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A Partially Male-Sterile Character in Upland Cotton[1]

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THE first heritable male-sterile line of upland cotton was reported by Justus and Leinweber (1). It was a partial male-sterile, controlled by a single recessive gene, *ms*-1. Richmond and Kohel (5) reported the development of a completely male-sterile line, ms_2, also controlled by a single recessive gene. Meyer and Meyer (4) have reported cytoplasmic-genetic sterility developed from interspecific crosses in cotton. The purpose of this paper is to report results of a study of the inheritance of a second partially male-sterile character in upland cotton.

MATERIALS AND METHODS

The original partially male-sterile plant was found by the junior author in a D_2 smooth progeny that had M8 (M8948) as a recurrent parent. Meyer (2) described the development of D_2 smoothness. The partially male-sterile plant was morphologically normal except for flowers that lacked pollen or had a reduced amount.

The partial male-sterile plant or plants from its self-pollinated (S_1) progeny were crossed to 5 normal lines: M8, Dixie Triumph, Acala W 29–6, Delfos 9169, and Cook 307–6. M8 is a doubled haploid from Deltapine 14 (3) and the other four lines were from the Regional Collection of Upland Cotton. The resulting F_1 progenies were self-pollinated and backcrossed to the partially male-sterile line. Each plant in the segregating generations was classified male-sterile or male-fertile based on the scale described by Justus and Leinweber (1) where 0= no anthers dehisced, 1= about 25% of anthers dehisced, 2= about 50% of anthers dehisced, 3= about 75% of anthers dehisced, and 4= all anthers dehisced. Flowers from each plant were scored several times in 1958, a few times in 1959, and 5 times in 1960. A plant consistently scoring 4 was considered male-fertile, and plants scoring less than 4 were classed as partially male-sterile. Selected plants from the 1959 planting were moved to the greenhouse and self-pollinated seeds were obtained from them. The parent plants were again moved to the field and they and their progenies were scored for male-fertility and male-sterility.

RESULTS AND DISCUSSION

Data presented in Tables 1 and 2 indicate that the partial male-sterility in these populations is controlled by a single recessive gene. The symbol *ms*-3 is proposed for this gene. The 1958 backcross (BC_1) and F_2 progenies involving partial male-sterile and M8 indicated a good fit to the expected ratios. The segregating progenies of the partial male-sterile crossed with the remaining 4 male-fertile lines

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Table 1—Classification and chi-square analysis of backcross and F_2 populations from crosses of partially male-sterile and fertile plants of upland cotton grown in 1958.

Population	Number of plants		χ^2	P
	Male fertile	Male sterile		
BC_1:				
(ms-3 ms-3 × M8)-1 × (ms-3 ms-3)-1	4	7	0.8182	.50 -.25*
(ms-3 ms-3 × M8)-1 × (ms-3 ms-3)-3	8	3	2.2737	.25 -.10
(ms-3 ms-3 × M8)-1 × (ms-3 ms-3)-4	6	4	0.4000	.050-.025
(ms-3 ms-3 × M8)-3 × (ms-3 ms-3)-3	3	2	0.2000	.25 -.10
(ms-3 ms-3 × M8)-7 × (ms-3 ms-3)-3	3	3	0.0000	1
(ms-3 ms-3 × M8)-7 × (ms-3 ms-3)-1	8	2	3.6000	.10 -.05
Total	32	21	7.2919	
Deviation			2.2830	.25 -.10
Heterogeneity			5.0079	.50 -.25
F_2:				
(ms-3 ms-3 × M8)-1-1	68	18	0.760	.50 -.25†
(ms-3 ms-3 × M8)-2-1	28	6	0.980	.50 -.25
(ms-3 ms-3 × M8)-4-1	19	7	0.051	.90 -.75
Total	115	31	1.791	
Deviation			1.105	.50 -.25
Heterogeneity			0.686	.80 -.70

* 1:1 expected ratio. † 3:1 expected ratio.

Table 2—Classification and chi-square analysis of backcross and F_2 populations from crosses of partially male-sterile and fertile plants of upland cotton grown in 1960.

Population	Number of plants		χ^2	P
	Male-fertile	Male-sterile		
BC_1:				
ms-3 ms-3 × (ms-3 ms-3 × Dixie Triumph)	4	2	0.667	.50-.25*
(ms-3 ms-3 × Dixie Triumph) × ms-3 ms-3	3	10	3.769	.10-.05
(Dixie Triumph × ms-3 ms-3) × ms-3 ms-3	6	5	0.091	.90-.75
(Acala W 29-6 × ms-3 ms-3) × ms-3 ms-3	9	16	1.960	.25-.10
(ms-3 ms-3 × Delfos 9169) × ms-3 ms-3	4	1	1.800	.25-.10
(ms-3 ms-3 × Cook 307-6) × ms-3 ms-3	4	8	1.333	.25-.10
Total	30	42	9.619	
Deviation			2.000	.25-.10
Heterogeneity			7.619	.20-.10
F_2:				
ms-3 ms-3 × Dixie Triumph	4	7	8.758	.01†
Acala W 29-6 × ms-3 ms-3	7	6	3.103	.10-.05
ms-3 ms-3 × Delfos 9169	10	1	1.485	.30-.20
ms-3 ms-3 × Cook 307-6	5	2	0.048	.90-.80
Total	26	16	13.392	
Deviation			3.841	.05
Heterogeneity			9.551	.05-.02

* 1:1 expected ratio. † 3:1 expected ratio.

Table 3—Results of F_3 and F_4 progeny tests of male-sterile and fertile segregants form the M8 × ms-3 ms-3 cross in cotton.

No.	Parent plant*				Progeny test			
	1959 mean†	1960 array	Assumed genotype	Generation	Observed‡		χ^2 (3:1)	P
					F	S		
1	0	0-1-1-2-3	ms-3 ms-3	F_3	0	11	-	-
2	1	1-1-0-0-1	ms-3 ms-3	F_3	0	10	-	-
3	1	2-0-2-1-2	ms-3 ms-3	F_3	0	9	-	-
4	2	4-4-4-4-4	Ms-3 ms-3	F_3	17	8	.653	.50-.30
5	2	0-1-1-1-4	ms-3 ms-3	F_3	0	11	-	-
6	2	0-1-1-2-0	ms-3 ms-3	F_3	0	14	-	-
7	3	1-1-3-0-0	ms-3 ms-3	F_3	0	13	-	-
8	3	4-4-4-4-4	Ms-3 ms-3	F_3	9	3	.000	-
9	4	4-4-4-4-4	Ms-3 ms-3	F_3	16	0	-	-
10	4	4-4-4-4-4	Ms-3 ms-3	F_3	12	2	.857	.50-.25
11	1	3-1-1-2-4	ms-3 ms-3	F_4	0	13	-	-
12	3	2-0-1-1-2	ms-3 ms-3	F_4	0	14	-	-
13	4	3-1-0-2-1	ms-3 ms-3	F_4	0	13	-	-

* F_2 and F_3 segregant plants grown from seed in 1959 then cut-back and grown again in 1960 from stubs. † Sterility scores used were those suggested by Justus and Leinweber (1). ‡ F = male-fertile. S = partially male-sterile.

were grown in 1960 to determine whether this factor was stable in other backgrounds. All populations fit the expected ratios fairly well except the F_2 generation involving Dixie Triumph, which had an excess of male-sterile plants. The excess of male-sterile plants may well be due to sampling error since the backcross generations involving Dixie Triumph fit the expected ratio. Two of these progenies had an excess of male-fertile plants and 1 had an excess of male-sterile plants. The F_1 generation of *ms*-3 crossed to *ms*-1 was always male-fertile, indicating that these genes are not allelic. Since ms_2 is completely male-sterile, *ms*-3 and ms_2 were assumed to be different genetic factors.

The flowers of the advanced-generation steriles resembled the original male-steriles in that they lack pollen or have

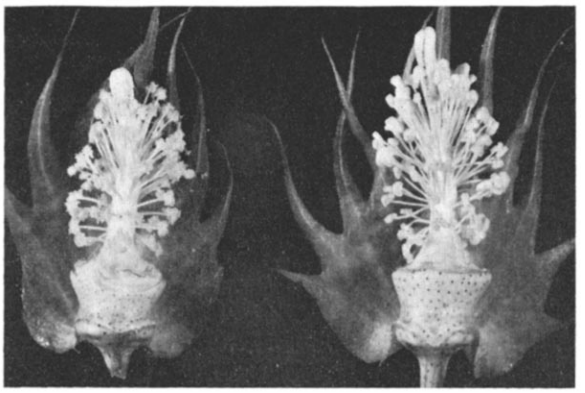

Figure 1—Normal pollen-fertile upland cotton flower showing dehiscent anthers (left) and a partially male-sterile cotton showing nondehiscent anthers (right).

a reduced amount (Figure 1). The amount of pollen produced is affected by environment, but the environmental stimulus has not been determined. Partially male-sterile plants are more fertile in the greenhouse than in the field. The pollen produced is viable and can be used for self-pollination or outcrossing. Data presented in Table 3 indicate that the method used to classify plants as either male-fertile or male-sterile was sound, but not infallible. This is evidenced by plants 4, 8, and 13 having different scores in 1959 and 1960. (If a plant had a partially male-sterile flower during the season, it was considered as being homozygous male-sterile.) In using this criterion for classifying, it should be kept in mind that normal varieties often have partially sterile flowers during periods of stress.

The homozygous self-pollinated seed from the partial male-steriles could be used for female rows in natural-crossing blocks for hybrid seed production. Smith (6) suggested a scheme similar to this for producing hybrids in normally self-pollinated crops with partial male-steriles that were sensitive to environmental changes. Justus and Leinweber (1) suggested methods for utilizing partial male-sterile lines of cotton to produce hybrids. If the percentage of natural crossing is sufficient on the homozygous partial male-sterile plants, this would be a workable means of producing F_1 hybrids.

Seed of the *ms*-3 *ms*-3 genotype has been placed in the Regional Collection of Upland Cotton.

SUMMARY

A second recessive gene for partial male-sterility of upland cotton is reported. The percent of sterile anthers for homozygous plants varies in response to environment. The symbol *ms*-3 is proposed for this gene.

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