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Seed Damage by Pink Bollworm to Race Stocks, Cultivars, and Hybrids of Cotton[1]

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ABSTRACT

Noncultivated race stocks of cotton (*Gossypium hirsutum* L.) previously selected via diet bioassays for antibiosis to pink bollworm (*Pectinophora gossypiella* Saunders), were field-tested for resistance along with cultivars and race stock × cultivar F_1 hybrids. No race stock or hybrid was consistently more resistant than the cultivars in 1975. In 1976, one race stock, Texas 40, and two hybrids showed some resistance. The general lack of resistance in the field among race stocks previously selected for antibiosis in diets was disturbing but not necessarily unexpected because the two types of tests might have measured different facets of resistance. Results showed the need for a more direct measure of antibiosis in diet-selected stocks, such as placing larvae on bolls of live plants. Genetic differences in hybrids were attributed to differences among their race-stock parents. Race stock × harvest-date interactions in both years, and cultivar × harvest-date interactions in 1975 were caused by hybrid combinations in which seed damage by pink bollworm increased at different rates. Gene action was presumably primarily additive because cultivar × race-stock interactions were nonsignificant and because most hybrid/harvest-date combinations did not differ from the midparent (MP). One hybrid array deviated consistently from MP in the direction of increased seed damage and one deviated in the opposite direction. Correlations between seed damage and six agronomic characters showed no consistent pattern.

***Additional index words:* Gossypium hirsutum L., *Pectinophora gossypiella* Saunders, Host-plant resistance.**

NONCULTIVATED cottons (*Gossypium* spp.) provide significant genetic variability for cotton scientists to exploit in their search for characters of potential use in breeding programs (2). We have added carpel-wall and boll-content material to artificial diets to screen primitive race stocks of *G. hirsutum* L. for antibiosis to larvae of pink bollworm (*Pectinophora gossypiella* Saunders) (4).

Certain race stocks selected from the bioassays were crossed to cultivars. Race stocks, cultivars, and F_1 hybrids were field-tested for resistance to pink bollworm. In this paper we report the results of these field tests and discuss the lack of correlation between the bioassay and field data.

MATERIALS AND METHODS

On 31 March 1975, we planted seeds in the greenhouse of two cultivars, 'Deltapine 16' (DPL-16) and 'Stoneville 7A' (St 7A), three day-neutral Texas (T) race-stocks (T-39, T-72, and T-101) that were similar in flowering response to the cultivars, and 19 race-stock × cultivar F_1 hybrids (Table 1). On 17 April, seedlings were transplanted to the field at Tempe in five randomized blocks. Twenty seedlings were spaced 36 cm apart in each single-row plot; rows were spaced 1 m apart. On 31 March 1976, we planted seeds of the two cultivars, four day-neutral Texas race-stocks (T-31, T-40, T-55, and T-203), and eight cultivar × Texas race stock F_1 hybrids in the greenhouse (Table 1). Seedlings were transplanted to the field at Tempe on 19 April. Individual plot size and number of replications were the same in 1976 as in 1975.

Individual plant data obtained were date of first flower, plant height, and bolls/plant. In 1975, we picked all available seedcotton every 2 weeks from 4 August to 29 September; remnant seedcotton was picked 4 November. In 1976, plots were harvested every 2 weeks from 10 August to 21 September. The following data were obtained from the seedcotton samples harvested 15 September 1975, and 24 August 1976: boll size (g seedcotton/boll); lint percentage (lint yield/seedcotton yield); seed index (wt 100 seeds, g). Estimates of seed damage by pink bollworm were obtained by our x-ray method (3).

We analyzed seed damage caused by pink bollworm for each harvest date, except for 4 August 1975 because too few entries had been harvested on that date. Means were compared by use of the "restricted" L.S.D. test (1). We also analyzed the eight hybrid combinations that had been harvested all five times in 1975 (18 August = first harvest; 4 November = fifth harvest; the other 11 combinations had been harvested less than five times) and the other eight combinations that had been harvested all four times in 1976 (10 August = first harvest; 21 September = fourth harvest). Hybrid (H) variances were subdivided into variances attributed to differences between cultivars (C), race stocks (R), and to cultivar × race-stock (C × R) interaction effects. We also analyzed the effects of date of harvest (D) and the various interactions of dates with hybrid combinations (H × D, C × D, R × D, C × R × D).

We calculated deviations of individual hybrid means from midparental (MP) values where both parents were represented. Phenotypic correlation coefficients were also calculated for seed damage × six agronomic characters for all cultivars, race stocks, and hybrids available at each harvest date.

Table 1. Seed damage caused by pink bollworm to cultivars, race stocks, and hybrids of cotton.

	Seed damage by pink bollworm					
	Third harvest data†			Seasonal mean data‡		
		F_1 with			F_1 with	
Cultivar or race stock	Selfed	DPL-16	St 7A	Selfed	DPL-16	St 7A
	%					
1975						
DPL-16	21.4 d-i*			26.3 cd		
St 7A	10.2 k			19.6 e		
T-39	20.1 e-j	18.9 g-k	21.9 c-i	24.5 d	25.2 d	25.7 d
T-72	31.5 ab	30.9 ab	27.8 a-f	30.6 bc	37.5 a	31.3 b
T-101	13.5 i-k	19.2 f-j	28.0 a-e	22.4 de	(14.8)§¶	(27.3)¶
T-53		21.0 d-i	29.4 a-d	–	27.9 b-d	30.4 bc
T-65		25.0 b-g	23.2 b-h	–	31.3 b	31.6 b
T-78		30.6 a-c	34.6 a			
T-181		23.3 b-h	12.3 jk			
T-207		23.7 b-h	–			
T-216		20.2 e-j	16.2 h-k			
T-232		16.9 h-k	13.8 i-k			
1976						
DPL-16	18.3 ef			23.2 b-e		
St 7A	22.8 c-e			25.8 a-c		
T-31	22.8 c-e	15.5 f	15.9 f	21.8 c-f	17.6 f	19.0 ef
T-40	19.4 d-f	19.7 d-f	15.4 f	20.6 d-f	23.2 b-e	20.5 d-f
T-55	25.3 a-d	22.9 b-e	27.0 a-c	28.6 a	22.3 c-e	26.9 ab
T-203	29.5 ab	26.8 a-c	31.7 a	23.2 b-e	22.4 b-e	24.7 a-d

* Means with letters in common, within year and harvest category, not significantly different at the 0.05 level of probability, according to the "restricted" L.S.D. test (1). † 15 Sept. 1975; 7 Sept. 1976.
‡ Five harvests, 1975; four harvests, 1976. § T-101 × DPL-16 harvested only four times. ¶ Not included in combined analysis.

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Table 2. Mean squares (MS) from combined analyses of variance of seed damage.

Source	1975 df	1975 MS	1976 df	1976 MS
Replications	4	238.37*	4	605.06**
Hybrids (H)	7	381.36**	7	181.12**
Cultivars (C)	1	26.79	1	77.28
Race stocks (R)	3	707.88**	3	303.45**
C × R	3	173.02	3	93.40
Error (a)	28	68.26	28	47.51
Date of harvest (D)	4	18,645.35**	3	6,329.68**
H × D	28	91.55**	21	124.42**
C × D	12	164.10**	3	19.61
R × D	4	132.65**	9	240.27**
C × R × D	12	33.77	9	43.51
Error (b)	128	40.89	96	56.83

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

RESULTS

In 1975, seed damage data were obtained for all five parents and 19 hybrids only at the third harvest date. St 7A had significantly less seed damage than DPL-16 at this date and also over the season. None of the three race stocks had less seed damage than the cultivars. In fact, Texas 72 (T-72) had more damage than both cultivars at third harvest and more than St 7A over the season. T-39 had more seed damage than St 7A at third harvest and over the season. In general, the F_1 hybrids had no less seed damage than the cultivars (Table 1). Three exceptions were T-181 × DPL-16 and T-207 × DPL-16 for fifth harvest only (data not shown), and T-101 × DPL-16 over the first four harvests (Table 1).

In 1976, the two cultivars did not differ significantly in seed damage. None of the four race stocks had less damage than DPL-16. Also, none of the four had less damage than St 7A at third harvest but one, T-40, had less damage over the season. T-55 had more damage than DPL-16 at third harvest and over the season. T-203 had more damage than both cultivars at third harvest. DPL-16 × T-31 had less seed damage than its parental cultivar over the season, and St 7A × T-31 and St 7A × T-40 had less damage than St 7A both at third harvest and over the season.

Combined analyses of variance over dates are presented in Table 2 for the eight hybrids harvested all five times in 1975 and for another eight harvested all four times in 1976. Subdivision of the hybrid variances for both years showed that differences were significant between their race-stock but not their cultivar parents. Differences among harvest dates and race-stock × harvest date interactions were significant both years, and the cultivar × harvest-date interaction was significant in 1975.

In 1975, four of the 29 hybrid/harvest date combinations sustained significantly greater seed damage than MP (T-72 × DPL-16, second and fourth harvests; T-72 × St 7A, fourth harvest; T-101 × St 7A, second harvest); the other 25 did not differ significantly from MP. In 1976, two of 32 hybrid/harvest-date combinations had significantly less damage than MP (St 7A × T-31, third harvest; DPL-16 × T-55, second harvest); the remaining 30 did not differ from MP. The T-31 hybrids showed progressively less damage in relation to MP at each harvest date. Thus, seed damage in DPL-16 × T-31 increased two-fold (12.3 to 25.8%), while MP increased three-fold (13.3 to 40.6%) from first to fourth harvest.

Table 3. Significant phenotypic correlations between seed damage by pink bollworm and several agronomic characters in cotton parents and hybrids.

Seed damage correlated with†	1975 Harvest	1975 r	1976 Harvest	1976 r
Date first flower	1	0.67**		
	2	0.54*		
	5	−0.43*		
Boll size	1	−0.53*	2	−0.86**
	2	−0.63**		
Lint percentage	1	−0.52*	1	0.68**
	2	−0.63**		
Seed index			2	−0.92**
Plant height	2	0.57**	1	−0.66*
			3	0.68**
			4	0.60*

*,** Correlation coefficient significant at the 0.05 and 0.01 level of probability, respectively; n = 17, 21, and 22 at harvests 1, 2, and 5, 1975; n = 14, harvests 1-4, 1976. † Total no. pairs correlated = 30 in 1975, 24 in 1976.

No consistent pattern was shown of correlation of seed damage at each harvest date with the six agronomic characters measured (Table 3).

DISCUSSION

The race stocks represented in our study had been selected originally because artificial diets to which carpel wall or boll content material had been added significantly reduced pink bollworm larval and pupal growth and development (4). The failure of most of these stocks to show field resistance is disturbing but perhaps not surprising. Diet bioassays are designed to detect toxic substances in boll material incorporated into artificial diets. In the intact cotton boll, these substances may not occur in sufficient quantities to exert more than a subtle effect. Also, antibiosis could be offset by increased preference of the insect in the field for a particular stock.

The race stocks and hybrids were field-tested only one season and at one location. Any race stocks with measurable field resistance would have been prime candidates for future testing. Because none of these stocks showed unequivocal field resistance, however, does not mean that they should be discarded. It does mean that we should obtain a more direct measure of antibiosis among these diet-selected cottons that would eliminate differences such as those caused by insect nonpreference. One such measure can be obtained by monitoring growth and development of larvae and pupae after larvae have been placed directly on bolls of intact plants. Preliminary results of such tests show that some stocks selected from diet bioassays affected growth and development deleteriously while others did not. The former stocks should thus be better candidates for field screening and for use in hybrid production.

Our field tests revealed significant genetic differences in damage to seeds among hybrid combinations. These differences are attributed to genetic variability among the race-stock parents because neither cultivar nor cultivar × race-stock interaction effects were significant in either year. The significant harvest-date effects for both years were caused by the expected general increase in seed damage as the seasons progressed. In both 1975 and 1976, the race-stock $\times$ harvest-date interactions were caused by hybrid combinations in which seed damage increased at different rates. In 1975, damage in the T-39 hybrids increased more slowly than in the others; in 1976, the T-31 hybrids assumed that role. In 1975, the significant cultivar $\times$ harvest date interaction effect reflected the slower rate of increase of the St 7A hybrids from the fourth to the fifth harvest; this effect was not repeated in 1976.

Gene action was presumably primarily additive as shown by a lack of C $\times$ R interaction and nonsignificant deviations from MP for the majority of the hybrids. Hybrids of a given race stock with both cultivars acted similarly but there were some exceptions. For example, T-72 $\times$ DPL-16 consistently (but not always significantly) deviated from MP in the direction of higher seed damage. The T-31 hybrids, on the other hand, deviated in the opposite direction. Thus, while no race stock or hybrid was unequivocally superior to the cultivars, our results suggest that perhaps T-31, T-39, and T-40 deserve further study.

The lack of consistent correlations between seed damage and agronomic characters is in a sense encouraging. At least we should not expect a strong consistent correlation between seed damage and an agronomic character, say bolls/plant, that would make it more difficult to compare seed damage directly in different cotton entries. Conversely, we should consider the possibility of correlated responses in any given set of race stocks or hybrids and should routinely obtain ancillary agronomic information to aid us in interpreting insect data.

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