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Breeding for hybrid sesame suited for summer rice fallow

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Abstract: *Sesame (Sesamum indicum L.) is usually grown in summer rice fallows as catch crop by utilizing the residual moisture. The area under this crop is getting reduced day by day due to its low yield. In this study, an attempt was made for the development of male sterile lines through mutation and wide crosses so as to exploit heterosis. In order to find out the best specific combiners, first a diallel analysis was carried out. The best combiners were reciprocally crossed with a wild species Sesamum malabaricum L. Male sterility was observed in F_1s of the cross in which S. malabaricum was used as the female parent, while the reciprocal was fertile. This indicates the presence of cytoplasmic male sterility in the cross with the source of sterility as S. malabaricum cytoplasm. The F_1s were found to resemble more the wild parent than the cultivar. Flower colour and appearance were similar to that of S. malabaricum. Seed coats were rough, showing its resemblance with the wild parent. Oil content was low. The F_1 was later backcrossed repeatedly with the cultivar to develop cytoplasmic male sterile line with the genome of the cultivar so as to use it in hybrid seed production programme.*

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the oldest oil seed crops known to and used by man. It yields oil and protein of high quality and holds tremendous potential for export. However the average per hectare yield of sesame in India is very low as compared to other producing countries. This is mainly due to the lack of improved cultivars. The potential of sesame breeding is amply demonstrated by the achievements in South Korea (Kang, 1994), in its traditional areas of production in India (Sharma, 1994) and in China (Zhao, 1994). There is an urgent need to augment its productivity through exploitation of heterosis which is a quick and convenient way of combining desirable traits from diverse parents. There are two basic prerequisites for the successful economic exploitation of heterosis on a commercial basis. First, a significant heterotic effect must be present in a hybrid over its parents. Second, production of large scale hybrid seed should be possible economically. Though sesame is a self pollinated crop, it is very easy for hand emasculation and pollination and a single attempt gives about 50-60 seeds. It is therefore easier to exploit its heterosis and high level of heterosis has been observed in sesame hybrid populations (Dixit, 1976). In all the early works, F_1 populations were developed by hand emasculation and pollination which is time consuming and laborious and it could not be used for the production of hybrid sesame seeds for commercial planting.

True male sterility has not been described in sesame. This phenomenon will be much useful in hybrid sesame only if a stable male sterility, either cytoplasmic or genetic is identified and utilized. The discovery of cytoplasmic male sterility (CMS) in wild relatives of numerous cultivated plants has contributed enormously to agriculture by making possible large scale production of hybrid seeds. With this background the present study was formulated with a view to assess the variability and to estimate the combining ability of selected genotypes. Exploitation of male sterility in sesame through mutagenesis and wide hybridization for future development of hybrid sesame was also aimed at.

MATERIALS AND METHOD

Eight diverse genotypes representing accessions and varieties of various eco-geographical conditions throughout India constituted the materials for the present study. The field trials were laid out at Regional Agricultural Research Station, Kayamkulam, Kerala of Kerala Agricultural University (KAU). Soil in this region is predominantly sandy loam and it constitutes the main sesame growing area in the state. Cultural operations were carried out as per the package of practices recommendations of KAU.

The present investigation consisted of two sets of experiments: *Experiment 1* was aimed at production of intervarietal hybrids through crossing selected lines to study the combining ability in order to identify the best general combiners using diallel analysis. *Experiment 2* was aimed at induction of male

sterility through physical (gamma radiation) and chemical mutagens (EMS) and study of the inheritance of male sterility. It also aimed at interspecific crosses of the general combiners with the wild species *Sesamum malabaricum* L. to explore the possibility of development of CMS lines.

Eight diverse genotypes representing accessions and varieties procured from different eco-geographical regions of India were selected based on multivariate analysis of yield components. These genotypes were raised in a crossing block for diallel analysis. 56 cross combinations between these eight genotypes in all possible combinations including reciprocals were effected. Emasculation and hybridization were carried out as per Thankavelu and Nallathambi (1982). Best general combiners were then utilized for the development of male sterility through induced mutagenesis and wide hybridization with *S. malabaricum*. For induced mutagenesis seed samples each consisting of 600 seeds of the two selected varieties were introduced into Co^{60} gamma cell installed at Radio Tracer Lab, KAU, Vellanikkara, Thrissur, Kerala and exposed to radiation for appropriate periods to irradiate with gamma rays from 100gy to 600gy. For chemical mutagenesis seeds presoaked in water for two hours were treated by keeping immersed in mutagen solutions (aqueous) of concentrations 0.2% to 1.0% for four hours with intermittent shaking.

RESULTS AND DISCUSSION

The success of a plant breeding programme greatly depends on the choice of parents for hybridization and the type of gene action in the case of different agronomic traits. Combining ability analysis provides such information so as to frame the breeding programme effectively. Combining ability studies in general reveal the nature of gene action and lead to identification of parents with general combining ability effects (gca) and the cross combinations with high specific combining ability (sca) effects. In order to study the combining ability effects eight genetically diverse parents were subjected to 8x8 full diallel analysis. Based on the general combining ability of yield and related components, two best combiners, Thilak and OS2 were selected and were subjected to induced mutagenesis and wide hybridization.

Induced mutagenesis

Under induced mutagenesis, in M_1 generation, the percentages of germination and survival at 30 days were adversely affected by both the physical and chemical mutagens. Reduction was drastic in higher doses of the chemical mutagen (Table. 1). Percentage of pollen fertility was also decreased with increase in doses of mutagens. Reduction in fertility was more drastic in chemical mutagen. Similar reduction in seed fertility was also noticed in both the genotypes.

In M_2, study of viable sterile mutations was confined to those doses in which pollen fertility got reduced to less than 50%. All mutants in which pollen fertility was completely affected were classified as viable sterile mutants. These viable mutants were screened in M_1 plant progenies. The frequencies of these were estimated as mutations per M_1 plants and 100 M_2 plants (Table. 2).

Table. 1. Effect of mutagens on germination and survival on 30^{th} day in M_1 generation.

Mutagen/Dose	% germination	% survival on 30^{th} day
1.Gamma rays (Gy)		
100	88.94	93.09
200	81.06	73.79
300	73.94	61.18
400	63.19	53.07
500	49.26	38.71
600	38.83	33.11
2.EMS (%)		
0.2	82.49	90.18
0.4	64.00	76.38
0.6	50.16	64.24
0.8	26.38	51.10
1.0	22.59	35.21

Table. 2. Frequency of viable mutants in the M_1 and M_2 generations.

Mutagen/ dose	No. of plants scored in M_1	% frequency	No. of plants scored in M_2	% frequency
Gamma 500	30	0	250	0.0
Gamma 600	30	3.3	250	0.8
EMS 0.8	30	3.3	250	0.8
EMS 1.0	30	10.0	250	0.4

On sibmating and open pollination capsule set was observed in three out of six sterile plants. The sibmating and open pollination failure in the remaining plants showed cent percent pollen sterility. This was indicative of total female sterility in these plants along with complete male sterility resulting in the total absence of capsules. All floral parts except anthers were normal in size and colour in male sterile plants. Anthers were flatter and greenish than normal which is whitish and plumy.

The decrease in germination contributed mainly to the lethality of the seeds from physiological injuries, chromosomal aberrations and toxic effects of the hydrolytic products of the mutagen (Freese-Gertzen *et al*., 1964). Konzak *et al.* (1965) reported that the alkyl sulphonates and alkyl sulphates form strong acids upon hydrolysis. Since hydrolysis may occur both externally and internally in the cells, significant amount of acid may become available which cause toxicity. The reduction in germination with EMS treatment can be attributed to these hydrolytic products. The reduction in survival on the 30^{th} day is an index of post germination mortality in the treated material. In the present study both physical and chemical mutagens induced pollen sterility. A linear increase in sterility with increased doses of mutagens was also reported earlier (Nair and Nair, 1978; Ganesan, 1995).

The crossing success on male sterile plants was normal indicating female fertility. The inheritance study indicated that male sterility observed in the present case was also governed by a single recessive allele. Similar green anther mutants with complete male sterility were isolated by Brar (1982) and Osman and Yermanos (1982). They used this trait to differentiate male sterile and fertile plants.

The present study has also shown the feasibility for the generation of CMS line in sesame through interspecific hybridization between *Sesamum indicum* and *S. malabaricum* as *S. malabaricum* was found to be more cross compatible compared to two other wild species of sesame with *S. indicum*. F_1, BC_1 and BC_2 generations were observed. The interspecific hybrids both direct and reciprocals resulted in successful capsule and seed set indicating cross compatibility between the species. The hybrids with *S. malabaricum* as ovule parent resulted to be male sterile while the reciprocals were fertile. This pointed out the cytoplasmic difference of the crosses which resulted in male sterility. In several species CMS results from nuclear cytoplasmic interaction which fails to produce functional pollen but maintains female fertility as reported by Newton (1988). CMS has also been exploited for the production of hybrid seeds in many crops such as maize, sorghum, sunflower *etc*. Yuan (1993) reported a wild abortive (WA) cytoplasm derived from *Oryza sativa* f. *spontanea* as a source of sterility in rice. Here in the present study the cytoplasm of *S. malabaricum* may be the factor which induced sterility system. It was evident from the studies that the F_1 hybrids of both direct and reciprocals exhibited the dominance of wild parent characters-stem colour, branching pattern, leaf shape, corolla colour, seed texture, etc. But on fertility status only a difference was noted. *S. indicum* cultivar x *S. malabaricum* showed high percentage of pollen fertility resulting in fairly good capsule set on selfing whereas reciprocals showed very high percentage of sterility leading to very few or no capsule set on selfing. Though F_1 was similar to wild parent, in the progenies of back crosses there was an increased resemblance to the qualitative characters of *Sesamum indicum* which indicates the accumulation of cultivar genome along with the sterility factor from the donor.

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