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Gl_2^s—A New Allele for Pigment Glands in Cotton[1]

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ABSTRACT

A new gland phenotype was observed in cotton (*Gossypium hirsutum* L.) segregating for Gl_2 and Gl_3. A genetic analysis was conducted to determine the inheritance of this character. It was found that the gene responsible was allelic to Gl_2. The new allele was designated Gl_2^s. Gl_2^s in the homozygous condition ($Gl_2^sGl_2^s$ gl_3gl_3) imparts reduced gland density in the cotyledons, as compared to Gl_2 or Gl_3, with apparent normal gland distribution in the stems and petioles.

Additional index words: Allelism, Insect resistance, Seed gossypol.

THE pigment glands of *Gossypium* species are potentially important in contributing insect resistance to cotton plants, mainly because they contain the toxic substance gossypol (4). However, gossypol imposes problems in the processing of cottonseed oil and meal because it is toxic to humans and certain domestic animals, as well as to insects.

McMichael (2) found in *G. hirsutum* L. a gene designated gl_1 that, when homozygous, removed glands from the hypocotyl, stem, petiole, and boll. Later, he (3) selected completely glandless plants, and these were assigned the genotype $gl_2gl_2gl_3gl_3$.

Lee (1) established the gland-distribution patterns in the cotyledons of plants carrying various combinations of the active alleles Gl_2 and Gl_3. Two or more doses of the dominant alleles, Gl_2 or Gl_3, give the "A" or "wild" phenotype in which the glands are seemingly distributed at random throughout the entire area of the cotyledon. A single dose of Gl_2 (i.e., heterozygous Gl_2) gives the "B" type class in which glands are distributed about the margins and along the midvein of the cotyledon. A single dose of dominant Gl_3 gives the "C" type class in which glands are distributed only along the margins of the cotyledon. Cotyledons of the "D" class are glandless.

The purpose of the investigation reported herein was to determine the inheritance of a new gland phenotype in cotton and its relationship to known genes for glandedness.

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MATERIALS AND METHODS

XG-15, a densely glanded line selected from segregating generations after the cross of *Gossypium hirsutum* var. *punctatum* cv. 'Socorro Island' ($Gl_2Gl_2Gl_3Gl_3$) with 'Deltapine 15,' was crossed with glandless 'Acala B6532' ($gl_2gl_2gl_3gl_3$). The F_1 was then test-crossed to glandless 'Coker 100A' ($gl_2gl_2gl_3gl_3$). The testcross progeny of 255 plants segregated 1A:1B:1C:1D, as expected. However, a single plant in the "D" class showed only one gland on the hypocotyl. This plant and its progeny were selfed to obtain S_1, S_2, and S_3 progenies. Various selections among these were selfed and test-crossed to monomeric Gl_2 and Gl_3 in attempts to determine the inheritance of the new phenotype. Later testcrosses were made with monomeric 'Coker' plants $Gl_2Gl_2gl_3gl_3$ and $gl_2gl_2Gl_3Gl_3$ in efforts to determine linkage relationships.

RESULTS AND DISCUSSION

The first generation of selfing yielded three different phenotypic classes: (1) "B" and "C" phenotype cotyledons with glanded hypocotyls; 2) phenotypes similar to the parent, with very few glands (1 to 12) on the hypocotyls or cotyledons; and 3) the glandless phenotype. Ratios were variable, presumably because of errors in classifying glandless and slightly glanded parental-type seedlings. In subsequent generations, the three different classifications were acurately distinguished by careful observations. It thus became evident that the parental-type, slightly glandular seedling was heterozygous for a gland-determining gene The S_2 generation, obtained by selfing slightly glanded plants, gave 36 seedlings with "B" or "C" cotyledons and normally glanded hypocotyl; 86 of the slightly glandular parental type; and 44 that were glandless. This result gives a good fit to a 1:2:1 ratio, indicating the presence of a single allelic pair.

Plants from each of the three phenotypic classes were grown and selfed for the S_3 generation. Table 1 gives the numbers and classes of progenies from each of the three classes of parents. The "B" or "C" type plants with glanded hypocotyls bred true. The variability of the "B" or "C" classes appeared to be introduced by segregation of a modifer or by differing rate of penetrance. The parental or slightly glanded plants segregated in a 1:2:1 ratio, whereas the glandless plants also bred true. The slightly glanded, parental-type plants test-crossed to glandless plants segregated one slightly glanded to one glandless, and "B" and "C" types test-crossed to glandless

Table 1. The numbers of phenotypic and genotypic classes of Gl_s progenies and test crosses of the Gl_s material.

Phenotypic class	A or B	Slightly glanded	D		
genotype	Gl_sGl_s	Gl_sgl_s	gl_sgl_s	χ^2	P
Apparent parental genotype:					
Gl_sGl_s	747	0	0		
Gl_sgl_s	642	1,145	627	6.557	0.02-0.05
Apparent test-cross parental genotype:					
$Gl_sgl_s \times gl_sgl_s$	0	182	172	0.282	0.50-0.70
$Gl_sGl_s \times gl_sgl_s$	0	86	0		

Table 2. Segregates of a test of independence of Gl_s with Gl_2 and Gl_3.

	Phenotypic classes				
Parental genotypes	A	B	C	D	Slightly glanded
$Gl_sgl_sGl_2gl_2gl_3gl_3 \times gl_sgl_sgl_2gl_2\,gl_3gl_3$	3*	183	0	0	199
$Gl_sgl_sgl_2gl_2Gl_3gl_3 \times gl_sgl_sgl_2gl_2gl_3gl_3$†	101	0	75	109	93

* Apparent contaminants.
† χ^2 for goodness of fit to 1:1:1:1 ratio is 6.720 with P 0.05 to 0.10.

gave all slightly glanded progenies. These data confirm the monogenic inheritance for the new gland phenotype.

For illustration, we shall assume that the new allele is independent of gl_2 and gl_3 and designate it gl_s. Figure 1 shows the phenotypic comparisons of Gl_2, Gl_3, and Gl_s.

The homozygous Gl_sGl_s and the heterozygous Gl_sgl_s plants have fewer glands in the cotyledons than the corresponding Gl_2 and Gl_3 genotypes. The mature Gl_sGl_s plants are comparable to mature Gl_2Gl_2 plants in gland density in stems, petioles, leaves, and carpel walls. The variability within the Gl_sGl_s and Gl_sgl_s phenotypes is illustrated in Fig. 2.

To determine the genetic relationship of Gl_s with Gl_2 and Gl_3, plants of the $(Gl_sGl_s)\ gl_2gl_2gl_3gl_3$ genotype were crossed with Coker 100A monomeric Gl_2 $[(gl_sgl_s)\ Gl_2Gl_2gl_3gl_3]$, and Coker 100A monomeric Gl_3 $[(gl_sgl_s)\ gl_2gl_2Gl_3Gl_3]$. The F_1 plants of each cross were of the "A" phenotypic class, containing a single dose of Gl_s and Gl_2 or Gl_s and Gl_3, and were test-crossed to glandless Coker 100A $gl_sgl_s\ gl_2gl_2gl_3gl_3$.

If Gl_s and Gl_2 are independent, one would expect the monomeric Gl_2, Gl_s F_1 test-cross progeny to segregate 1 $(Gl_sgl_s)\ Gl_2gl_2gl_3gl_3$ (class "A"): 1 $(gl_sgl_s)\ Gl_2gl_2gl_3gl_3$ (Class "B"): 1 $(Gl_sgl_s)\ gl_2gl_2gl_3gl_3$ slightly glanded): 1 $(gl_sgl_s)\ gl_2gl_2gl_3gl_3$ (class "D"). A significant reduction of the two recombinant classes "A" and "D" would indicate linkage, and if only classes "B" and slightly glanded were observed, one would conclude that Gl_s *and* Gl_2 are alleles. Similar results would be expected in the progeny from the monomeric Gl_3 F_1 test-crossed to glandless, except that class "C" $(gl_sgl_sgl_2gl_2Gl_3gl_3)$ would replace class "B".

Table 2 gives the results of the two test crosses. These data suggested that Gl_s and Gl_2 are allelic. The three classes "A" seedlings in the test for allelism with Gl_2 were apparently contaminants from accidental selfing. We must conclude, therefore, that Gl_s is an allele of Gl_2 and independent of Gl_3, because of the 1:1:1:1 ratio of A:C:D and slightly glanded phenotypes. Since these data show Gl_s to be allelic to Gl_2, we designate it $Gl_2{}^s$.

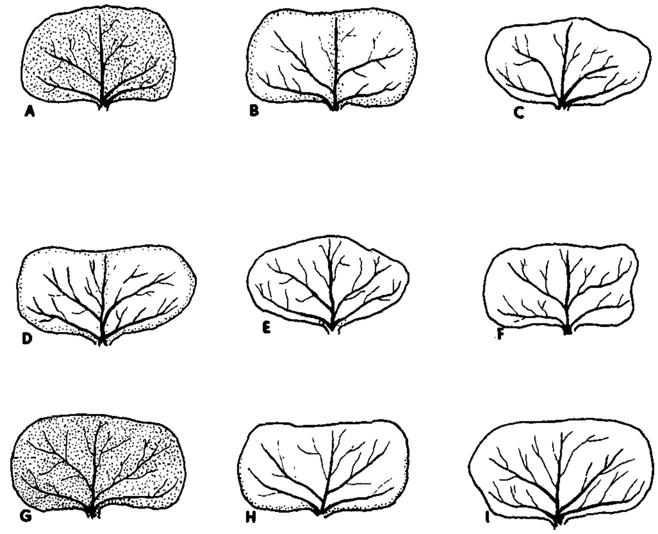

Fig. 1. Phenotypic comparisons of Gl_2, $Gl_2{}^s$, and Gl_3.* (A) $Gl_2Gl_2\ gl_3gl_3$; (B) $Gl_2gl_2\ gl_3gl_3$; (C) $gl_2gl_2\ gl_3gl_3$; (D) $Gl_2{}^sGl_2{}^s\ gl_3gl_3$; (E) $Gl_2{}^sgl_2{}^s\ gl_3gl_3$; (F) $gl_2gl_2\ gl_3gl_3$; (G) $gl_2gl_2\ Gl_3Gl_3$; (H) $gl_2gl_2\ Gl_3gl_3$; (I) $gl_2gl_2\ gl_3gl_3$.
* Gl_2 — Major allele at locus, fully glanded cotyledon when homozygous. $Gl_2{}^s$ — Secondary allele of Gl_2, cotyledon partially glanded when homozygous. gl_2 — Lower allele, cotyledons are glandless in homozygous condition if gl_3gl_3 is also present. Gl_3 — Major gene in D genome, cotyledons are fully glanded when homozygous. gl_3 — Secondary allele, cotyledons are glandless in homozygous condition if gl_2gl_2 is also present.

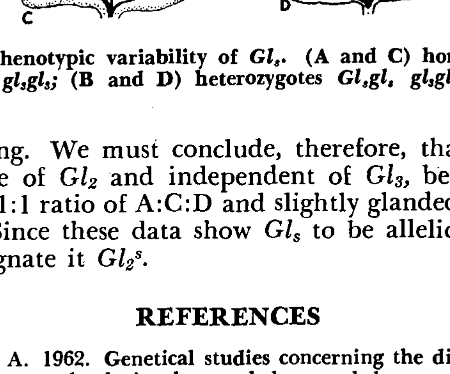

Fig. 2. Phenotypic variability of Gl_s. (A and C) homozygotes $Gl_sGl_s\ gl_3gl_3$; (B and D) heterozygotes $Gl_sgl_s\ gl_3gl_3$.

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