced and the anthers were narrow, thin, needle shaped, and whitish in colour. Examination of the anthers revealed that they were devoid of healthy pollen suggesting that the abnormal plants were naturally occurring male-sterile mutants. A detailed study was undertaken on the morphology of these mutants and mode of inheritance of male sterility. The results obtained are discussed in this paper.

MATERIALS AND METHODS

The male-sterile mutants observed were crossed with other normal plants and F_1 grown during 1961–62. The F_1 plants, which were all normal, were selfed to obtain seeds for growing the F_2 generation. A few test crosses were also made.

Classification into normal and male-sterile plants was made on the basis of floral characters. In male-sterile mutants, flowers were smaller and contained thin, pointed, and whitish anthers without any pollen dust on the surface. For a quantitative determination of size differences, measurements of petals and anthers of normal and male-sterile plants were made.

RESULTS

MORPHOLOGY OF THE MALE-STERILE MUTANTS :

The male-sterile plants under study were similar to normal plants in respect of general appearance, vegetative growth, flowering time, and maturity period. However, a decrease in flower size was observed in the male-sterile plants and the anthers were pointed, narrow, and whitish as compared to the long, well developed and yellow anthers in normal plants. The difference in size of flowers and anthers is clearly seen in Figs. 1 and 2.

The length of petal and length and width of blade as well as length of anther was measured and data statistically analysed (Table 1).

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FIG. 1. Normal flowers on the left and flowers from male-sterile plants on the right

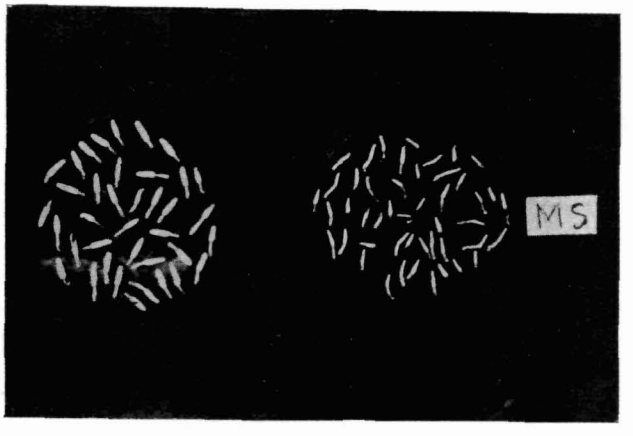

FIG. 2. Normal anthers on the left and anthers from male-sterile plants on the right

TABLE 1

Analysis of variance for length of petal, length and width of blade and length of anthers in normal and male-sterile plants

Source	D.F.	M.S.			
		Length of petal	Length of blade	Width of blade	Length of anther
Between treatments	9				
Type (T)	1	199·600†	38·369†	52·839†	10·849†
Families (F)	4	0·130	0·250	0·059	0·772†
F×T	4	0·200	0·126	0·091	0·051†
With in treatments (Error)	40	0·380	0·118	0·085	0·013

†Significant at 1 per cent level.

The mean values of these measurements are given below:

	Petal length (mm.)	Blade length (mm.)	Blade width (mm.)	Anther length (mm.)
Normal	13·80	8·77	7·50	3·62
Male-sterile	9·80	7·02	5·44	2·69

It will be noted that there is a significant difference in length of petal as also in length and width of petal blade of flowers of male-sterile and of normal plants. A significant difference also exists between the lengths of anthers. It is of interest to note that the variation due to families and the interaction of families × types are also significant indicating that difference with regard to length of anther exists between families also.

A careful examination of the anthers of male-sterile and normal flowers in the field in the afternoon revealed a striking difference between the two. Anthers of normal flowers showed an abundance of yellow pollen on the outer surface while those of male-sterile plants were whitish, narrow, and empty. Absence of normal and viable pollen grains in the anthers of male-sterile plants was confirmed by examination of acetocarmine mounts. In the case of male-sterile plants, a few lightly stained, crumpled and sterile pollen grains were observed whereas in slides of normal anthers, healthy, well-developed and deeply stained grains were seen in abundance.

In five families segregating for male sterility, five male-sterile and five normal plants were bagged from each family. In normal plants pod formation varied from 57·14 to 100 per cent. while in the case of male-sterile plants almost no pods were formed. Rarely one or two pods were seen on male-sterile plants which may, possibly, be due to contamination.

It was further noticed that under open pollination normal pod formation took place in male-sterile plants (Fig. 3). Such pod formation was also observed when controlled pollination with pollen from normal plant was carried out using male-sterile plant as a female parent. This showed that these plants were ovule-fertile.

INHERITANCE OF MALE STERILITY

Crosses were made between seven male-sterile plants and normal ones, using the former as female parents. One male-sterile plant Y-7, dried up early and crossed seed could not be collected. Open pollinated seeds were also collected from all the male-sterile plants.

In all the six F_1 families grown only normal plants appeared. Similar observations were made in seven families raised from open pollinated seeds of the male-sterile plants, indicating male sterility to be recessive. All the families from selfed seeds of the normals used as male parents contained only normal plants suggesting that the male parents were homozygous for normal condition.

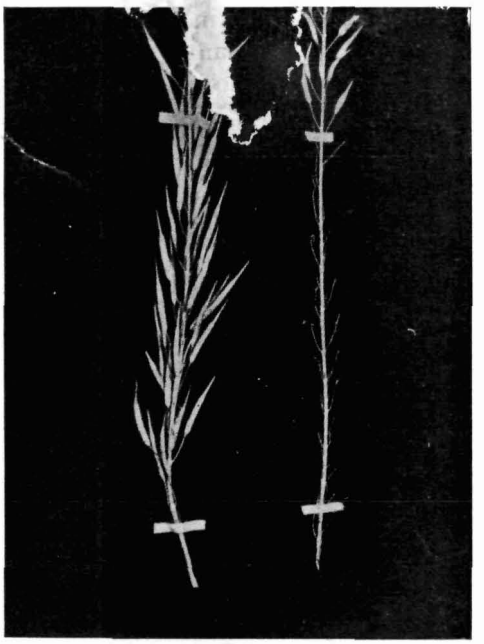

FIG. 3. Normal pod-formation in male-sterile plants under open pollination on the left and no pod-formation in the sector covered under cloth bag on the right.

Data on the segregation of 12 F_2 families are presented in Table 2. All the families showed a 3 : 1 segregation for normal and male-sterile plants. A

TABLE 2

Segregation in F_2 generation of crosses between normal and male-sterile plants

Crosses 1960–61	F families and Plant no. 1961–62	F_2 families 1962–63	Normal	Male sterile	χ^2 (3 : 1)	P
Y-1ms × Y–2	Y 15–2	Y72	45	13	0·206	0·50
	–3	Y73	35	12	0·006	0·90
	–4	Y74	31	8	0·417	0·50
	–5	Y75	30	13	0·627	0·30
Y-3ms × Y–4	Y 16–1	Y76	50	18	0·078	0·70
	–3	Y77	43	18	0·661	0·30
	–4	Y78	41	10	0·790	0·30
	–5	Y79	31	8	0·417	0·50
Y-11ms × Y–12	Y 19–2	Y83	22	6	0·191	0·50
	–3	Y84	31	8	0·417	0·50
	–4	Y85	31	13	0·484	0·30
Y-13ms × Y–14	Y 20–2	Y87	62	19	0·102	0·70
Total all F_2 families			452	146	0·113	0·70

similar 3 : 1 segregation was obtained in 17 families originating from open pollinated progenies of male-sterile plants. However, in three plants–(Y–5, Y–7, and Y–9) neither the crosses with normal plants nor the progeny from open pollinated seeds produced on selfing any male-sterile plant. It may be that the abnormality in these plants was just due to environment and not genetically caused.

Data on segregation in the progeny of test crosses made in 1962-63 and S_1 generation of the male parents used are given in Table 3. As expected, the families from crosses between male-sterile plants and heterozygous normal plants have shown a ratio of 1 normal : 1 male-sterile.

TABLE 3

Segregation in the progeny of test crosses made during 1962–63 between normal and male-sterile plants

Test crosses 1962–63	Test cross progeny 1963–64	Segregation		χ^2 (1:1/3:1)	P
		Normal	Male-sterile		
Y58–5ms × –3	Y142	32	25	0·429	0·50
Y59–3ms × –7	Y144	40	27	2·522	0·10
Y83–2ms × Y85–3	Y145	30	22	1·230	0·20
Y85–4ms × Y85–3	Y147	29	24	0·470	0·30
Y86–8ms × –2	Y148	34	29	0·396	0·50
	Male parents				
Y58–3	Y153	17	5	0·060	0·80
Y86–2	Y154	8	2	0·133	0·70
Y85–3	Y154a	19	7	0·050	0·80

A few normal plants in the segregating F_2 families were selfed and the progeny studied. Out of a total of 17 families, 10 showed a 3 : 1 segregation while in the remaining 7 only normal plants were found. It may be noted that the ratio between segregating and non-segregating families fits a 2 : 1 ratio as expected in the case of a character showing monogenic inheritance (between 0·50–0·30).

DISCUSSION

The findings of the present study on male sterility in yellow *sarson* can be considered from two view points : (i) the possibility of utilization of this character in the production of hybrid seeds and (ii) its theoretical implications.

There are some general problems a plant breeder comes across when a hybrid-seed production programme is taken up on a commercial basis, such as,

identification of male-sterile plants, maintenance of inbred lines, transferring male-sterility to other varieties, restoration of fertility in the case of cytoplasmic male-sterility etc. The present case is one of nuclear pollen sterility which shows a monogenic recessive type of inheritance and hence maintenance and continued production of male-sterile plants may not be very easy. It would involve the pollination of male-sterile plants with pollen from plants heterozygous for male sterility. These pollen parents must be previously obtained by artificial pollination or by collecting the seeds set under open pollination of male-sterile plants. The progeny of the hybrid seeds will show a 1 : 1 segregation. Half of the population has to be rogued out and the other half consisting of male-sterile plants allowed to cross with a good combining inbred. Roguing out of normal plants in the hybrid seed production plot is not a difficult job as the male-sterile plants can be easily isolated in the field as soon as the flowering starts, since there is a significant reduction in petal and anther size in these plants. Anthers are also narrow, pointed and lighter in colour and are devoid of healthy pollen grains. A general reduction in flower and anther size in the case of male-sterile plants has also been reported in flax (Bateson and Gairdner, 1921), maize (Beadle, 1932) tomato (Rick, 1944; Rick and Robinson, 1951 and Bishop, 1954), onion (Petersen and Foskett, 1953), *Brassica* (Johnson, 1958), cowpea (Sen and Bhowal, 1962) etc. In some cases differences other than size or shape of petals and anthers have also been reported. The anthers may change to petal like structures (Sansome, 1936, in *Geranium*) or there may be a relationship between flower colour and degree of male sterility as observed in tobacco (Bhat and Krishnamoorthi, 1956). No such observation could be made in the present material.

Among the systems providing means to encourage or enforce cross pollination in flowering plants, self-incompatibility is a fairly widespread phenomenon. In the cruciferous group Fryxell (1957) has listed 18 genera with 34 species almost all of which show self-incompatibility. Self-compatibility even when present is generally accompanied by good amount of out-crossing as is found in yellow *sarson* also. Consequently, suggestions have been made that male-sterility would be rare in *Brassica* (Vanderly, 1954). However, occurrence of male-sterile mutants have been reported in a few cases (Pal and Ramanujam, 1948; Johnson, 1958 and the present finding) which indicates that male-sterility genes could be floating in the population masked by heterozygosity. Rajan (1958a) has also reported the uncovering of male-sterile genes by minute deletions induced by gamma radiation treatment of materials which must have been heterozygous for male sterility.

That male sterility could arise on account of a peculiar combination of pollen and stylar control of self-incompatibility reactions has been suggested by Bateman (1952). It is probable that the male sterility in the present case could be of this kind since Rajan (1958 b) has adduced evidence to show that self-fertility of yellow *sarson* is a derived phenomenon from pre-existing self-incompatibility involving loci other than ' S ', thus making the situation conceived by Bateman possible.

SUMMARY

A case of male sterility is reported in yellow *sarson*. The male-sterile mutants were morphologically similar to normal plants with regard to vegetative characters. But a significant reduction was observed in petal and anther size in the case of male-sterile plants.

Investigations on the mode of inheritance of male sterility have suggested that it is a monogenic recessive character. Its practical utility and theoretical implications are also discussed.

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