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Inheritance of Male-sterile Mutant Ms_{12} in American Pima Cotton[1]

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ABSTRACT

A male-sterile American Pima cotton (*Gossypium barbadense* L.) plant was found in the field in 1976. Genetic male steriles in cotton are useful as markers and in controlled crossing by providing male-sterile stocks as female parents. In this study our objectives were to determine the inheritance of the genes conditioning the Pima male-sterile trait and to detect possible linkage between Pima male-sterile and other mutant genes in cotton. Crosses made between Pima male-sterile and normally male-fertile 'Pima S-5' plants produced male-sterile and male-feritle F_1 plants in a 1:1 ratio. BC_1 progenies from sterile F_1 plants crossed with Pima S-5 fit a ratio of 1 sterile : 1 fertile. Fertile F_1 plants crossed with Pima S-5 produced only fertile progeny. These data show that the male-sterile trait is conditioned by one dominant gene. We propose the name Male-sterile-12 and the gene symbol Ms_{12} for this trait. Linkage tests between Ms_{12} and 23 *Gossypium* mutant genes were negative. Relationships between Ms_{12} and other genetic male steriles in cotton are discussed.

***Additional index words:* *Gossypium barbadense* L., *G. hirsutum* L., Linkage, Pollen shed, Heat tolerance, Genetic marker.**

FOUR dominant and seven recessive genes conditioning male sterility have been identified in allotetraploid *Gossypium* (Bowman and Weaver, 1979; Turcotte and Feaster, 1979). One dominant and three recessive male-sterility genes have been located in linkage groups: ms_3 in linkage group III, ms_8 and Ms_{11} in linkage group V, and ms_9 in linkage group IX. The recessive duplicate factors for male-sterility, ms_5ms_6, are used in India to facilitate crossing in the production of F_1 seed for hybrid cotton production (Weaver, 1968). A Pima cotton (*Gossypium barbadense* L.) plant with only a few partially filled bolls was observed in an otherwise productive progeny row in 1976 at Phoenix, AZ. Anthers in flowers on this plant

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Table 1. F_1 and BC_1 data from crosses involving a Pima cotton male-sterile trait and fertile Pima S-5.

Parent		Year		No. of plants		Chi square	
Female	Male	tested	Generation	Sterile	Fertile	(1:1 ratio)	P
76-336 sterile	Pima S-5	1978	F_1	39	36	0.12	0.80–0.70
Sterile F_1	Pima S-5	1979	BC_1	96	81	1.27	0.30–0.20
Sterile F_1	Pima S-5	1981	BC_1	87	92	0.14	0.80–0.70
Sterile F_1	Pima S-5	1982	BC_1	103	136	4.56	0.05–0.02
		Pooled	BC_1	286	309	0.89	0.50–0.30
		Heterogeneity	BC_1			5.08	0.10–0.05
Sterile F_1's	Fertile genetic markers	1983	BC_1, pooled	1987	2048	0.92	0.50–0.30
Fertile F_1	Pima S-5	1979	BC_1	0	207	–	–

appeared to shed no pollen, indicating the plant could be male sterile. Open-pollinated seed were harvested in 1976 and planted in the field in 1977 and male-sterile and male-fertile plants were observed. These observations indicated the male sterility to be under genetic control. The present paper describes the inheritance and linkage relationships of the male-sterile trait found in Pima cotton in 1976.

MATERIALS AND METHODS

The original male-sterile plant, which had been transplanted to a greenhouse at Phoenix and designated 76-336, was crossed in 1977 as female with normally fertile Pima S-5 to initiate inheritance studies of the sterility trait. F_1 plants from this cross segregated sterile and fertile plants. Sterile F_1's were crossed with Pima S-5 and these backcross-one (BC_1) seed were planted in the field at Phoenix in 1979, 1981, and 1982. The soil type was Avondale clay loam, a member of the fine-loamy, mixed, hyperthermic Torrifluventic Haplustolls. Fertile F_1 plants were self-pollinated for F_2 seed and were also backcrossed to Pima S-5. The resulting seed were planted in the field in 1979. All progenies were scored for sterile and fertile segregates.

Crosses also were made between sterile F_1 plants and 23 *Gossypium* mutant genes to test for linkage via testcrosses or backcrosses. The 23 mutant loci were in a *G. barbadense* background, although certain of the mutant traits had been transferred from *G. hirsutum* L. Mutant genes from 12 of the 17 described allotetraploid *Gossypium* linkage groups and nine independent genes were tested. Segregating populations were grown in the field and scored for the appropriate traits in 1983 at the Univ. of Arizona Maricopa Agricultural Center. Soil type was Mohall clay loam, a member of the fine-loamy, mixed, hyperthermic Typic Haplargids. Conventional management practices including insect control were used in the field nurseries each year.

Chi-square analysis was used for fit of observed to expected genetic ratios and for detection of linkage. Recombination values were calculated by the maximum likelihood method (Mather, 1951).

RESULTS AND DISCUSSION

The original male-sterile plant, 76-336, when crossed with normally fertile Pima S-5, segregated 1 sterile : 1 fertile plant in F_1 (Table 1). The F_2 progenies of nine fertile F_1 plants resulted in 378 fertile and no sterile plants. BC_1 progenies from sterile F_1 plants crossed with Pima S-5 fit a ratio of 1 sterile : 1 fertile in 1979 and 1981. Data from 1982 showed a significant deviation from the 1:1 ratio, which resulted from a deficiency of male-sterile plants. A deficiency of male-sterile plants has been observed in several genetic male-sterile lines in cotton (Weaver, 1969). A heterogeneity chi-square value was not significant and the 3 years' data were pooled. The combined data fit a ratio of 1 sterile : 1 fertile. Additional inheritance data were obtained when sterile and fertile segregates were counted as part of the tests for genetic linkage. Pooled data from these BC_1 plants also segregated 1 sterile : 1 fertile. Fertile F_1 plants crossed with Pima S-5 produced only fertile progeny (Table 1). These data show that the male-sterile trait is conditioned by one dominant gene.

Table 2. Summary of linkage tests via testcrosses or backcrosses between a Pima male-sterile trait and 23 *Gossypium* mutant genes.†

Gene symbol	Linkage group	Pima male sterile		
		Chi-square: linkage	Recombination percentage	No. of plants
G_v		3.32	58	146
L_1^L	VII	2.53	57	128
L_2^O	II	0.13	48	124
Lc_1	I	0.58	53	139
Lc_2	IV	0.35	47	104
N_1	V	0.08	51	317
PM-1‡		0.77	54	130
R_1	III	0.01	50	127
R_2^V	I	0.01	50	129
Ru	XVII	0.33	52	194
cu		0.04	51	102
fg	VI	1.30	44	93
gl_1		0.74	53	163
gl_2,gl_3	V, IX	2.55	54	754
gl_2	V	0.31	48	324
gl_3	IX	0.68	53	177
ltg		0.17	52	145
p_1	XI	0.21	52	119
p_2		0.43	53	115
rl_1	X	0.59	53	137
rs		0.01	50	157
v_7		0.07	51	133
wr		0.24	52	150
y_1	XII	0.03	51	134

† Name, linkage group, and reference of cotton mutants provided in Endrizzi et al., 1984.

‡ PM-1 is an undescribed, incompletely dominant, aberrant leaf trait in Pima cotton.

Chi-square values for detection of linkage were nonsignificant. This indicated that the male-sterile trait was inherited independently of the 23 mutant genes tested, including gl_2 (reduced foliar glands) and N_1 (naked seed) in linkage Group V (Table 2). These two genes have been associated with Ms_{11}, a dominant male sterile in Pima cotton described earlier (Turcotte and Feaster, 1979). Thus the male sterile described in the present paper and Ms_{11} are independent dominant genes. The new male-sterile trait also was independent of gl_3 (reduced foliar glands) in linkage Group IX, showing that the Pima dominant male-

sterile genes are not homoeologous loci. Homology of the dominant Pima male-sterile gene described in the present paper and Ms_4 (Allison and Fisher, 1964), Ms_7 (Weaver and Ashley, 1971), and Ms_{10} (Bowman and Weaver, 1979) in *G. hirsutum* cannot be established directly. Linkage tests can be made when the genes are located in linkage groups and/or on specific chromosomes.

We propose the name Male-sterile-12 and the gene symbol Ms_{12} (Kohel, 1973) for the new dominant gene for male sterility in Pima cotton with male-sterile plants having the genotype $Ms_{12}ms_{12}$.

The degree of anther and pollen development differs for the dominant male-sterile genes in *Gossypium* (Bowman et al., 1978). At Phoenix, AZ, anthers of Ms_4 remain rudimentary and never shed pollen, and anthers of Ms_7, Ms_{10}, and Ms_{11} occasionally shed pollen; however, attempts to effect fertilization with pollen from these sources have been unsuccessful. Bowman et al. (1978) have reported the occurrence of occasional viable pollen grains from anthers of Ms_{10}. Anthers of Ms_{12} occasionally shed pollen also, but self-pollination and crossing as male parent have failed to set bolls at Phoenix and Maricopa. Anthers of Ms_{12} contain shrunken pollen grains that are more developed than Ms_{11}. This was evidenced by the buff rather than white color of the anthers, by pollen with better developed exine spines, and by the partial red staining of the pollen cytoplasm with Alexander's stain (Barrow, 1983). No effect on female fertility has been noted in male-sterile plants conditioned by Ms_{12}.

Microenvironmental differences affect the timing and degree of anther dehiscence of certain genetic male steriles (Bowman and Weaver, 1979). These influences on Ms_{11} and Ms_{12} may be useful in studies of heat tolerance in Pima cotton.

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