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Inheritance of Ephemeral Leaf Mutant of Upland Cotton[1]

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ABSTRACT

Developmental mutants of plants may be useful in studies of physiological development and of gene expression and gene action. The objectives of the study were to determine the inheritance of a newly discovered developmental leaf mutant of upland coton (*Gossypium hirsutum* L.) and to determine whether it was allelic to, or linked to veins-fused (*vf*) or to strap leaf (*s*). This mutant is named ephemeral, because it expresses only for a short time during plant growth. The gene associated with this expression was assigned the symbol *ep*. It was inherited as a monofactorial recessive in 1985, but in 1984, about half of the (normal × ephemeral)F_1 plants were intermediate in expression. In the greenhouse, usually a single leaf is affected at about Node 6, and progressively more leaves are affected until Node 15, but leaves at Node 18 and above appear normal. In the field, expression is much more restricted and may be limited to just a few leaves at Nodes 5 to 10. The mutant phenotype resembles that of veins-fused, but *ep* is not allelic to, nor closely linked to *vf* or to *s*.

***Additional index words:* *Gossypium hirsutum* L., Developmental mutant, Qualitative inheritance.**

DEVELOPMENTAL mutants of plants (i.e., those that express their phenotype only during certain stages of the life cycle), besides being of intrinsic interest, may also be useful in studies of physiological development, gene expression, and gene action (1). A number of developmental mutants have been identified in cotton (*Gossypium* spp.), among them several virescent types (4) and *wrinkled leaf* (7).

The major objective of the studies was to determine the inheritance of a newly discovered developmental leaf mutant of upland cotton (*Gossypium hirsutum* L.). This mutant is named ephemeral because the phenotype is expressed only for a relatively short time during plant growth. The associated gene is assigned the

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symbol *ep*. A secondary objective was to determine whether *ep* is allelic to, or linked to veins-fused (*vf*), which it resembles phenotypically, or to strap leaf (s), which is closely linked to *vf*. Both *vf* and *s* were assigned to chromosome 15 (2), but recent evidence has shown that they are not associated with that chromosome (M.Y. Menzel, 1985, personal communication). Homozygous veins-fused plants have small misshapen leaves with the margins curled toward the abaxial surface and with irregularly fused veins. Heterozygous veins-fused plants have leaves with an intermediate expression (5). Both homozygous and heterozygous veins-fused plants produced bolls at Phoenix, AZ. Homozygous strap leaf plants have very small strap-shaped leaves and other phenotypic irregularities, but heterozygous plants have an intermediate phenotype (2,3). Homozygous strap leaf plants were sterile at Phoenix, but heterozygous plants produced some bolls.

MATERIALS AND METHODS

A potted plant of 'Deltapine 61', growing in a winter greenhouse at Phoenix, AZ, was observed to have several leaves that resembled the veins-fused mutant, but most leaves were normal (see description below). Seeds from this plant, designated FDW 838, were sown in the greenhouse. Some seedlings were transplanted to the field, while other seedlings were left in the greenhouse to determine if the mutant character bred true.

FDW 838 was crossed as pistillate parent to the veins-fused mutant in 1982 to test for allelism and linkage. FDW 838 was also crossed to heterozygous strap leaf (homozygous strap leaf was sterile at Phoenix). Veins-fused and strap leaf were received from R.J. Kohel, who maintains these mutants in the Texas Marker-1 (TM-1) genetic background (6). In 1983, the F_1 populations were scored and selfed. In 1984, parental and F_2 populations were scored.

Some variability of expression of the ephemeral character was observed among 10 plants of FDW 838 in the winter greenhouse in 1983. The plant that expressed the ephemeral character most clearly, FDW 838-2, was crossed as pollen parent to Deltapine 61 in the greenhouse. Seedlings of F_1 plants of this cross were transplanted to the field in 1984. The F_1 plants were selfed and backcrossed as pollen parent to Deltapine 61 and to FDW 838-2. In 1985, seedlings of both parents, F_1, F_2, and backcross progenies were transplanted to the field and scored for leaf phenotype. Soil type at Phoenix is Avondale clay loam, a member of the fine, loamy, mixed, hyperthemic Torrifluventic Haplustolls. Data from each population were analyzed with the use of the chi-square test for goodness-of-fit to expected ratios.

RESULTS AND DISCUSSION

Description

In the greenhouse, the mutant had normal leaves up to the sixth node, or the node of the first sympodium. At least one leaf on the first sympodium exhibited a light-green circular area at the base of the lamina, which was larger in successive leaves. Some leaves of mutants also had small, light-green mosaic patches. As later leaves developed, the major leaf veins were parallel to each other near the base and diverged near the apex of each leaf. All the leaves at about the 15th node were affected. Full expression of the mutant produced an undulate, rather than flat, leaf lamina, which was curved or cupped toward the abaxial side. The affected leaves were abnormally thick, relatively inflexible, and significantly smaller than normal leaves on the same plant (Fig. 1). All leaves appeared normal by about the 18th node.

Among transplanted seedlings in the field, affected leaves of mutant plants appeared on the main axis of the plant at about the fifth node, but all leaves at the 10th and higher nodes appeared normal. Instead of a light circular area at the base, the affected leaves of the mutant had a patchy, sun-red area, which aided in scoring the mutant. In 1985, it was possible to score the mutant plants 28 days after transplanting seedlings to the field (42 days after planting seeds in the greenhouse), but by 47 days after transplanting, the affected leaves on mutant plants had abscised or were hidden in the canopy and all visible leaves appeared normal. The mutant character had no obvious effect on the productivity of individual plants.

Inheritance, Allelism, and Linkage

In the field in 1985, ephemeral was inherited as a monofactorial recessive in Deltapine 61 background (Table 1). All F_1 plants and all those from the backcross to Deltapine 61 were scored as normal at every date (28, 33, 37, and 47 days after transplanting). In 1984, however, 21 F_1 plants had been scored as normal and 19 as heterozygous mutant 40 days after transplanting seedlings to the field. The heterozygous mutant plants had one to a few leaves with misshapen

Table 1. Segregation for ephemeral leaf mutant in upland cotton.

Pedigree	Leaf phenotype		χ^2	*P*
	Normal	Ephemeral		
Deltapine 61 (DPL-61)	22	0	--	--
FDW 838-2	0	18	--	--
(DPL-61 × FDW 838-2) F_1	21	0	--	--
(DPL-61 × FDW 838-2) F_2	148(147)†	48(49)	0.03	0.8–0.9
(DPL-61 × FDW 838-2) × DPL 61	105	0	--	--
(DPL-61 × FDW 838-2) × FDW 838-2	55(50)	45(50)	1.00	0.3–0.4

† Expected frequencies in parentheses.

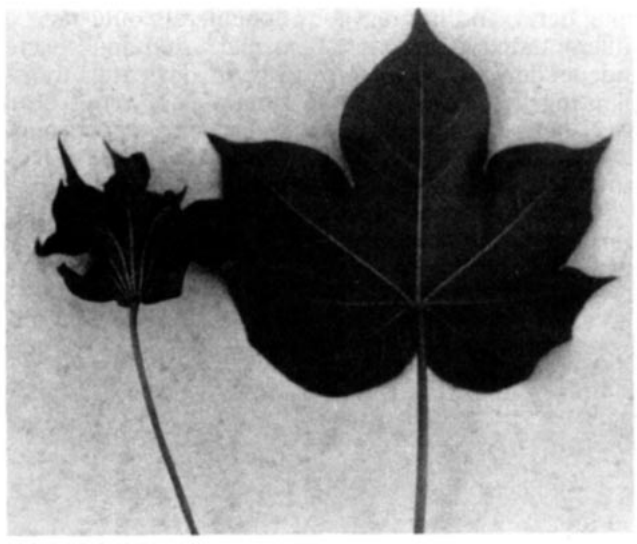

Fig. 1. Ephemeral leaf (left) and normal leaf (right) from the same greenhouse-grown cotton plant, FDW 838-2.

Table 2. Segregation ratios in F_2 populations of ephemeral × heterozygous strap leaf and ephemeral × veins-fused cotton, 37 and 61 days after transplanting seedlings to the field.

Cross and phenotype	Days after transplanting: 37 Observed	37 Expected (4:11:1)	61 Observed	61 Expected (4:8:3:1)
	no. plants			
Ephemeral × heterozygous strap leaf F_2 from heterozygous strap leaf F_1:				
Strap leaf	18	21.5	18	21.5
Heterozygous strap leaf	64	59.1	22	38.2
Ephemeral + heterozygous ephemeral			42	16.1
Normal	4	5.4	4	5.4
χ^2	0.2		49.5	
P	>0.6		<0.0005	
from heterozygous ephemeral F_1:	(1:3 expected)			
Ephemeral	33	31.0	(Same as 37 days)	
Heterozygous ephemeral + normal	91	93.0		
χ^2	0.2			
P	>0.6			
Ephemeral × veins-fused F_2:				
Veins-fused	31	26.0	31	26.0
Heterozygous veins-fused	70	71.5	47	51.5
Ephemeral + heterozygous ephemeral			23	19.5
Normal	3	6.5	3	6.5
χ^2	2.9		3.9	
P	>0.2		>0.2	

areas of light-green vascular tissue. The 1984 results, including those from crosses of the mutant with strap leaf and veins-fused, indicate that ephemeral is not completely recessive to normal, but that the heterozygous expression is either inconsistent or it is inconspicuous enough to be missed occasionally.

The 39 ephemeral × heterozygous strap leaf F_1 plants segregated 1 heterozygous strap leaf: 1 heterozygous ephemeral (18:21; $\chi^2 = 0.2$; $P>0.6$). It was not possible to determine allelism or linkage from the F_1 ratios. At 37 days after transplanting, the segregation ratio of the F_2 from heterozygous strap leaf F_1 was not significantly different from the expected ratio of 4 strap:11 mutant (heterozygous strap leaf, heterozygous ephemeral, and homozygous ephemeral could not be differentiated at 37 days):1 normal, if *ep* and *s* were independent (Table 2). However, 61 days after transplanting, the 64 plants of the mutant class were scored as 22 heterozygous strap leaf and 42 normal (presumably heterozygous + homozygous ephemeral). This ratio was significantly different from the expected 8 heterozygous strap leaf:3 normal ratio if heterozygous strap leaf had expressed consistently. Perhaps the ephemeral gene had an ameliorating effect on the expression of strap leaf as the plants aged. The F_2 from heterozygous ephemeral F_1 did not deviate significantly from the ratio of 3 normal:1 ephemeral, expected if *ep* and *s* were independent and if heterozygous ephemeral did not express, or could not be distinguished from normal.

The 39 ephemeral × veins-fused F_1 plants were all scored as heterozygous veins-fused. At 37 days after transplanting, the ephemeral × veins-fused F_2 segregated 4 veins-fused:11 mutant (heterozygous veins-fused + heterozygous and homozygous ephemeral):1 normal, the expected segregation ratio if *ep* and *vf* were independent (Table 2). At 61 days after transplanting, the 70 plants of the mutant class were scored as 47 heterozygous veins-fused and 23 normal (presumably heterozygous + homozygous ephemeral), which also fit the expected 8:3 ratio for independent segregation. In this population, differences between heterozygous and homozygous ephemeral were apparent, but the two classes were difficult to separate because the leaves were scarred from insect attack and other environmental stresses.

In summary, the F_2 and backcross data from the cross of ephemeral with Deltapine 61, and the F_2 data from the crosses of ephemeral with strap leaf and veins-fused showed the following: i) *ep* is inherited monofactorially and may be variable in expression in the heterozygous state; and ii) *ep* does not appear to be allelic to, nor closely linked to *s* or *vf*.

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