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Breeding Potentials of Noncultivated Cottons. IV. Location and Parental Effects on Agronomic Characters and Fiber Properties in Hybrids[1]

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ABSTRACT

We studied the inheritance of six agronomic characters and five fiber properties in F_1 hybrids between two cultivars and eight primitive race stocks of cotton, *Gossypium hirsutum* L., in 1975 and between the same two cultivars and four other race stocks in 1976. Plants were grown at Phoenix, Ariz., where insecticides were applied as needed for control of pink bollworm, *Pectinophora gossypiella* (Saunders), and at Tempe, Ariz., where no insecticides were applied. Location effects were significant for most characters both years. Location × race-stock interactions were also significant for several characters. Usually, however, hybrid arrays that ranked first at one location also ranked first or second at the other location, thus suggesting that inconsistencies in performance occurred in other arrays. The Tempe location, therefore, was usually as suitable as the Phoenix location, revealing superior hybrid performance in spite of heavy pink bollworm pressure. One exception was bolls/plant in 1976, where the highest ranked array at Phoenix was the lowest ranked array at Tempe. Genetic variability in hybrids was attributed mostly to differences in race stocks, but cultivars contributed variability in a few characters. In 1975, significant race-stock effects coupled with the absence of cultivar × race-stock interactions indicated the presence of adequate amounts of additive genetic variability. In 1976, however, five of 11 characters showed significant cultivar × race-stock interactions, indicating that these race stocks may be more refractory. Individual heterotic combinations also indicated the presence of nonadditive genetic variability. F_1 vs. parental cultivar "favorable" heterosis was shown in a number of combinations but did not consistently appear in the same combinations at both locations.

Additional index words: Gossypium hirsutum L., *Pectinophora gossypiella* (Saunders), Pink bollworm, Host-plant resistance, Additive genetic variability, Nonadditive genetic variability, Heterosis, Genotype × environment interactions.

To find antibiosis in cotton, *Gossypium hirsutum* L., to pink bollworm, *Pectinophora gossypiella* (Saunders) we screened over 300 primitive strains (Texas race stocks) via diet bioassays (8). F_1 hybrids between race stocks selected from the diet tests and two cultivars, and their day-neutral parents, were screened for field response to the insect (one set of hybrids and parents in 1975 and another in 1976) at Tempe, Ariz. We earlier (7) reported the variation in plant response to insect infestations and the interactions of this response with agronomic characters.

In this paper, we report the results of tests in which these hybrids and parents were evaluated for agronomic characters and fiber properties at two locations, Tempe and Phoenix, Ariz. Our objectives were to determine 1) the relative performance of hybrids and parents at locations where insects were and were not controlled, 2) the field performance and fiber properties of race stocks that also showed pink bollworm resistance, 3) whether any race stocks were equal to or superior to the cultivars in the characters measured, 4) the relative amounts of usable genetic variability in the race stocks and cultivars, and 5) the magnitude and direction of heterosis in F_1 hybrids between divergent parents.

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Table 1. Means for locations and cotton cultivars, and ranges of eight Texas race-stock × cultivar F_1 hybrid-array means for six agronomic characters and five fiber properties, 1975.

Character	Location mean		Cultivar mean $\left(\frac{\bar{X}\,DPL\text{-}16+\bar{X}\,St\,7A}{2}\right)$		Race-stock hybrid arrays† Range of means	
	Phoenix	Tempe	Phoenix	Tempe	Phoenix	Tempe
Days to flower	88.8	88.7	79.8	80.5	81.4–103.5	82.0–103.7
Plant height, cm	152.7	133.2	86.2	71.9	88.2–205.0	77.5–193.4
Bolls/plant	24.2	19.2	32.0	19.3	1.5– 47.5	2.8– 35.4
Boll size, g	4.5	4.0	4.8	4.1	2.4– 6.0	2.4– 5.2
Lint percentage	32.3	34.0	37.4	39.5	27.2– 36.1	27.1– 38.4
Seed index, g	10.1	10.2	10.2	10.0	8.0– 11.8	7.8– 12.4
2.5% Fiber span length, mm	26.7	25.8	27.9	27.7	24.6– 28.3	24.8– 28.0
50% Fiber span length, mm	13.5	13.8	13.4	14.2	11.8– 14.7	12.8– 15.1
T_1 Fiber strength, mN/tex	214.8	212.9	203.6	196.8	197.2–238.4	190.3–230.5
E_1 Fiber elongation, %	6.4	4.4	6.9	4.0	5.9– 7.3	3.3– 6.4
Micronaire	4.5	4.4	4.7	4.3	3.3– 5.3	3.4– 5.2

† Hybrid array data are means of the following race stocks crossed with DPL-16 and St 7A: T-39, T-53, T-65, T-72, T-78, T-101, T-181, and T-216.

Table 2. Means for locations and cotton cultivars, and ranges of four Texas race-stock × cultivar F_1 hybrid-array means for six agronomic characters and five fiber properties, 1976.

Character	Location mean		Cultivar mean $\left(\frac{\bar{X}\,DPL\text{-}16+\bar{X}\,St\,7A}{2}\right)$		Race-stock hybrid arrays† Range of means	
	Phoenix	Tempe	Phoenix	Tempe	Phoenix	Tempe
Days to flower	77.9	79.1	79.3	80.3	75.2– 82.1	77.5– 81.2
Plant height, cm	116.5	96.1	80.2	67.8	74.3–182.7	75.9–128.2
Bolls/plant	30.8	31.3	35.6	24.1	27.9– 37.2	26.5– 43.8
Boll size, g	5.3	3.3	4.8	3.2	4.9– 5.5	2.9– 3.7
Lint percentage	30.4	34.2	32.9	35.9	28.7– 32.9	33.0– 35.1
Seed index, g	12.4	10.4	11.1	9.5	11.8– 12.8	9.7– 11.2
2.5% Fiber span length, mm	26.1	24.7	29.5	28.1	25.4– 27.1	23.6– 26.3
50% Fiber span length, mm	14.1	12.7	14.6	13.5	13.8– 14.5	12.3– 13.0
T_1 Fiber strength, mN/tex	223.9	207.7	203.1	202.4	212.9–239.9	188.1–227.6
E_1 Fiber elongation, %	5.5	6.1	6.1	6.6	4.7– 5.9	5.2– 6.5
Micronaire	5.3	4.3	4.4	3.5	4.7– 5.7	3.7– 4.9

† Hybrid array data are means of the following race stocks crossed with DPL-16 and St 7A: T-31, T-40, T-55, and T-203.

MATERIALS AND METHODS

On 31 Mar. 1975, we planted seeds of two cultivars, 'Deltapine 16' (DPL-16) and 'Stoneville 7A' (St 7A), seven Texas (T) race stocks (T-39, T-53, T-65, T-72, T-78, T-101, and T-181), and 16 race-stock × cultivar F_1 hybrids (T-216 was represented by hybrids but was not itself planted). These seeds were planted in expanded peat pellets in the greenhouse of the Western Cotton Research Laboratory at Phoenix, Ariz.

We transplanted seedlings of all entries to our breeding nursery at the Univ. of Arizona Cotton Research Center, Phoenix, on 16 Apr. 1975. Seedlings were spaced 36 cm apart in single-row plots, 20 seedlings/plot, in two randomized complete blocks. Rows were spaced 1.0 m apart. The standard cultural practices that were followed included the application of insecticides as determined by monitoring insect populations.

We also transplanted seedlings of the two cultivars, three race stocks that were similar in maturity characteristics to the cultivars (T-39, T-72, and T-101), and the same 16 F_1 hybrids to field plots at the Arizona State Univ. Farm Laboratory, Tempe, on 17 Apr. 1975 in five randomized complete blocks. Plant and row spacing were the same as at Phoenix. No insecticides were applied because plots were later to be sampled to determine insect damage.

The two locations are in the Salt River Valley, about 11 km apart. At Phoenix, the soil type is Avondale clay loam and at Tempe, the soil type is Contine clay loam. Cotton is the primary crop at the Phoenix location and is carefully cultivated, receiving timely applications of fertilizer, herbicides, insecticides, and water. At the Tempe location, alfalfa, *Medicago sativa* L., and other forages constitute the major crops and cotton is less intensively cultivated. In our judgment, however, the major environmental difference was the carefully monitored insect-control program at Phoenix and the deliberate lack of insect control at Tempe (no insecticides have been used at Tempe for cotton insect control since 1972).

On 24 Mar. 1976, we planted seeds of the same two cultivars, four race stocks (T-31, T-40, T-55, and T-203), and the eight cultivar × race-stock F_1 hybrids in the greenhouse at Phoenix. On 31 Mar. 1976, we planted another set of the same entries. We transplanted seedlings to our breeding nursery at Phoenix on 8 Apr. 1976 and to the field at Tempe on 19 Apr. 1976. Plots were the same size as in 1975. The only difference was that, in 1976, rows of parents and hybrids at Tempe were interplanted with guard rows of DPL-16 to minimize interplot competition for insect sampling. This design also allowed us to harvest the plots for yield.

Individual plant data obtained were days to first flower, plant height, and total bolls/plant. In 1975, height and boll-count data were obtained at Phoenix 1 Oct. (184 days after planting) and at Tempe 4 Nov. (218 days after planting). In 1976, height and boll-count data were obtained at Phoenix 1 Sept. (161 days after planting) and at Tempe 26 Aug. (148 days after planting).

Plot data obtained are shown in the tables. Fiber properties were determined at the USDA Fiber Testing Laboratory at Phoenix. At Phoenix, these data were obtained from 50-boll samples harvested from each plot 26 Aug. 1975 and 1 Sept. 1976. At Tempe, data were obtained from all available seedcotton harvested from each plot 15 Sept. 1975 and 24 Aug. 1976. Samples were comparable [i.e., "selective samples" (4)] because both the 50-boll samples at Phoenix and the boll samples at Tempe were harvested from the midportion of the plants (at Tempe, the earliest bolls had been harvested 2 weeks earlier in the first of our sequential picks to estimate pink bollworm damage).

We analyzed mean data separately at each location for all entries (parents and hybrids) and determined that entry differences were significant for all characters. We then performed a combined analysis of variance for the 16 F_1 hybrids common to both locations in 1975 and the eight hybrids common to both locations in 1976. For the combined analysis, we arbitrarily chose the first two of the five replications at Tempe. Means were compared using a "restricted" L.S.D. test (2). We subdivided the hybrids sum of squares into effects attributable to

Table 3. Mean squares from the combined analyses of variance of six agronomic characters in cotton hybrids.

	df		Days to flower		Plant height†		Bolls/plant‡		Boll size		Lint percentage		Seed index	
Source	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Location (L)	1	1	0.2	10.4	61.1*	34.7**	60.3**	0.4	3.00**	3.13**	47.5**	117.2**	0.01	30.05**
Hybrids (H)	15	7	214.1**	21.4**	73.6**	48.9**	88.4**	7.3*	4.13**	0.45	48.9**	5.0**	9.51**	1.34**
L × H	15	7	15.2	4.4	4.0	5.8**	12.9	11.5**	0.43*	0.14	2.1	3.4*	0.61	0.22
Replications/L	2	2	92.2*	0.1	10.6	0.2	2.8	2.6	0.31	0.39	5.6*	1.3	0.18	1.68*
Cultivars (C)	1	1	0.8	0.5	3.7	1.9	7.8	12.5*	0.01	0.51	6.7*	0.2	1.15	0.97
L × C	1	1	8.3	1.1	2.3	0.1	0.6	1.0	0.82	0.04	0.5	0.2	2.30*	0.18
Race stocks (R)	7	3	436.4**	41.1**	156.6**	113.1**	173.7**	12.1*	8.63**	0.65	101.6*	10.0**	19.74**	1.68**
L × R	7	3	17.7	4.9	7.3	13.0**	25.6**	26.1**	0.66*	0.24	2.5	7.6**	0.23	0.33
C × R	7	3	22.2	8.7	0.5	0.4	14.7	8.2*	0.22	0.23	2.2	1.5	0.48	1.11*
L × C × R	7	3	13.7	5.0	1.0	0.5	2.0	0.3	0.15	0.08	1.9	0.3	0.75	0.12
Error	30	14	20.4	2.6	11.8	0.9	6.8	2.4	0.22	0.64	1.3	1.1	0.36	0.28

*,** Significant at the 0.05 and 0.01 levels of probability, respectively. † Mean squares/100. ‡ Mean squares/10.

Table 4. Mean squares from the combined analyses of variance of five fiber properties in cotton hybrids.

	df		Fiber span length, 2.5%		Fiber span length, 50%		T_1 fiber strength		E_1 fiber elongation		Micronaire	
Source	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976	1975	1976
Location (L)	1	1	13.55**	15.68**	0.84*	16.25**	0.87	21.78**	62.01**	3.25**	0.04	7.43**
Hybrids (H)	15	7	4.39**	3.94**	2.56**	0.33	7.65**	9.44**	3.07**	3.92**	1.96**	0.85**
L × H	15	7	1.16**	0.90*	0.93**	0.16	1.16	0.50	0.43*	0.05	0.24*	0.04
Replications/L	2	2	0.45	0.45	0.01	0.09	1.79	0.04	1.31**	0.10	0.02	0.01
Cultivars (C)	1	1	0.32	0.71	0.06	0.28	2.76	0.18	14.63**	14.85**	0.39	0.10
L × C	1	1	0.06	0.13	0.03	0.02	1.97	0.10	0.18	0.02	0.92**	0.07
Race stocks (R)	7	3	8.65**	8.77**	5.06**	0.35	14.87**	18.07**	4.39**	2.65**	3.92**	1.74**
L × R	7	3	2.00**	1.16*	1.61**	0.16	1.59	0.69	0.75**	0.07	0.32*	0.04
C × R	7	3	0.65	0.10	0.43	0.33	1.13	3.90**	0.10	1.54**	0.23	0.20**
L × C × R	7	3	0.45	0.84	0.38	0.21	0.61	0.45	0.15	0.04	0.06	0.03
Error	30	14	0.39	0.26	0.21	0.19	0.70	0.63	0.16	0.04	0.11	0.02

*,** Significant at the 0.05 and 0.01 levels of probability, respectively.

race stocks, cultivars, and their interactions. Race-stock and cultivar variances include additive and various additive × additive sources of genetic variation whereas interaction variances include nonadditive variation (1). We also subdivided the location × hybrid (L × H) sums of squares into location × race stocks (L × R), location × cultivars (L × C), and the second-order interaction effects.

Deviations of F_1 from the midparent (MP) were calculated for all 11 characters in each hybrid combination that was represented by both parents. Significant heterotic effects were indicated by deviations as large as, or larger than, L.S.D.$_{0.05}$. We designated heterosis as "favorable" or "unfavorable", depending upon our subjective judgment of the agronomic superiority or inferiority of the direction of deviation of a specific character ("favorable" direction: *days to flower*, fewer; *plant height*, shorter; *bolls/plant*, more; *boll size*, larger; *lint percentage*, higher; *seed index*, smaller; *2.5% and 50% fiber span length*, longer; *T_1 fiber strength*, higher; *E_1 fiber elongation*, higher; *micronaire*, not specified because some race stocks had finer fiber and some had coarser fiber than the acceptable level of the cultivars). We also calculated deviations from the cultivar parent for four of the six agronomic characters (plant height and seed index were omitted because we believe that F_1 vs. cultivar heterosis would confer no obvious agronomic advantages) and four of five fiber properties (micronaire omitted).

RESULTS

Means for location, of both cultivars, and ranges of means for the race-stock hybrid arrays are presented in Table 1 for 1975 and in Table 2 for 1976. Individual parental means are not shown. The cultivars differed significantly from each other only in fiber elongation. DPL-16 had higher values than St 7A, a relationship reported earlier (5, 6). The race stocks differed from each other and/or from the cultivars in every character measured. In 1975, T-101 compared favorably with the cultivars except for its lower lint percentage than both DPL-16 and St 7A and its lower fiber elongation than DPL-16. Texas 39 had larger bolls, T-53 had more bolls/plant, and T-72 had higher T_1 fiber strength than the cultivars. Judging from hybrid performance, T-78 had an unusual combination of strong, fine lint (e.g., T-78 × DPL-16: T_1 = 234.7; micronaire = 3.66; DPL-16: T_1 = 211.7; micronaire = 4.50). In 1976, T-40 compared favorably with the cultivars except for lint percentage, fiber length, and fiber elongation. Texas 31 was earlier flowering and had finer fiber than the cultivars. Most of the race stocks, however, were generally inferior to the cultivars.

Hybrid data in Tables 1 and 2 are presented as race-stock arrays because hybrids from a given race stock with the two cultivars usually behaved similarly. Hybrid-array means can be compared directly with cultivar means as presented because the former are means of hybrids, ranked highest and lowest, from race stocks crossed with the two cultivars, and the latter are means of the two cultivars. The best of the hybrid-array means were at least equal to those of the cultivars for every character except perhaps fiber length in 1976.

The combined analyses of variance of the 16 hybrids in 1975 and the eight in 1976 (Tables 3 and 4) showed significant differences between locations for seven of the 11 characters in 1975 and for nine of 11 in 1976. There were no significant location differences either year for days to flower. In 1975, plants were unexpectedly taller and had more bolls at Phoenix than at Tempe in spite of the fact that data were obtained later at the latter location. In 1976, plants were expectedly taller at Phoenix because data were obtained later at that location, but had no more bolls/plant.

Differences between hybrids were significant for every hybrid/year combination except for boll size and

50% fiber span length in 1976. Subdivision of the hybrid sums of squares showed a significant cultivar effect in only three instances, as follows: St 7A hybrids had higher lint percentages in 1975 and more bolls/plant in 1976 than DPL-16 hybrids, and DPL-16 hybrids had higher E_1 fiber elongation both years. The race-stock effect was significant for every character at both locations in 1975 and 1976, except for boll size and 50% fiber span length in the latter year.

Location × hybrid interaction effects (L × H) in 1975 were significant for boll size, 2.5% and 50% fiber span length, fiber elongation, and micronaire. Subdivision of L × H revealed significant location × race-stock effects (L × R) in every instance. The 1975 analysis also showed a significant location × cultivar effect (L × C) for seed index (even though L × H was not significant), and for micronaire. In 1976, L × H was significant for plant height, bolls/plant, lint percentage, and 2.5% fiber span length. Subdivision of L × H revealed significant L × R for all four characters.

Table 5. Seedcotton and lint yields, and percentages of seedcotton harvested at 2-week intervals; Tempe, Ariz., 1976.

Hybrid or parent	Cumulative percentage of total seedcotton at harvest 1	2	3	Total seedcotton yield	Lint yield
	%			kg/ha	
DPL-16 × T-31	30.2	53.6	87.8	1,818	622
DPL-16 × T-40	21.3	49.8	90.2	2,198	777
DPL-16 × T-55	19.0	42.1	84.0	1,466	495
DPL-16 × T-203	17.4	37.9	79.3	1,324	546
St 7A × T-31	22.8	51.4	87.4	2,025	702
St 7A × T-40	22.4	54.6	87.8	1,971	691
St 7A × T-55	19.9	38.9	87.1	1,396	459
St 7A × T-203	15.1	33.4	73.0	1,509	526
DPL-16	19.1	47.7	89.4	1,714	612
St 7A	13.9	39.6	87.6	1,731	626
T-31	19.7	40.6	80.4	1,034	332
T-40	14.7	42.9	85.6	1,521	480
T-55	16.4	30.9	77.8	377	88
T-203	13.1	38.7	71.2	111	26
L.S.D.$_{0.05}$	6.6	10.1	9.0	361	129

Table 6. Mean squares from analyses of seedcotton and lint yields; Tempe, Ariz., 1976.

Source	df	Cumulative percentage of total seedcotton at harvest no. 1	2	3	Total seedcotton yield†	Total lint yield†
Replications	4	63.0	17.8	30.0	453.0	66.5
Hybrids	7	102.1**	329.4**	162.8**	2,569.8**	372.1**
Cultivars (C)	1	36.0	17.0	22.9	102.0	13.3
Race stocks (R)	3	187.1**	718.5**	334.0**	5,486.7**	793.1**
C × R	3	39.0	44.4	38.2	475.4	70.6
Error	28	30.3	66.5	37.8	623.8	85.8

** Significant at the 0.01 level of probability. † g/plot/100.

The cultivar × race-stock effect (C × R) was not significant for any character in 1975 but was significant for bolls/plant, seed index, T_1 fiber strength, E_1 fiber elongation, and micronaire in 1976.

At Tempe in 1976, percentages of total seedcotton picked at first harvest were not significantly different among the race stocks and cultivars, but one hybrid, DPL-16 × T-31, was significantly earlier than any other entry. Cultivars did not differ significantly in cumulative percentages of seedcotton picked at second and third harvests, but certain race stocks and hybrids differed from each other and from the cultivars. Total seedcotton yields were significantly higher in the cultivars than in the race stocks except for T-40. Lint yields were higher in the cultivars than in any of the race stocks. One F_1 hybrid, DPL-16 × T-40, significantly outyielded both cultivars in both seedcotton and lint (Table 5).

Differences among hybrids in earliness (cumulative percentages of seedcotton picked at first, second, and third harvests) and yield were caused by differences among race stocks (R). Neither cultivar (C) nor C × R interactions were significant (Table 6).

For the six agronomic characters in 1975, "favorable" F_1 vs. MP heterosis was shown only in a small percentage of the combinations at Phoenix and in none of those at Tempe. In 1976, however, "favorable" F_1 vs. MP heterosis was shown in more than one-fourth of the combinations at Phoenix and in one-sixth of those at Tempe. F_1 means differed from parental cultivar means in a favorable direction in 5 to 8% of the combinations in 1975 and in 16 to 19% of the combinations in 1976 (Table 7).

At Tempe in 1976, F_1 vs. MP heterosis for earliness varied from 25.0% of the eight hybrid combinations at first harvest to 0.0% at third harvest. F_1 vs. MP heterosis for seedcotton and lint yield was 75.0% and 87.5%, respectively, of those combinations. F_1 vs. parent cultivar heterosis in a favorable direction for earliness varied from 37.5% at first harvest to 0.0% at third harvest. F_1 vs. parent cultivar heterosis for seedcotton and lint yield was 12.5% of the eight combinations (DPL-16 × T-40).

For fiber properties in 1975, "favorable" F_1 vs. MP heterosis was shown in almost half of the combinations at Phoenix but in none at Tempe. In 1976, however,

Table 7. Mean percentages of heterotic combinations for six agronomic characters and five fiber properties.

Category	Year	Location	Heterotic combinations: F_1 vs. midparent, Favorable	F_1 vs. midparent, Unfavorable	F_1 vs. cultivar, Favorable	F_1 vs. cultivar, Unfavorable
			%			
Agronomic characters	1975	Phoenix	3.6	14.3	4.7	48.4
		Tempe	0.0	8.3	7.8	42.2
	1976	Phoenix	29.2	10.4	15.6	9.4
		Tempe	16.7	8.3	18.8	6.3
Fiber properties	1975	Phoenix	47.2	0.0	25.0	25.0
		Tempe	0.0	0.0	14.1	29.7
	1976	Phoenix	31.3	6.3	15.6	46.9
		Tempe	37.5	16.7	9.4	62.5

about a third of the combinations showed F_1 vs. MP heterosis at both locations. F_1 vs. parental cultivar "favorable" heterosis was shown for one-fourth of the combinations in 1975 and in one-sixth in 1976 at Phoenix, and in lower proportions at Tempe both years (Table 7).

DISCUSSION

Significant location effects for seven of the 11 characters in 1975 and for nine of 11 in 1976 show that the hybrids responded differently in the lightly insect-infested environment at Phoenix and in the heavily infested environment at Tempe. Perhaps of more importance, however, are the results of subdividing the L $\times$ H variances. L $\times$ C was significant only for seed index in 1975. L $\times$ R, on the other hand, was significant for six characters in 1975 and for four characters in 1976. Careful examination of our data revealed that the race-stock array that ranked first at one location usually ranked first or second at the other location. Therefore, L $\times$ R interactions were usually caused by inconsistencies in arrays that did not perform well at either location. This result suggests that the Tempe location, in spite of plant damage by pink bollworm, was suitable for revealing superior hybrid performance.

An exception was the L $\times$ R interaction for bolls/plant in 1976, where the T-55 array ranked first at Phoenix and last at Tempe. Bolls/plant (or bolls/unit area) is probably the most important single component of lint yield (9). If the interaction that we observed in F_1 is carried over into segregating generations, selection for bolls/plant would yield different products at the two locations.

The genetic variability among the hybrids is attributed largely to differences among the race stocks, although cultivars contributed to genetic differences in bolls/plant in 1976, to lint percentages in 1975, and to E_1 fiber elongation both years (bolls/plant and lint percentages were higher in St 7A arrays, E_1 was higher in DPL-16 arrays).

No single race stock was equal agronomically to the cultivars but T-101 and T-40 approximated their performance except for a few deficiencies. Both of these race stocks or their hybrids have given some indication of resistance to pink bollworm (7). The other race stocks were deficient in more characters. The best of the race stocks, however, might be used in breeding programs to alter bolls/plant, boll size, seed index, T_1 fiber strength, and micronaire in desirable directions.

The generally significant race stock (R) effects and the lack of C $\times$ R interactions suggest the presence of adequate amounts of additive genetic variability for all characters among the race-stock hybrids grown in 1975. In 1976, however, the significant C $\times$ R interactions for two agronomic characters and three fiber properties suggest that those race stocks may be more refractory. Also, heterosis for individual combinations both years indicated the presence of nonadditive genetic variation.

Earliness and yield data are available for only one location and one year but also show that genetic variability among the hybrids was caused by differences in the race stocks and not by those in the cultivars. No race stock was earlier or yielded as much seedcotton or lint as the cultivars, but several F_1 hybrids were as early as, or earlier than, the cultivars and produced comparable or higher yields.

A superficial analysis would suggest that selection for F_1 vs. parental cultivar "favorable" heterosis for agronomic characters would have been equally effective at both locations because percentages of heterotic combinations were only slightly higher at Tempe than at Phoenix. In fact, F_1 vs. cultivar heterosis was inconsistent at the two locations. For example, in 1976 four combinations were heterotic for early flowering at Phoenix but only two of these four were early at Tempe. Conversely, three combinations had larger bolls than the cultivar at Tempe, but only one of these had larger bolls at Phoenix. Results were also similar for both agronomic characters and fiber properties in 1975 and for fiber properties in 1976. That is, there was little consistency between the two locations in the specific hybrid combinations that showed heterosis.

Percentages of F_1 vs. parental cultivar "favorable" heterosis were higher at both locations and in both years than those in a 1973 study involving the same two cultivars and three Texas race stocks (T-203 was common to the 1973 and 1976 tests). In fact, in 1973, only two of 120 hybrid/character combinations (1.7%) showed this type of heterosis (6). We expected perhaps more heterosis than we observed because the cultivars and race-stock parents are presumably not closely related. On the other hand, it is probably fruitless to generalize on the expected amounts of heterosis because numerous other workers have reported heterosis in hybrids from closely to distantly related parents (3).

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