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Inheritance of Ragged Leaf Mutant in American Upland Cotton, *Gossypium hirsutum L.*[1]

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IN 1954, seeds of a mutant stock of American Upland cotton, *Gossypium hirsutum* L., designated as "Ragged Leaf," were obtained from the Regional Collection of Genetic Stocks maintained at the Mississippi Delta Branch Experiment Station. According to communication from Zane F. Lund accompanying the seeds, limited and inconclusive data suggested the Ragged Leaf character was conditioned by a single gene pair in the heterozygous condition. The two other phenotypes observed in the F_2, plants with normal phenotype and plants with extremely aberrant growth, were considered to have been conditioned by homozygous normal and mutant alleles, respectively. Similar segregation was noted in observational plots at College Station, Texas. It also was noted that Ragged Leaf was similar in genetic behavior to several other characters being studied in qualitative genetic experiments at this station.

The study reported here was initiated to obtain critical data on the inheritance of the Ragged Leaf character and to test allelism with three other mutant characters each of which is conditioned by a single pair of genes in the heterozygous condition.

EXPERIMENTAL PROCEDURE AND RESULTS

Inheritance of Ragged Leaf

A few seeds of the Ragged Leaf stock were planted in the greenhouse during the winter of 1957–58. When the seedlings had developed to the stage at which they could be scored accurately for the mutant expression, two plants which exhibited the Ragged Leaf character were selected and grown to maturity; the others were discarded. Several flowers on each of the two selected plants were self-pollinated. Also, each plant was crossed to D&PL-14, an inbred tester line with normal phenotype. Small S_1 and F_1 populations were grown in the field nursery in 1958. Both the S_1 and F_1 populations segregated, confirming the heterozygous nature of the two Ragged Leaf plants selected the previous winter. During the summer and following winter, certain types were selfed and crossed to furnish material for a critical test of the presumed mode of inheritance and gene action associated with Ragged Leaf. Selfed seeds were produced on Ragged Leaf plants in the original stock, Ragged Leaf plants in the F_1 of the Ragged Leaf × D&PL-14 cross, and on normal and Ragged Leaf plants in the F_2 of this cross. Since the semilethal type seldom lived beyond midsummer and never produced fruit, this type could not be progeny-tested. Also, Ragged Leaf and non-Ragged Leaf (normal) plants in the F_1 were backcrossed to D&PL-14.

S_1, F_2, F_3, and BC populations were grown in the field nursery in 1959 and scored for phenotypic expression of the mutant character. The populations grown (grouped according to expected ratios), data on the total number of plants scored, the number of plants in each phenotypic class, and the test for "goodness of fit" of observed to expected ratios are given in Table 1 and will not be presented in detail in the text.

In the S_1, F_2, and F_3 populations, which were produced by selfing Ragged Leaf phenotypes, three phenotypic classes (normal, Ragged Leaf, and semilethal) were observed, and these segregated in the ratio of 1:2:1, respectively. Backcrosses of Ragged Leaf phenotypes to D&PL-14 gave 2-class segregation of normal and Ragged Leaf in 1:1 ratios. Nonmutant segregants when selfed or backcrossed to D&PL-14 produced only normal progeny. The chi-square test showed that the observed segregations did not deviate significantly from those expected on the basis of a monosomic system. These data substantiate the earlier assumptions regarding the monofactorial inheritance of the mutant character, Ragged Leaf.

The symbol, *Rg,* is proposed for the allele that conditions this mutant expression. The mutant expression is considered dominant to normal; so the genotype of Ragged Leaf becomes *Rg rg;* the semilethal, *Rg Rg;* and the normal phenotype, *rg rg.*

The semilethal (Figure 1) is characterized by extremely rosetted growth. Normally, the semilethal does not survive under field cultural practices, but it can be maintained by individual care in the greenhouse. Figure 2 compares the

Figure 1—Semilethal homozygote of the Ragged Leaf mutant of cotton.

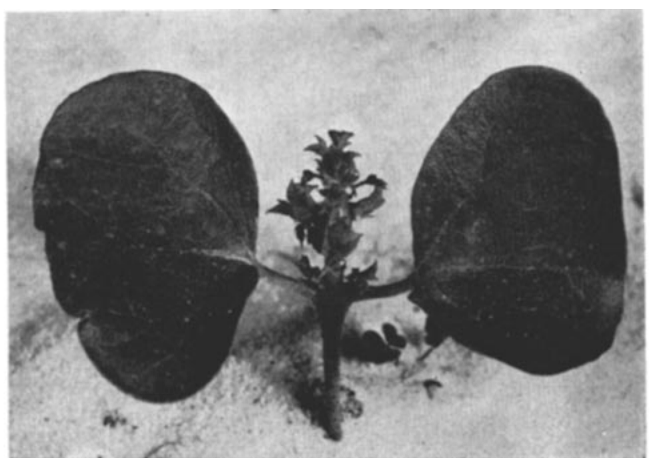

Figure 2—Leaves of the Ragged Leaf mutant and normal Upland cotton.

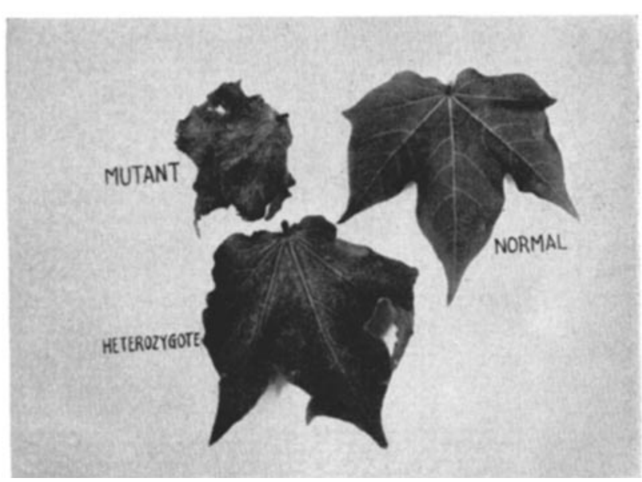

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Table 1—Segregation of Ragged Leaf in the population grown in 1959.

Hybrid	Number of plants					χ^2*	P
	Normal	HA	Ragged Leaf	HA & RL	Total		
Ragged Leaf × HA-1	9	3	4	6	22	3.45	.5 -.3
Ragged Leaf × HA-2	14	9	13	2	38	9.37	.05-.02
Ragged Leaf × HA-3	5	4	6	5	20	1.50	.7 -.5
Pooled	28	16	23	13	80	6.90	.1 -.05
Heterogeneity						7.42	.3 -.2

* Chi-square values for deviations from an expected 1:1:1:1 ratio.

Table 2—Segregation in crosses of Ragged Leaf and three "Heritable abnormality" stocks.

Population*	Number of plants				χ^2	P
	Normal	Ragged Leaf	Semilethal	Total		
Expected 1:2:1						
S_1 Ragged Leaf	17	16	9	42	5.23	.1 -.05
F_2 D&PL-14 × RL (Ragged Leaf F_1)	44	96	53	193	0.68	.8 -.7
S_1 D&PL-14 × [F_1 D&PL-14 × RL] (Ragged Leaf BC)	6	21	6	33	2.45	.3 -.2
F_3 D&PL-14 × RL (Ragged Leaf F_2)	10	23	12	45	0.20	.95-.9
S_1 D&PL-14 × [F_1 D&PL-14 RL] (Ragged Leaf F_1)	7	10	5	22	0.54	.8 -.7
F_3 D&PL-14 × RL (Ragged Leaf F_2)	5	11	6	22	0.94	.98-.95
Pooled	89	117	91	357	0.05	.98-.95
Heterogeneity					9.14	.7 -.5
Expected 1:1						
BC D&PL × [F_1 D&PL-14 × RL] (Ragged Leaf F_1)	63	59	0	122	0.13	.8 -.7
No segregation expected						
BC D&PL-14 × [F_1 D&PL-14 × RL] (non-Ragged Leaf F_1)	146	0	0	146		
F_3 D&PL-14 × RL (non-Ragged Leaf F_2)	84	0	0	84		

* RL = Ragged Leaf.

leaf of the Ragged Leaf mutant to a normal Upland cotton leaf. The leaf of Ragged Leaf mutant is smaller than the normal and has a crinkled appearance caused by curved interveinal surfaces and a downward rolling of the leaf edge. In addition to the mutant leaf expression, heterozygous plants showed reduced vegetative vigor and were unproductive; they set fewer bolls and produced fewer seeds per boll than normal plants in the same segregating populations.

Test of Allelism

The gene action of the Ragged Leaf mutant is similar to that of three mutant characters reported by McNamara and Porter[3] and called "Heritable Abnormalities." These types have been designated HA-1, HA-2, and HA-3. Ragged Leaf is phenotypically distinct from the HA types, but all four of these mutants show single-factor segregation with the heterozygote being a distinct mutant type and the homozygote semilethal. HA-1 and HA-2 show some phenotypic similarity but were shown to be genetically independent.

To test the possible homology between the Ragged Leaf gene and each of the three types of Heritable Abnormalities, heterozygotes of the HA's were crossed with Ragged Leaf heterozygotes in the greenhouse during the winter of 1959–60.

Seeds from these crosses were planted singly in 6-ounce paper cups in the greenhouse in the spring of 1960, and approximately two weeks after emergence the seedlings were transplanted to the field. This method guarded against overlooking semilethals that may have died shortly after emergence. In scoring the populations for plant type and leaf abnormalities and in tabulating and analyzing the data, the following theoretical expectations were considered: *(1)* If the 2 genes are members of an allelic series but condition different mutant expressions, the phenotypic ratio will be 1 normal: 1 HA: 1 Ragged Leaf: 1 semilethal; and *(2)* if they are nonallelic, the phenotypic ratio will be 1 normal: 1 HA: 1 Ragged Leaf: 1 "double-mutant" or type combining certain features contributed by both the HA and Ragged Leaf genes in the heterozygous condition.

The populations grown, the segregation ratios, and the analysis of the data are given in Table 2. The populations were too small to give completely reliable segregation ratios; however, the observed ratios did not deviate significantly from theoretical ratios against which they were tested, and there was no significant heterogeneity among families. However, these data do differentiate between the two proposed alternative segregations. Since double-mutants occurred while no semilethals were found, it is obvious these genetic factors are nonallelic.

The double-mutant condition was easier to recognize in the segregations involving HA-1 and HA-2 than in those involving HA-3. Apparently the Ragged Leaf expression masked the HA-3 expression during the early part of the growing season, but differentiation continued so that what was considered to be the double-mutant class was distinguishable late in the season.

The double-mutants were more reduced in vigor than either of the parental heterozygotes, and no selfed bolls were obtained in the field nursery. The suspect double-mutants were cut back, dug, and brought into the greenhouse, but the ratoons failed to survive. This was to be expected since ratoons of plants exhibiting the heterozygous condition of the gene for Ragged Leaf as well as those for the HA types are more difficult to establish in the greenhouse than normal cottons.

Although the data are not entirely conclusive, they form a reasonably reliable basis for assuming that the gene which conditions Ragged Leaf is not an allele of the genes which condition the mutant expressions in HA-1, HA-2, or HA-3. Of course, it may be argued that the double-mutant phenotype results from intra-allelic interaction rather than from physiological interaction of two independent genes in the heterozygous condition. However, the occurrence of double-mutants in all three hybrid populations was consistent with what would be expected if they were nonallelic. Progeny testing the double-mutants would furnish critical proof, but until such time as seeds can be produced from double-mutants, conclusions regarding allelism will have to be inferred.

SUMMARY

Investigations on the inheritance of a mutant character, Ragged Leaf, confirmed the hypothesis, made earlier from observations and limited data, that the character is controlled by a monogenic system. The symbol *Rg* is assigned to the gene in question. Three phenotypes were recognized in the F_2 in the following ratio—1 normal (*rg rg*): 2 Ragged Leaf (*Rg rg*): 1 semilethal (*Rg Rg*).

Tests of allelism of the Ragged Leaf gene with genes conditioning similar expressions in three other stocks (HA-1, HA-2, and HA-3) were conducted. The data and observations form a reasonably reliable basis for assuming that *Rg* is not an allele of the genes which condition the mutant expressions in the three HA stocks.

[3] Homer C. McNamara and Dow D. Porter. Heritable abnormalities in cotton and segregation ratios. Journal of Heredity 41: 311–315. 1950.