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Inheritance of Resistance to Chemical Defoliation in American Upland Cotton, *Gossypium hirsutum* L.[1]

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ABSTRACT

Data from S_1, F_1, F_2, and BC_1 populations treated with the defoliant, Def, indicated that resistance to chemical defoliation in Upland cotton, *Gossypium hirsutum* L., was controlled at a single locus. The symbol *df* was assigned to the gene in question. Two phenotypes were recognized in the F_2 in the ratio of 3 susceptible (*Df*—): 1 resistant to chemical defoliation (*dfdf*).

Additional index words: **Plant genetics, Defoliator, Nondefoliator.**

MACHINE harvesting of American Upland cotton, *Gossypium hirsutum* L., has created a need for cotton varieties that will defoliate when treated with a chemical defoliant. As long as cotton was harvested by hand, resistance to chemical defoliation was unimportant. It is common practice for producers to apply a chemical defoliant to remove leaves from cotton plants before harvest in order for the mechanical cotton harvester to be efficient and to prevent trash and stained lint grades.

Just as machine harvest has created a need for varieties that will defoliate, it has created a need for understanding the mode of inheritance of resistance to chemical defoliants. Commercial varieties now on the market defoliate satisfactorily. Most breeding material presents no unusual defoliation problem; however, in recent years, two breeders have noticed that some of their strains would not defoliate properly. Their material is used widely in crosses by other breeders, and we anticipate that this nondefoliating trait will appear in other programs. Thus, it is important to understand the mode of inheritance of resistance to chemical defoliation.

According to communications from him, J. G. Jenkins, Georgia Coastal Plain Experiment Station, Tifton, Georgia, suspected that resistance to chemical defoliation was controlled by a single factor pair. This was based on his field breeding experience.

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The objective of this study was to determine the genetic inheritance of resistance to chemical defoliation.

MATERIALS AND METHODS

In 1965 seed of four nondefoliating 'Atlas' breeding lines were obtained from J. G. Jenkins (see above). Seed of one nondefoliating 'FTA' breeding line was obtained from D. C. Harrell, Pee Dee Station, Florence, South Carolina. According to communications from Jenkins and Harrell, progeny rows of the lines were resistant to chemical defoliation and had been classified as nondefoliators.

Seed of the five lines thought to be resistant to chemical defoliation and 'Coker 201' were planted in the field in the spring of 1966. Plants were thinned to one plant in 61 cm (24 in) of row about 7 weeks after emergence. Normal fertilization and cultural practices were used. To study the inheritance of resistance to chemical defoliants (hereafter, plants susceptible to chemical defoliation are referred to as defoliators, and plants resistant to chemical defoliation are referred to as nondefoliators), plants from each of the five nondefoliating lines were crossed reciprocally and with Coker 201, a known defoliator. At the same time flowers on plants of each of the five nondefoliating lines and Coker 201 were bagged to produce selfed (S_1) seed. In October, when about 60% of the bolls were open, the rows of nondefoliators and Coker 201 were sprayed with a chemical defoliant, S,S,S-tributyl phosphorotrithioate, commonly called Def[3], at the rate of 2.34 liters Def (32 oz/A) + 0.80 liters (11 oz/A) spreader-activator (X-77)[3] in 374.75 liters (40 gal/A) water per hectare. Plants were examined 10 days later and classified as defoliators or nondefoliators.

Progeny rows of the five nondefoliating lines segregated for defoliators, indicating that the lines were not homozygous for the nondefoliating characteristic. Coker 201 did not segregate; all plants were defoliators. Since most plants in the progeny rows had two or three bagged bolls, both defoliators and nondefoliators were selected within each of the five lines. Seed of each S_1 selection and each F_1 were planted in the spring of 1967 in plant-to-row progenies. Plants were thinned as in 1966. Flowers on plants of each progeny row were bagged to produce selfed (S_2) seed. In October all rows were sprayed with Def and X-77 at the same rate as in 1966. Progeny rows of selected S_1 nondefoliators did not segregate, but several nondefoliators were evident in progeny rows of the selected S_1 defoliators. Because of the segregation within the defoliating S_1 selections, F_1 progenies were not classified for the characteristic. Again, selections were made for defoliators and nondefoliators within each of the five lines. Selections were not made on progeny rows that had segregated. Seed of each S_2 selection were planted in the spring of 1968 in plant-to-row progenies. Plants were thinned as in 1967. Flowers on plants from each of the five families (each family consisted of defoliating and nondefoliating selections from the same line) were bagged to produce S_3 seed. In October all rows were sprayed with Def and X-77 as in 1967. Neither defoliating nor nondefoliating sister lines within families segregated. This lack of segregation indicated that the lines within each family were homozygous for either defoliators or nondefoliators.

In the spring of 1969 bulked S_3 seed of each line were planted in the field and plants were later thinned as in 1968. Flowers on plants from each of the five families (Table 1) were crossed reciprocally within families and between families. Coker 201 was not used in the crossing program because sister defoliating and nondefoliating lines had been created through selection. In October all progenies were sprayed with Def and X-77 as in 1968. Neither defoliating nor nondefoliating S_3 lines within families segregated. Therefore, F_1 seed originating from crosses between homozygous defoliating and nondefoliating lines along with remnant S_3 seed were sent to Iguala, Mexico, in November 1969, for the production of F_2 seed and seed of backcrosses to each recurrent parent.

In the spring of 1970 remnant S_3 and F_1 seed and seed of F_2's and BC_1's were planted in progeny rows in the field. Seed were spaced in the drill so that each plant had the opportunity for individual expression. Normal fertilization and cultural practices were used. In October, when about 65% of the bolls were open, the progenies were sprayed with Def and X-77 at the same rate used in previous years. Plants were examined 11 days after spraying and classified as defoliators or nondefoliators.

[3] Mention of trade names does not imply endorsement or preferential treatment of the product by the U. S. Department of Agriculture or the University of Georgia.

Table 1. Description of parents used in defoliation study. Experiment, Georgia, 1969-1970.

Family	Parent		Description	Origin
1	1	Nondefoliating	Atlas 63-255	J. G. Jenkins, Tifton, Ga.
	2	Defoliating	Atals 63-255	
2	3	Nondefoliating	Atlas 63-274	J. G. Jenkins, Tifton, Ga.
	4	Defoliating	Atlas 63-274	
3	5	Nondefoliating	Atlas 63-252	J. G. Jenkins, Tifton, Ga.
	6	Defoliating	Atlas 63-252	
4	7	Nondefoliating	Atlas 59-182	J. G. Jenkins, Tifton, Ga.
	8	Defoliating	Atlas 59-182	
5	9	Nondefoliating	FTA 266-72	D. C. Harrell, Florence, S. C.
	10	Defoliating	FTA 266-72	

RESULTS AND DISCUSSION

No reciprocal differences were evident among the F_1 progenies (Table 2). When nondefoliators were crossed with defoliators, the F_1 plants were uniformly defoliators with no intermediate phenotype. S_3 populations were uniformly defoliators (Fig. 1) or nondefoliators (Fig. 2) with no segregation within lines (Table 2). From the S_1, S_2, and F_1 data, we hypothesized that

Table 2. Segregation of defoliators and nondefoliators in S_3 and F_1 progenies in defoliation study. Experiment, Georgia, 1970.

Generation	Entry	Number of plants		
		Defoliator	Nondefoliator	Total
S_3	1 (ND)*	0	40	40
S_3	2 (D)	44	0	44
S_3	3 (ND)	0	44	44
S_3	4 (D)	44	0	44
S_3	5 (ND)	0	88	88
S_3	6 (D)	47	0	47
S_3	7 (ND)	0	48	48
S_3	8 (D)	50	0	50
S_3	9 (ND)	0	35	35
S_3	10 (D)	38	0	38
F_1	(ND × D)	1,116	0	1,116†
F_1	(D × ND)	624	0	624†
F_1	(D × D)	290	0	290†
F_1	(ND × ND)	0	188	188†

* ND = nondefoliator, D = defoliator. † Crosses within and between families combined.

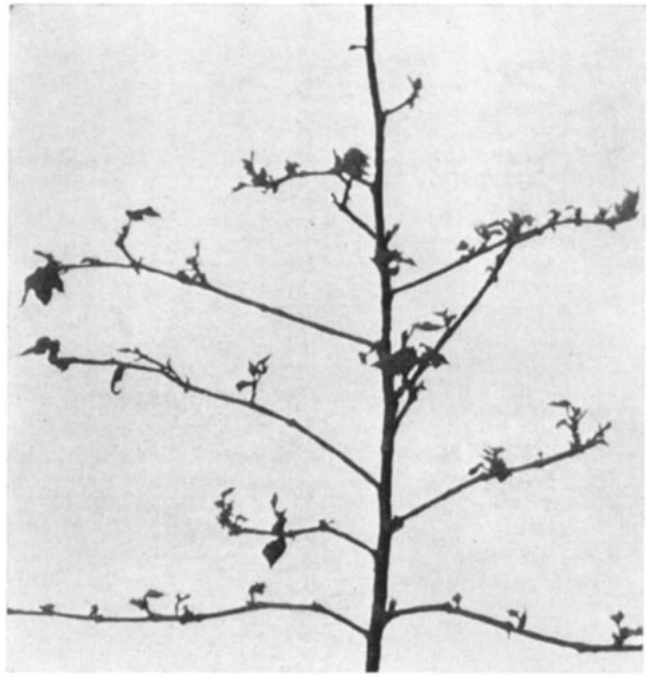

Fig. 1. A plant of the defoliator line of Atlas 63-274 cotton showing complete leaf fall 10 days after treatment with Def. (All fruit were removed by hand).

Fig. 2. A plant of the nondefoliator line of Atlas 63-274 cotton showing lack of leaf fall 10 days after treatment with Def. (All fruit were removed by hand).

segregation for nondefoliators was at a single locus and that homozygous recessive alleles produced the nondefoliator phenotype, while heterozygous and homozygous dominant alleles produced the defoliator phenotype.

Segregation was readily apparent in the F_2 populations, and plants were classified as either defoliators or nondefoliators with no intermediate types. Data from F_2 populations were tested for deviation from the 3:1 segregation of a single factor pair with complete dominance. The observed segregations did not deviate significantly from that expected for a single factor (Table 3), and there was no significant heterogeneity among or between families. The relatively large, but nonsignificant, chi-square obtained from the pooled F_2 data was due to an excess of nondefoliators. Only one F_2 population exhibited a chi-square value approaching or surpassing the magnitude of the pooled F_2 chi-square and, again, an excess of nondefoliators was responsible. In this instance the total number of individuals was small. F_2 populations of defoliator $\times$ defoliator and nondefoliator $\times$ nondefoliator (between families) were all defoliators or nondefoliators, respectively.

The five BC_1 families (crosses between sib lines within a family), in which the nondefoliator was the recurrent parent, segregated into defoliators and nondefoliators (Table 4). The segregation did not deviate significantly from the expected 1:1 segregation for a single factor pair. Likewise, BC_1 populations between families in which the nondefoliator was used as the recurrent parent segregated in a 1:1 ratio. The five BC_1 families (crosses between sib lines within a family) in which the defoliator was the recurrent parent were not expected to segregate if only one factor pair were involved in the expression of the characteristic (Table 4). Also, BC_1 populations between families in which the defoliator was used as the recurrent parent were not expected to segregate. The BC_1 data supported this hypothesis.

The observed F_2 and BC_1 data did not deviate significantly from theoretical ratios for monogenic inheritance of the characteristic. Results from F_2 and BC_1 data also indicated that the same gene was involved in the expression of the characteristic in each of the five parental lines. The symbol *df* is assigned to the gene in question. Two phenotypes were recognized in the F_2 in the ratio of 3 defoliators (*Df*-):1 nondefoliator (*dfdf*).

Table 3. Segregation of defoliators and nondefoliators in F_2 populations in defoliation study. Experiment, Georgia, 1970.

Entry	Number of plants: Defoliator	Nondefoliator	Total	χ^{2*}	P
1 × 2 (ND × D)†	123	40	163	.0184	.90-.80
3 × 4 (ND × D)	85	27	112	.0476	.90-.80
5 × 6 (ND × D)	150	52	202	.0593	.90-.80
7 × 8 (ND × D)	80	28	108	.0493	.90-.80
9 × 10 (ND × D)	164	54	218	.0060	.95-.90
1 × 4 (ND × D)	163	57	220	.0968	.80-.70
1 × 6 (ND × D)	60	24	84	.5713	.50-.30
1 × 8 (ND × D)	18	7	25	.1200	.80-.70
1 × 10 (ND × D)	92	31	123	.0026	.98-.95
2 × 3 (D × ND)	85	30	115	.0724	.80-.70
2 × 5 (D × ND)	92	28	120	.1777	.70-.50
2 × 7 (D × ND)	76	28	104	.2050	.70-.50
2 × 9 (D × ND)	77	25	102	.0130	.95-.90
3 × 6 (ND × D)	70	26	96	.2221	.70-.50
3 × 10 (ND × D)	70	24	94	.0141	.95-.90
4 × 5 (D × ND)	94	30	124	.0429	.90-.80
4 × 7 (D × ND)	99	32	131	.0228	.90-.80
5 × 8 (ND × D)	100	34	134	.0098	.95-.90
5 × 10 (ND × D)	100	36	136	.1568	.70-.50
6 × 7 (D × ND)	93	34	127	.2125	.70-.50
6 × 9 (D × ND)	69	24	93	.0321	.90-.80
7 × 10 (ND × D)	63	23	86	.1394	.80-.70
8 × 5 (D × ND)	72	24	96	.0000	1.00
8 × 9 (D × ND)	78	28	106	.1132	.80-.70
9 × 4 (ND × D)	83	27	110	.0120	.95-.90
9 × 6 (ND × D)	79	25	104	.0512	.90-.80
9 × 8 (ND × D)	101	35	136	.0392	.90-.80
Pooled F_2	2,432	837	3,269	.4046	.70-.50
Heterogeneity				2.1029	1.00-.99

* Chi-square values for deviations from an expected 3:1 ratio. † ND = nondefoliator, D = defoliator.

Table 4. Segregation of defoliators and nondefoliators in BC_1 progenies in defoliation study. Experiment, Georgia, 1970.

Entry	Number of plants: Defoliator	Nondefoliator	Total	χ^{2*}	P
Expected 1:1					
(1 × 2) × 1 (ND × D) × ND†	45	40	85	.2940	.70-.50
(3 × 4) × 3 (ND × D) × ND	41	43	84	.0476	.90-.80
(5 × 6) × 5 (ND × D) × ND	52	49	101	.0890	.80-.70
(7 × 8) × 7 (ND × D) × ND	49	50	99	.0100	.95-.90
(9 × 10) × 9 (ND × D) × ND	47	48	95	.0104	.95-.90
(1 × 4) × 1 (ND × D) × ND	35	37	72	.0554	.90-.80
(1 × 6) × 1 (ND × D) × ND	38	35	73	.1232	.80-.70
(2 × 3) × 3 (D × ND) × ND	29	31	60	.0666	.80-.70
(2 × 7) × 7 (D × ND) × ND	33	30	63	.1428	.80-.70
(3 × 8) × 3 (ND × D) × ND	28	31	59	.1524	.70-.50
(4 × 9) × 9 (D × ND) × ND	33	27	60	.6000	.50-.30
(5 × 10) × 5 (ND × D) × ND	35	39	74	.2162	.70-.50
(6 × 7) × 7 (D × ND) × ND	41	40	81	.0122	.95-.90
(7 × 10) × 7 (ND × D) × ND	39	35	74	.2162	.70-.50
(8 × 9) × 9 (D × ND) × ND	40	42	82	.0486	.90-.80
Pooled BC_1	585	577	1,162	.0550	.90-.80
Heterogeneity				2.0296	1.00-.99
No segregation expected					
(1 × 2) × 2 (ND × D) × D	86	0	86		
(3 × 4) × 4 (ND × D) × D	89	0	89		
(5 × 6) × 6 (ND × D) × D	94	0	94		
(7 × 8) × 8 (ND × D) × D	89	0	89		
(9 × 10) × 10 (ND × D) × D	92	0	92		
(1 × 4) × 4 (ND × D) × D	70	0	70		
(1 × 6) × 6 (ND × D) × D	64	0	64		
(2 × 3) × 2 (D × ND) × D	60	0	60		
(2 × 7) × 2 (D × ND) × D	58	0	58		
(3 × 8) × 8 (ND × D) × D	71	0	71		
(4 × 9) × 4 (D × ND) × D	74	0	74		
(5 × 10) × 10 (ND × D) × D	76	0	76		
(6 × 7) × 6 (D × ND) × D	70	0	70		
(7 × 10) × 10 (ND × D) × D	78	0	78		
(8 × 9) × 8 (D × ND) × D	81	0	81		

* Chi-square values for deviations from an expected 1:1 ratio. † ND = nondefoliator, D = defoliator.