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INHERITANCE OF A SECOND VIRESCENT MUTANT IN AMERICAN PIMA COTTON

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Abstract

Eighteen virescent mutants have been described in allotetraploid cotton (*Gossypium* sp.); however, only one originated in *G. barbadense* L. These mutants are useful as seedling and mature plant markers for studies of genetic systems and photosynthesis. A second virescent mutant was found in a *G. barbadense* (Pima) breeding nursery at Maricopa, AZ in 1984. Experiments indicated that it was under genetic control and was a new phenotype in Pima cotton. The objectives of the present study were to determine the inheritance of this new virescent trait and its linkage and allelic relationships with other *Gossypium* mutants. The genetic studies showed that the virescent trait is inherited as a monogenic recessive, and that it is not linked with 22 *Gossypium* mutant genes or allelic with v_7 in *G. barbadense* of v_1 and v_2 in *G. hirsutum* L. The name virescent-21 and the gene symbol v_{21} are assigned to the new Pima plant color trait.

VIRESCENT MUTANTS of cotton occur occasionally in growers' fields and in breeding and genetic nurseries. These plant-color mutants are useful as seedling and mature plant markers for studies of genetic systems and for studies of photosynthesis of cotton (Benedict et al., 1972).

Eighteen virescent mutants have been described in allotetraploid cotton, 17 in *G. hirsutum* L. and one in *G. barbadense* L. Sixteen are inherited as monogenic recessives and two, v_5 v_6, and v_{16} v_{17}, are conditioned by duplicate factors (Endrizzi et al., 1984; Kohel, 1983; R.J. Kohel, 1988, personal communication). The virescent expression of the mutants is variable from one mutant to another and also may vary during the life of the plant. Several nonvirescent *Gossypium* plant color mutants also have been described (Endrizzi et al., 1984).

A new virescent phenotype, which had not been observed previously in Pima cotton, was found in the 1984 breeding nursery. Seedlings and plants in the progeny of the two plants that originally expressed the phenotype were all similar with yellow leaves that turned pale green at maturity. This result indicated that the yellow color trait was inherited, and since it was a new phenotype in Pima cotton, it was deserving of further study.

The present paper describes the inheritance and linkage relationships of the new virescent phenotype.

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Table 1. The F_1, F_2, and backcross data from crosses of a virescent mutant of Pima cotton, pm-2, with Pima S-6 and other genetic marker stocks.

Parent		Generation	No. of plants		Ratio tested	χ^2	p
Female	Male		Normal	Mutant			
Pima S-6	pm-2	F_1	52	0			
pm-2	Pima S-6	F_1	20	0			
Pima S-6	pm-2	F_2	502	140	3:1	3.49	0.10–0.05
pm-2	Pima S-6	F_2	664	212	3:1	0.30	0.70–0.50
Various genetic markers	pm-2	F_2 pooled	2337	723	3:1	3.07	0.10–0.05
(Pima S-6 × pm-2)	pm-2	BC_2	70	87	1:1	1.84	0.20–0.10
Pima S-6	(Pima S-6 × pm-2)	BC_1	144	0			

Materials and Methods

Two plants having yellow leaves, that later turned pale green, were found in Pima breeding row 84–896. This row had been planted with Pima strain 7909–38–5–5, an F_5 progeny row selected for its short and coarse fiber characteristics. Progeny from both plants were similar in appearance and plant color expression indicating complete penetrance. Open-pollinated seed from each plant were bulked to form a parental stock designation pm-2 (Turcotte, 1987). In addition, the yellow-leaved plants were crossed, as male, with normal leaf 'Pima S-6' to begin inheritance studies. Additional crosses between Pima S-6 and pm-2 were made reciprocally in a greenhouse and in the field in 1985. The F_1 plants were grown in the field in 1985 and 1986 and self-pollinated for F_2 seed. The F_1 plants also were crossed with Pima S-6 and pm-2 parental stocks for Backcross 1 (BC_1) and Backcross 2 (BC_2) seed. The F_2 and BC_1 populations were grown in the field for scoring in 1986 and 1987.

Crosses also were made between pm-2 and several genetic marker stocks for allelism and linkage studies. The crosses were made in a greenhouse and in the field in 1986 and progenies scored in the field in 1987. Chi-square analyses were used for fit of observed : expected genetic ratios and for detection of linkage. Recombination values were calculated by the maximum likelihood method (Allard, 1956).

Field plots were grown at the University of Arizona Maricopa Agricultural Center, Maricopa, AZ. 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 plots each year.

Results and Discussion

The F_1 plants from reciprocal crosses of Pima S-6 and pm-2 had normal, green leaves indicating that the virescent trait was recessive. The F_2 and BC_2 data

Table 2. Linkage tests via testcrosses between a virescent mutant of Pima cottou, pm-2, and 22 other *Gossypium* mutants.

Gene symbol†	Linkage group	No. of plants AB	Ab	aB	ab	χ^2 linkage	Recombination percentage
Gv		68	23	23	7	0.05	51.48
H_2 (T_1)	IV	136	31	57	15	0.02	49.26
L_2°	II	80	24	26	11	0.68	45.22
Lc$_1$	I	31	7	10	1	0.27	59.34
Ms$_{12}$‡		40	21	38	29	0.78	46.09
N_1	V	32	9	13	2	0.61	58.76
R_1	III	36	10	23	5	0.49	55.21
R_2^v	I	73	29	27	7	0.84	56.00
Rf	XVIII	78	5	41	7	2.68	49.39
cu		124	40	43	17	0.39	52.87
fg	VI	117	21	41	9	0.21	51.94
gl$_2$, *gl*$_3$	V, IX	160	43	10	4	0.38	57.10
ne$_1$, *ne*$_2$	V, IX	241	61	21	4	0.40	44.10
p_1	XI	317	112	92	48	3.67	55.35
p_2		278	98	76	23	0.32	47.78
rl$_1$	X	84	30	24	9	0.01	50.52
v_7		315	113	107	34	0.30	48.29
vf	II	26	3	4	1	0.64	67.33
wr		83	21	24	4	0.22	45.61
y_1	XII	362	86	124	27	0.12	48.74

† Name, linkage group, and reference of cotton mutants given in Endrizzi et al. (1985).
‡ Backcross data.

showed that the trait was conditioned by one pair of recessive genes (Table 1). Additional F_2 data were obtained from crosses of various genetic markers as female parents and pm-2 as male parent that were made for linkage tests. These data also supported the genetic model of monogenie recessive inheritance for pm-2.

Linkage tests of pm-2 and 22 other *Gossypium* mutant genes were made (Table 2). Six independent genes and 11 allotetraploid linkage groups were tested. Chi-square values for detection of linkage were all nonsignificant indicating that pm-2 is inherited independently of the 22 mutant genes tested, or is beyond the limits of detection, if on the same chromosome. Thus, pm-2 can be considered a new, independent gene conditioning plant color in Pima cotton.

One virescent mutant, v_7, was described in Pima cotton and was shown to be a homoeologue of v_1 in *G. hirsutum* (Turcotte and Feaster, 1973). Allelism tests were made between pm-2 and v_1 and v_7. The F_1 plants were green, and 9 green : 7 virescent plants were observed in F_2 indicating that pm-2 and v_1 and v_7 are not allelic (Table 3). One additional *G. hirsutum* virescent, v_2, also was tested for allelism with pm-2. The v_2 virescent had been transferred to a *G. barbadense*

Table 3. The F_2 data from crosses involving a virescent mutant of Pima cottan, pm-2, and four other *Gossypium* mutants for abnormal plant color.

Parent Female	Parent Male	No. of plants Normal	Mutant	Ratio tested	χ^2	p
v_1 v_1	pm-2	225	168	9:7	0.16	0.70–0.50
v_7 v_7	pm-2	315	254	9:7	0.18	0.70–0.50
v_2 v_2	pm-2	42	28	9:7	0.40	0.70–0.50
pm-2	av_1 av_1	37	17	9:7	3.30	0.10–0.05

background by backcrossing. The expression of v_2, named golden crown to denote its phenotype typified by only the upper part of the plant being yellow, is similar to pm-2. The F_1 plants from crossing v_2 and pm-2 were green and F_2 plants segregated 9 green : 7 yellow (Table 3) indicating that the recessive genes conditioning the traits are not alleles. An allelism test between albivirescent-1 (av_1; Turcotte and Feaster, 1978) and pm-2 also was negative (Table 3).

The data presented above also support our conclusion that an independent recessive gene pair conditions the expression of the new plant eolor trait pm-2 in Pima cotton. The name virescent-21 and the gene symbol v_{21} are assigned to this trait (Kohel, 1973).

In contrast to several previously described virescents in *G. hirsutum*, which vary in expressivity, v_{21} is an easily scored trait with good expression at Maricopa. The trait will be utilized in studies of genetic systems in *G. barbadense* as both a seedling and a mature plant marker.

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