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Short communication

Studies on inheritance of Geneic Male Sterility (GMS) and hybrid seed production in okra [*Abelmoschus esculentus* (L.) Moench.]

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ABSTRACT

Inheritance of geneic male sterility in GMS line MS-1 of okra [*Abelmoschus esculentus* (L.) Moench.] was studied using F_1, F_2 and test-cross generations of crosses between GMS line MS-1 and normal fertile genotypes, and the varieties Arka Anamika, Parbhani Kranti, Arka Abhay, IIHR-108-1-31, IIHR-109-20-6, IIHR-116-23-6, IIHR-180-6-3, IIHR-161-10-1 and IIHR-130-2-10. All the F_1 were found fertile. Segregation of pollen fertility in F_2 and test - cross generations involving ms1 was segregated in the ratio 1 fertile: 1 sterile, respectively. This indicated that GMS trait in the line is controlled by a single recessive gene (ms1ms1). Large-scale F_1 hybrid seed production in okra becomes rather slow due to the tedious hand-emasculation, followed by hand-pollination, incurring additional labour and cost of F_1 seed production. In comparison to fertile lines, this saves approximately 70% time and manual labour. Use of Geneic Male Sterile (GMS) line MS-1 can make F_1 hybrid seed production in okra easy and more economical compared to hand-emasculation.

Key words: *Abelmoschus esculentus*, Geneic Male Sterility (GMS), back cross, generations, recessive allele

Okra [*Abelmoschus esculentus* (L.) Moench.] is a warm-season, traditional fruit- vegetable crop commercially grown in both tropical and subtropical parts of the world. Globally, India is the largest producer, where okra is grown in an area of 4.32 lakh hectares with annual production of 45.28 lakh tonnes and a productivity of 10.5 MT/ha (Vigneshwara Varmudy, 2011). It is a potential export revenue earner, accounting for 60% of all fresh vegetables exported (Sharma and Arora, 1993). In India, commercial production of F_1 hybrid in okra is done by hand emasculation and hand pollination which is a tedious process that takes 70 % of the time and labour in cultivation. Geneic Male Sterile (GMS) line MS-1 identified by the Division of Vegetable Crops, Indian Institute of Horticultural Research (IIHR), is being used for development of a commercial F_1 hybrid. Male sterility in okra is controlled by a pair of single, recessive genes and can be utilized by hybrid seed production.

Genetically Controlled male sterility (MS1) is an important trait for the production of F_1 hybrid seeds in several crops (Kaul, 1998). Some male sterile systems have been reported in *Brassica campestris* var. Japonica (Kato and Tokumasu, 1984). In okra, male sterility has not been observed in nature, but, has been induced by gamma radiation (Dutta, 1971). Male sterility in okra was seen to be a controlled by a single recessive gene (ms1) when present in the homozygous (ms1ms1) condition. The symbol ms1 was proposed for this gene (Dutta, 1980). The gene was stable, not being influenced by environmental factors. Anthesis was normal but anther dehiscence was partial. Microsporogeneisis was normal upto the tetrad stage. Hence, a great future for hybrid seed production is envisaged in a heterosis breeding programme.

Studies were conducted at IIHR during 2002-2003. IIHR-MS-1 was crossed with ten fertile parents, namely, Arka Anamika, Parbhani Kranti, Arka Abhay, IIHR-108-1-31-1, IIHR-109-1-20-6, IIHR-120-11-8-1, IIHR-116-12-23-6, IIHR-180-6-3, IIHR-161-10-1, IIHR-130-2-10. A Series of crosses were made to determine the genotype of F_1 progenies by selfing and backcrossing randomly for selected F_1 individuals from each progeny to their respective male fertile (Fig. 1) and male sterile parent (Fig. 2). Data were collected in respect of F_2 and BC_1 for all the ten segregating progenies (Tables 1 & 2). Segregation ratio of the male-sterile character was subjected to Chi-square test. Test on goodness of fit between expected and observed segregation ratio was calculated as per Snedecor and Cochran (1967).

Fig 1. Male-fertile plant showing yellow colored pollen

Fig 2. Male-sterile plant showing no pollen grains

Table 1. Behaviour of F_2 families in some crosses involving IIHR-MS-1 and testers during *Rabi*-Summer 2002-03

Cross combination of (F_2) IIHR-MS-1	No. of plants observed		No. of plants expected		Total	χ^2(3:1)	*P* value
	♂ fertile	♂ sterile	♂ fertile	♂ sterile			
IIHR-MS-1 X Arka Anamika	56	27	63.75	21.25	65	2.80	0.20-0.10
IIHR-MS-1 X Parbhani Kranti	50	25	56.25	18.75	75	2.77	0.10-0.05
IIHR-MS-1 X Arka Abhay	68	27	71.25	23.75	95	0.59	0.50-0.30
IIHR-MS-1 X IIHR-108-1-31-1	70	26	73.50	24.50	96	0.67	0.50-0.30
IIHR-MS-1 X IIHR-109-1-20-6	61	29	67.50	22.50	90	2.51	0.20-0.10
IIHR-MS-1 X IIHR-120-11-8-1	69	21	67.50	22.50	90	0.07	0.80-0.70
IIHR-MS-1 X IIHR-116-12-23-6	66	29	71.25	23.75	95	1.55	0.3.-0.20
IIHR-MS-1 X IIHR-180-6-3	77	21	73.50	24.50	98	0.67	0.50-0.30
IIHR-MS-1 X IIHR-161-10-1	65	13	58.50	19.50	78	2.59	0.10-0.05
IIHR-MS-1 X IIHR-130-2-10	70	18	66.00	22.00	88	0.97	0.50-0.30
Total	654	238	669	223	892	14.77	0.22-0.10
Pooled Chi-square values	-	-	-	-	-	1.35	0.33-0.20
Heterogeneity	-	-	-	-	-	13.42	0.20-0.10
Homogeneity	-	-	-	-	-	12.88	0.20-0.10

Table 2. Segregation in BC_1 generation of IIHR-MS-1 (Male sterile) X F_1s in okra during *Rabi* season 2002

Cross combination (BC_1) IIHR-MS-1	No. of plants observed		No. of plants expected		Total	χ^2(3:1)	*P* value
	♂ fertile	♂ sterile	♂ fertile	♂ sterile			
IIHR-MS-1 X Arka Anamika	56	27	63.75	21.25	65	2.80	0.20-0.10
IIHR-MS-1 X Arka Anamika	48	31	35.5	35.5	71	1.1	0.30-0.20
IIHR-MS-1 X Parbhani Kranti	41	29	35	35	70	2.06	0.20-0.10
IIHR-MS-1 X Arka Abhay	35	38	36.5	36.5	73	0.12	0.30-0.70
IIHR-MS-1 X IIHR-108-1-31-1	34	41	37.5	37.5	75	0.66	0.50-0.30
IIHR-MS-1 X IIHR-109-1-20-6	40	32	36	36	72	0.68	0.50-0.30
IIHR-MS-1 X IIHR-120-11-8-1	37	41	39	39	78	0.20	0.70-0.50
IIHR-MS-1 X IIHR-116-12-23-6	30	35	32.5	38.5	65	0.36	0.70-0.50
IIHR-MS-1 X IIHR-180-6-3	38	30	34	34	68	0.94	0.50-0.30
IIHR-MS-1 X IIHR-161-10-1	43	35	39	39	78	0.82	0.50-0.30
IIHR-MS-1 X IIHR-130-2-10	25	35	30	36	66	1.66	0.20-0.10
Total	363	347	355	355	710	9.13	0.70-0.50
Pooled Chi-square values	-	-	-	-	-	0.36	0.70-0.50
Heterogenity	-	-	-	-	-	8.77	0.50-0.30
Homogenity	-	-	-	-	-	8.56	0.50-0.30

In male sterile plants, anthesis was normal but anther dehiscence was partial, showing a small, longitudinal slit without pollen shed. All the F_1 plants obtained from hybridization between ms and the other ten cultivars (Arka Anamika, Parbhani Kranti, Arka Abhay, IIHR-108-1-31-1, IIHR-109-1-20-6, IIHR-120-11-8-1, IIHR-116-12-23-6, IIHR-180-6-3, IIHR-161-10-1, IIHR-130-2-10) were fertile. However, F_2 in all the crosses confirmed 3 fertile: 1 sterile ratio (Table 1), further confirmed by segregation behavior (1fertile: 1 sterile) in BC_1 population (Table 2). Segregation pattern in the crosses indicated that GMS trait of IIHR-MS-1 was controlled by a single recessive gene. Chi-square test, when applied to the ten individual F_2 progenies, indicated good fit for the expected ratio. Test for heterogenity indicated that there classes could be pooled; the total segregating progenies agreed and were quite close to the expected ratio of 3:1 (p=0.30, 0.20). The chi-square test for heterogenity for testing agreement of the progenies gave a chi-square value of 12.88, indicating that the progenies are non significant at 5% level.

The 10 F_1 progenies, when backcrossed to their respective fertile parent produced only fertile backcross progenies. The test for heterogeneity gave Chi-square value of 8.77 at 9 df, Which was non-significant at 5% level, indicating that, the progenies agreed with 1:1 ratio of male fertile to male sterile, and could be pooled. Chi-square test of the pooled data gave a good fit for 1:1 segregation g ratio (P=0.70-0.50). Chi-square test for homogenity was not significant suggesting that the progenies agreed with one another in whatever ratio obtained. F_1s of all the cross were fertile this indicating that geneic male sterility is governed by recessive genes and fertility restoration male in fertile genotype is controlled by the dominant gene MS . Data on sterile and fertile plants obtained in each test cross combination with Chi-square, e are presented in Table 2.

Segregation in the F_2 and backcross populations of the crosses - (MS-1 X 130-2-10 and MS-1 X 116-12-23-6)- involving one GMS line and several tester parents, confirmed 3:1 and 1:1 ratio, respectively. These results were similar to those observed in okra by Dutta (1971) and by Thombre and Deshmukh (2006) in okra GMS line mutant. Latha *et al* (2003) corroborated single recessive gene control of TGMS in rice and geneic ms in *Brassica campestris* L. (Borkato and Virmani (1996). The recessive nature of GMS mutants facilitates their deployment in hybrid breeding programme, because any pollen - fertile line can be used as the male parent to develop a commercial okra hybrid. Single gene control of the trait also facilitates its transfer from one genotype to another. This geneic male sterility has been transferred to other commercial varieties like Arka Anamika, Arka Abhay, Parbhani Kranti and other multi- ribbed variety like Bo-13.

Use of male sterility in hybrid seed production in okra

Geneic Male Sterile line of okra was identified by Division of Vegetable Crops , Indian Institute of Horticultural Research (IIHR), and is being utilized for development of commercial F1 hybrid. Male sterility in okra is controlled by a pair of single, recessive genes and can be utilized for hybrid seed production. Field designs for maximizing hybrid seed yield using male sterile lines under natural cross – pollination have been standardized , and combining ability of the parents using male sterile lines has been worked out (Pitchaimuthu and Dutta, 2002) A field design where alternate planting of two rows of the male sterile plants and one row of fertile plants was done keeping a ratio of 2:1 and maintaining a plant population of 4,166 male sterile plants per hectare, which gave hybrid seed yield of 5.66 quintals per hectare, which was 52.56% higher seed yield in comparison with the fertile control (Dutta, 1980). Using male sterile plants and hand pollination, it takes 3 h to pollinate 274 flowers enough to produce 1 kg of seed. By hand – emasculation and pollinating of 274 perfect flowers takes over 9 h (Dutta, 1980). Thus, approximately 70% saving in time and manual labour is achieved for producing 1 kg of hybrid seeds using male sterile lines in okra.

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