Published November, 1976

Breeding Potentials of Noncultivated Cottons. III. Inheritance of Date of First Flower[1]

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ABSTRACT

Date of first flower was analyzed in parental, F_1, F_2, and backcross generations of two cultivars and three Texas race stocks of cotton (*Gossypium hirsutum* L.). The cultivar 'Deltapine 16' (DPL) differed from Texas 203 (T-203) by an additive component and from Texas 40Y (T-40Y) by an additive and an epistatic component. T-203 and T-40Y were similar phenotypically but showed slight genetic differences from one another in flowering response. Both differed from the third race stock, Texas 711 (T-711), by at least two genetic factors. DPL-16 differed from T-711 by more factors for flowering response than T-203 or T-40Y. The other cultivar, 'Stoneville 7A' (St 7A), seemed closely related phenotypically to DPL-16. However, the hybrid combination between the two revealed significant additive, dominance, and epistatic effects. St 7A differed genetically from T-40Y but not from T-203 for date of first flower. St 7A, like DPL-16, was quite different from T-711. Favorable F_1-midparent heterosis was exhibited by two of the 10 hybrid combinations, DPL-16 × T-711 and St 7A × T-711.

***Additional index words:* *Gossypium hirsutum* L., Additive variance, Dominance variance, Epistatic variances.**

MODERN cultivars of upland cotton (*Gossypium hirsutum* L.), are day-neutral in their flowering response. However, other strains and races of *G. hirsutum* vary from day-neutral to strictly photoperiodic (USDA, 1974). Therefore, cotton breeders must consider and adjust for those differences when they introduce germplasm from noncultivated cottons into cultivars.

Waddle et al. (1961) concluded that flowering response was under multigenic control and that the day-neutral reaction was partially dominant over short-day reaction in hybrids between an upland cultivar and two photoperiodic selections of *G. hirsutum* race *latifolium*. Kohel and Richmond (1962) reached a similar conclusion in a study of an upland cultivar crossed with another photoperiodic stock of race *latifolium*. Al-Rawi and Kohel (1969) found additive and dominance effects for days to first flower, as well as multiple allelism (and possibly correlated gene distributions), in a diallel among nine cultivars of cotton. They detected no significant epistasis.

In the first paper of this series (Wilson and Wilson, 1975), we presented data for flowering and other characteristics from a complete diallel set of two cultivars, three "day-neutral" Texas race stocks, and their F_1 hybrids. In the second one (Wilson and Wilson, 1976), we compared a qualitative with a quantitative genetic analysis of peduncle length in these cultivars and race stocks. In this paper, we present additional flowering-date results using a generation-mean analysis of parental, F_1, F_2, and backcross populations from the same cottons. The major objective of the study reported in this paper was to explore the ease of selecting for earlier flowering characteristics in these breeding stocks.

MATERIALS AND METHODS

Two race stocks, Texas 40Y (T-40Y) and Texas 203 (T-203), from Oaxaca and Chiapas, Mexico, respectively, represented race *latifolium*, as described by Hutchinson (1951). Both flowered 1 week later than the check cultivar, 'Deltapine 14', at College Station, Texas (USDA Agricultural Research Service, 1974). Texas 711 (T-711) also represented the race *latifolium* and it flowered three weeks later than the check. The two cultivars, 'Deltapine 16' (DPL-16) and 'Stoneville 7A' (St. 7A), are Delta-type cottons and are similar morphologically.

In 1973, we grew a complete diallel set of crosses (5 parents and 20 F_1 hybrids) in three randomized complete blocks at the Cotton Research Center, Arizona Agric. Exp. Stn., Phoenix (Wilson and Wilson, 1975). The study in 1974 consisted of 5 parents,

[1] Contribution from ARS-USDA, Phoenix, Ariz., in cooperation with the Arizona Agric. Exp. Stn. Received 1 May 1976.

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Table 1. Mean date of first flower (1 June = 152) in five cotton lines and their F_1, F_2, and backcross hybrids in 2 years.

Parent or hybrid	Flowering date*			
	1973 parental mean			1974 parental mean
DPL-16	164.4 cd			165.3 jk
St 7A	165.0 cd			172.5 c-g
T-40Y	168.2 bc			169.9 c-j
T-203	178.1 a			171.8 c-g
T-711	177.2 a			183.0 a
	1973	1974 mean		
	F_1	F_1	F_2	BC†
DPL-16 × St 7A	161.1 de	168.5 f-k	169.8 d-j	165.3 jk 167.8 f-k
× T-40Y	163.6 c-e	169.0 f-k	167.6 f-k	165.5 jk 170.0 c-j
× T-203	158.9 e	166.9 g-k	169.7 d-j	167.3 g-k 170.2 c-j
× T-711	161.9 de	163.7 k	171.8 c-g	164.9 jk 168.3 f-k
St 7A × T-40Y	163.6 c-e	166.9 h-k	169.9 c-j	170.0 c-j 167.7 f-k
× T-203	162.7 de	168.5 f-k	170.0 c-j	168.7 f-k 169.4 e-j
× T-711	163.2 de	167.9 f-k	171.0 c-h	168.1 f-k 167.7 f-k
T-40Y × T-203	164.4 cd	172.7 c-f	170.3 c-j	170.3 c-j 171.9 c-g
× T-711	168.7 bc	172.8 c-f	169.6 d-j	175.0 bc 171.5 c-h
T-203 × T-711	172.8 ab	174.6 b-e	174.2 b-e	178.5 ab 168.9 f-k

* Means within year followed by the same letter were not significantly different at the 0.05 probability level, according to the FLSD test (L.S.D. 0.05 = 5.37, 1973; 5.29, 1974). † First mean within a hybrid combination specifies F_1 × original pistillate parent, second mean specifies F_1 × original staminate parent.

10 F_1 hybrids (reciprocals not included), 10 F_2 hybrids, and 20 backcross hybrids grown in four randomized complete blocks at the Arizona State University Farm Laboratory, Tempe.

In 1973, each single-row plot contained 20 transplants, spaced 46 cm apart, that had been started earlier in expanded peat pellets in a greenhouse 27 March (day 86). Plots were spaced 1 m apart. Each block contained one row of each parent and each F_1. In 1974, each single-row plot contained 25 transplants, spaced 30 cm apart, which had been planted originally on 25 March (day 84). Plots were again spaced 1 m apart. Each block contained one row of each parent and F_1, four rows of each F_2, and two rows of each backcross combination.

Date of first flower was recorded for each plant as the Julian date (1 June = 152). The half-diallel analysis of Jones (1965) was used to compare parental and F_1 data in 1973 and 1974. The generation-mean analysis of Mather and Jinks (1971) was used to estimate genetic effects from the 1974 data.

RESULTS

Table 1 presents mean data on the date of first flower for parents and hybrid combinations in 1973 and 1974. In 1973, the two cultivars and T-40Y did not differ significantly, but all three flowered significantly earlier than T-203 and T-711. In 1974, however, St 7A flowered a week later and T-203 flowered a week earlier than in the previous year. Thus, the two entries were not significantly different from each other or from T-40Y. DPL-16 was significantly earlier than all the other parents except T-40Y, whereas T-711 was significantly later than all the others.

In 1973, all F_1 hybrids flowered earlier than T-203 and T-711 except for the cross between those two entries. Six of the 10 hybrids exhibited significant F_1-midparent heterosis for earlier flowering as follows: DPL-16 × T-203 (also significantly earlier than DPL-16), DPL-16 × T-711, St 7A × T-203, St 7A × T-711, T-40Y × T-203, and T-203 × T-711. In 1974, every F_1 flowered earlier than T-711, but only three of the 10 showed significant heterosis for early flowering, and none flowered significantly earlier than DPL-16. Only two hybrids, DPL-16 × T-711 and St 7A × T-711, demonstrated significant heterosis for early flowering in both years.

Table 2. Mean squares from half diallel analyses for date of first flower in five cotton lines and their F_1 hybrids in 2 years.

Source	1973		1974	
	df	MS	df	MS
Replicates	2	4.20	3	43.37
Entries	14	98.07**	14	86.57**
a†	4	180.11**	4	160.45**
b_1	1	422.37**	1	170.08**
b_2	4	20.60	4	33.84
b_3	5	29.57*	5	52.94*
Error	28	10.15	42	19.29

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.
† a = additive effects; b_1 = mean deviation from additivity; b_2 = consistency of nonadditive deviations among hybrid arrays; b_3 = deviation from additivity unique to each F_1.

Only one F_2 flowered significantly later than its F_1, DPL-16 × T-711. One backcross mean was significantly earlier than its F_1 (T-203 × T-711) × T-711; otherwise, backcross means were not significantly different from their corresponding F_1's.

Results from the half diallel analyses of parents and F_1's for 1973 and 1974 were similar (Table 2), except that mean deviation from additivity (b_1) contributed a substantially higher proportion of the genetic variance in 1973 than in 1974. In both years, additive effects (a) were significant, a result that does not agree with the previous analysis of the complete diallel in 1973 (Wilson and Wilson, 1975).

Table 3 presents results from the generation-mean analyses. Additive effects (d) were significant in eight of the 10 combinations, dominance (h) in four, homozygous × homozygous epistasis (i) in four, heterozygous × heterozygous epistasis (l) in three, and homozygous × heterozygous epistasis (j) in five. Two hybrid combinations, DPL-16 × T-711 and St 7A × T-711, exhibited significant effects for all three types of epistasis, as well as for additive and dominance effects.

DISCUSSION

The cultivar DPL-16 differed from T-203 only by additive effects but from T-40Y by an additive and an epistatic component. These results indicated that the two race stocks were not identical in their flowering response, even though no significant genetic effects were shown for T-40Y × T-203. Additional evidence for a difference between the two stocks is indicated in Table 1 in the 1973 data. Crosses of T-40Y and T-203 with T-711 also indicated that the former two differed genetically, because additive, dominance, and two of three epistatic effects were significant for T-40Y × T-711, whereas only the additive and one epistatic effect were significant for T-203 × T-711.

Table 3. Estimates of genetic effects from analyses of flowering-date generation means for 10 cotton hybrids in 1974.

	Genetic effects ± SE				
			Epistasis		
Combination	Additive [d]	Dominance [h]	Homozygous X homozygous [i]	Homozygous X heterozygous [j]	Heterozygous X heterozygous [l]
DPL-16 X St 7A	3.58 ±0.49*	-34.60 ± 5.83*	-12.86 ±2.49*	-2.27 ±1.51	21.37 ±3.43*
X T-40Y	2.30 ±0.48*	-0.15 ± 7.38	0.38 ±2.97	4.33 ±2.05*	1.95 ±4.71
X T-203	3.23 ±0.69*	-5.92 ± 9.04	-4.44 ±3.60	-0.71 ±2.63	0.29 ±5.66
X T-711	8.87 ±0.89*	-61.36 ± 7.85*	-20.72 ±4.15*	-10.87 ±2.94*	30.17 ±6.13*
St 7A X T-40Y	1.43 ±0.53*	-12.45 ± 7.86	-3.96 ±3.11	1.86 ±2.26	5.04 ±4.98
X T-203	0.35 ±0.52	-16.17 ± 9.51	-3.72 ±4.04	-2.26 ±2.45	8.82 ±5.77
X T-711	5.29 ±0.92*	-54.37 ± 8.64*	-12.40 ±3.42*	-11.30 ±2.70*	32.10 ±5.42*
T-40Y X T-203	0.93 ±0.72	5.38 ±12.80	3.16 ±5.09	1.38 ±3.62	-2.32 ±7.88
X T-711	6.72 ±0.91*	20.25 ± 8.68*	14.50 ±2.88*	-20.58 ±3.17*	-9.34 ±5.98
T-203 X T-711	5.64 ±1.04*	-17.87 ±10.97	-2.00 ±4.55	-30.64 ±3.11*	11.30 ±6.77

* Significantly different from zero at the 0.05 probability level, according to t-test.

DPL-16 probably differed from T-711 by more factors than did T-40Y or T-203, because all five genetic effects were significant for that combination, including large dominance and epistatic components.

The other cultivar, St 7A, differed from T-40Y only by a relatively small additive effect. However, no genetic effects were significant in St 7A × T-203, suggesting that all three cottons were closely related in flowering response. The significant difference between St 7A and T-203 in 1973 (Table 1), however, implies that the two are not identical.

DPL-16 × T-711 and St 7A × T-711 behaved similarly in that all the genetic effects were significant and of the same approximate magnitude. The difference in sign of (h) and (l) in both crosses indicated a predominantly duplicate type of epistasis (Mather and Jinks, 1971). When the two cultivars were crossed with each other, results indicated that they differed by at least two pairs of genes, because two epistatic effects were significant. In 1974, St 7A flowered one week later than DPL-16, but in 1973 both cultivars flowered essentially on the same day (Table 1). Results from other experiments at Phoenix and Tempe, 1973 to 1975, suggested that these two cultivars did not differ markedly in their flowering response, although St 7A usually flowered slightly later than DPL-16. For example, in 1974 St 7A flowered 3.1 and 2.3 days later than DPL-16 at Phoenix and Tempe, respectively. Neither difference was statistically significant. One possible explanation is that DPL-16 and St 7A do not differ as markedly as indicated by the generation-mean analysis. An alternative explanation is that different combinations of genes in the two cultivars provide a similar phenotypic response.

Conflicting results in the various year-cultivar combinations are disturbing but not surprising. An apparently simple character such as first-flowering date is in fact complex, because each genotype-environmental combination provides the opportunity for a different set of factors to operate. Each of the five cottons in this study is genetically unique for flowering response, even though some differences are subtle (e.g., between T-40Y and T-203) while others are striking (e.g., between DPL-16 and T-711).

The significant additive effects in crosses, combined with the lack of dominance and most epistatic effects, in two of the three DPL-16 × race stock combinations suggest that selection for earlier flowering should be effective. Selection in the hybrids between St 7A and these race stocks may not be as effective because of the limited amount of genetic variability. Selection for earlier flowering in DPL-16 × T-711 and St 7A × T-711 will probably be difficult, in spite of significant additive effects, because of the substantial dominance and epistatic effects in those crosses.

Heterosis for earlier flowering occurred in 20% of the possible combinations in both years. This proportion is higher than proportions observed for other characters previously measured in these hybrids. For example, favorable heterosis was detected in 10 other characters for only five of 100 possible hybrid-character combinations (Wilson and Wilson, 1975).

ACKNOWLEDGMENTS

Thanks are extended to C. W. Fitzgibbons and J. S. Byrd for maintaining field plots and to Benny Stapp, J. N. Smith, and R. R. Remington for field and laboratory assistance.

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