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Resistance to Boll Weevil (*Anthonomus grandis* Boh.) Oviposition in Cotton[1]

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ABSTRACT

Cotton (*Gossypium hirsutum* L. and *G. barbadense* L.) lines were tested for 3 years in small field plots for boll weevil (*Anthonomus grandis* Boh.) resistance. A total of 23, 29, and 100 lines were evaluated at one location in 1965, 1966, and 1967 respectively. Five frego, four red, and several Sea Island cotton lines received less boll weevil oviposition than the commercial check line. Oviposition under these field conditions may have measured a different component of preference than our standard laboratory test for oviposition factors. In general, however, lines selected in our laboratory test for low oviposition also showed reduced oviposition in the field tests. A covariance analysis adjusted the number of oviposition damaged squares for the number available to the weevil for oviposition. Gains in precision ranged from 49 to 105% from the use of covariance.

Additional indexing words: **Insect preference, Field evaluation.**

THE boll weevil (*Anthonomus grandis* Boh.) first entered the United States in 1892. Soon, plant collectors explored the Central American center of origin of upland cotton (*Gossypium hirsutum*) and found stocks with weevil-resisting adaptations (Cook, 1906). Cotton breeders, using these stocks developed early maturing, rapidly growing cotton varieties that could be produced economically when treated with effective insecticides. In the past several years, evidence for insecticide resistance in the boll weevil has generated renewed interest in the search for weevil-resistant cottons.

Hunter et al. (1965) reported on 4 years of work in which they measured antibiosis and 6 years in which they measured tolerance and preference. They utilized 336 diverse cotton lines; however, approximately one-third of these were photoperiodic and were dropped

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from the testing program after 1 year. Red plant color was less preferred than green, hairy plant parts were associated with tolerance, and the effects were cumulative in obtaining yield gains; however, no lines were sufficiently resistant for commercial production in the absence of other forms of insect control. Frego bract was associated with reduced punctures until population pressures became high. They observed two types of antibiosis, as follows: *(1)* failure of the larvae to show any signs of development in the squares (Hopi cotton, and *(2)* failure of larvae to complete development or to emerge (Russian 5A cotton). CB2545, a cotton introduced from India showed both types of antibiosis.

We conducted experiments in 1965, 1966, and 1967 with selected cotton lines. The objectives were *(1)* to develop field plot techniques to measure resistance which would take into account differences in squaring rate of the various lines, *(2)* to identify cotton lines showing resistance, and *(3)* to relate the characteristics of these lines to previously reported studies with morphological and biochemical factors affecting resistance.

MATERIALS AND METHODS

Small plot (6 rows × 9.14 m) evaluations of selected cotton lines were made for boll weevil resistance at State College, Miss. for 3 years (1965, 1966, 1967), evaluating 23, 29, and 100 lines during the respective years. Methyl parathion at 560 g/ha was applied each year to all plots for boll weevil control until all plots were fruiting rapidly. Natural infestations of weevils developed in years 1 and 3. The second year, two gravid females were released in each plot approximately 1 week before we began to record weevil infestations. No insecticide was applied to the plots after we began to record infestations. This allowed the population of weevils to build up naturally in each plot.

The boll weevil makes both feeding and oviposition punctures. Leigh and Lincoln (1964) found that 86% of the squares bloomed when they had only feeding punctures; whereas nearly all squares containing a developing larvae abscissed. Coakley et al. (1968) found no significant abscission from feeding punctures. The presence of a developing larvae or homogenates of second or third instar larvae caused abscission. Black and Leigh (1963) studied feeding and oviposition on five diverse cottons and found equal oviposition on all lines; however, Sea Island Short Sympodia received more feeding than oviposition whereas Hopi and *G. arboreum* showed the reverse. Considering these facts, we used oviposition punctures as the measure of the resistance of a cotton line in these studies.

The various cotton lines showed different rates of squaring which invalidated a simple percent count of oviposition damaged squares. Therefore, to determine the infestations levels, all the squares of sufficient size for oviposition were examined. The optimum size square for oviposition is 6.0 to 7.5 mm in diameter at the widest part. The row distance required to examine 50 squares and the number with oviposition punctures were recorded. The infestation level in relation to available squares was then determined on each line. This method is a modification of the point sample technique of Lincoln et al. (1963). When the infestation reached 75% in the control plots of 'Deltapine Smooth Leaf' (DPSL), the counts were terminated in all plots. Infestation counts were made bi-weekly in year 1, every 4 days in year 2 and weekly in year 3 with 11, 9, and 5 counts in each plot in the respective years.

The data were analyzed separately for each year by a split plot analysis of covariance. The individual infestation counts were the split plot in time; and the number of squares available for oviposition was corrected for as a covariant. The counts were converted to a squares-per-land unit (0.404 ha) basis, then transformed (square root) for analysis. The square root transformation was used since insect count data often follow the Poisson rather than the normal distribution, LeClerg et al. (1962). After statistical significance tests were computed, the data were reconverted to squares per land unit. They were then compared with the commercial check (DPSL) based on a ratio computed as follows: Mean number of oviposition punctured squares per land unit per record date (infestation count) on each test line divided by the mean number of oviposition punctured squares per land unit per record date on DPSL. This ratio was called the oviposition score and represents the mean infestation per record date in comparison to DPSL.

RESULTS AND DISCUSSION

The covariance analysis showed gains in precision over an ordinary split plot analysis of variance by factors of 2.05, 1.84, and 1.49 in years 1, 2, and 3, respectively. These gains in precision emphasize the importance of correcting for variable squaring rate among the cotton lines.

Where seed were available, those lines in years 1 and 2 which showed at least a 25% reduction in damage compared to DPSL (oviposition score < 0.75) were tested the next year. The use of the 0.75 oviposition score for selecting lines for further study rather than a statistical significance test allowed us to select a few additional lines to study.

In these field tests we were measuring general resistance to oviposition due to many factors all operating potentially at the same time. The factors associated with preference were the main ones being measured. The oviposition scores for all lines which rated below 0.75 in any one of the three years are shown in Table 1. (Resistance scores of all lines tested will be made available to interested investigators upon individual request.) Frego Nankeen, Frego Stoneville, Frego Crinkle Dwarf, and K2102 were significantly less damaged than DPSL in both the years they were tested. Clarksdale Red was significantly less damaged than DPSL in 2 of 3 years. King 82, Barbadense Tashkent, and Sea Island Tipless were significantly less damaged than DPSL in the one year they were tested.

A comparison of our results with previously reported work by others, allowed us to speculate on the causes of the reduction in oviposition in these lines. Clarksdale Red and K2102 showed resistance in 2 years. K2102 is a hairy line with medium-red foliage. Isely (1928) showed that red cotton was less preferred than green when a choice was given to the weevils. Wanna-

Table 1. Damage ratings of cotton lines which scored less than 0.75 in 1 or more years of testing.

Cotton line	Oviposition score†		
	1965	1966	1967
Pope Clean Seed	0.74	0.89	
Holden No. 4	0.73		
D_2 glandless	0.70	0.71*	
Hopi	0.66*	0.96	
Meade Clean Seed	0.63*	0.89	
Hopi Moencopi	0.62*	1.27	
Russian Sea Island	0.61*	1.19	0.61
Clarksdale Red	0.58*	0.59*	0.70
S. I. Seaberry	0.54*	0.88	0.80
King 82	0.53*		
K2102	0.46*	0.53*	
Frego Nankeen		0.54*	0.33*
Frego Cluster		0.52*	0.58
Frego Stoneville		0.51*	0.48*
Frego Akdjura		0.35*	0.75
Frego Crinkle Dwarf		0.64*	0.25*
Hite Red			0.75
D_2 nectariless, glandless			0.73
Sea Island Short Sympodium			0.69
Sampson Strain 11			0.68
Triple Hallmark Sea Island			0.66
N. C. Margin			0.66
Sampson Strain 6			0.61
Sea Island 36-12-B2			0.67
Barbadense Tashkent			0.45*
Sea Island Tipless			0.44*
DSPL	1.00	1.00	1.00
LSD .05	0.325	0.248	0.464

† Oviposition score = Mean number of oviposition punctured squares per land unit on the test line ÷ mean number of oviposition punctured square per land unit on DPSL.
* Significantly less than DPSL for respective year.

maker (1957), Wessling (1958a, 1958b), and Stephens and Lee (1961) found that hairy cotton was less preferred than lines with fewer hairs. Perhaps both red color and hairs conferred a measure of resistance of the non-preference type in K2102. In 1967 we tested four red lines none of which showed significantly less damage than DPSL. However, three of the four lines did have low resistance scores as follows: Hite Red, 0.75; McNamara Winesap, 0.79, and Clarksdale Red, 0.70. The fourth, Red Cluster C.O. Type, had a slightly reduced score: 0.91. Hunter et al. (1965), however, found that when red cottons were grown in large blocks the nonpreference of the boll weevil was not as strongly expressed as when a choice was given between red and green in small blocks. N. C. Margin, a breeding line released by the North Carolina Agriculture Experiment Station, has *G. arboreum, G. thurberi,* and *G. hirsutum* in its background. It differs from other cottons because the squares have a red flush of color. It scored 0.66 in 1967 and thus deserves additional testing. It is possible that its low score was caused by factors other than the red color since both *G. arboreum and G. thurberi* carry some resistance (Bailey et al., 1967; Jenkins et al., 1963, 1964; and Merkl and Meyer, 1963).

Frego bract was tested in five diverse backgrounds for 2 years and all had low oviposition scores; thus, it seems that the resistance is due to the frego character *per se.* Lincoln and Waddle (1966), Hunter et al. (1965), and Jones et al. (1964) have previously reported less damage in frego cotton. Frego is a mutation, governed by one recessive gene, which reduces the involucral bracts to narrow, twisted, structures in contrast to the wide bracts which enclose the square on normal cotton. Weevils spend much of their time within the square bracts, and the frego bract character alters their principal sites of feeding, ovipositing, and resting. This alteration has perhaps changed the behavior of the boll weevil resulting in less oviposition, Hunter et al. (1965).

We tested these same five frego lines in our standard laboratory oviposition test (unpublished data) and found no reduction in oviposition. In these tests the bracts were first removed and then the freshly picked squares were placed in a jar with the weevils. These tests measured oviposition suppression caused mainly by chemical factors, whereas the field plot test measured general resistance to oviposition and was influenced by several factors. Thus, it seems that our laboratory and field plot tests may measure different mechanisms of resistance both of the preference component.

S. I. Seaberry and Russian Sea Island are lines we selected in our laboratory oviposition tests because they carry factors which suppress oviposition (Buford et al., 1967, 1968). Russian Sea Island scored low in 2 of 3 years and S. I. Seaberry in all 3 years of field testing. Thus, our laboratory low oviposition selections also carry some resistance expressed under field conditions which suggest that the laboratory test is a useful one.

The two glandless lines in our test, D_2 glandless (grown in 1965 and 1966) and D_2 glandless-nectariless (grown in 1967), received less damage than DPSL in each year of the 3 years of the test; however, in only 1 of the 3 years was the difference significant. These results substantiated our previous work, which indicated no increased boll weevil problems on glandless lines (Jenkins et al., 1967; and Maxwell et al., 1966).

Results of both laboratory tests and 2 years of field tests with Sea Island cottons caused us to expand our field trials in 1967 to include additional Sea Island cottons and lines containing Sea Island introgression. We tested 14 lines of Sealand and Sea Island, and 12 lines of Sampson (Upland strains with Sea Island introgression). Seven of these lines: Sea Island Short Sympodium, Triple Hallmark Sea Island, Sea Island 36-12-B2, Barbadense Tashkent, Sea Island Tipless and Sampson strains 6 and 11 were selected as worthy of further study. Barbadense Tashkent and Sea Island Tipless were significantly less damaged than DPSL. Thus it appears that the Sea Island cottons may carry some resistance to boll weevil oviposition. Historically, the commercially grown Sea Island cottons were highly susceptible to the boll weevil under field production conditions. The Sea Island cotton industry was ruined by the boll weevil. The late initiation and slow progress of fruiting in the Sea Island cottons coupled with a thin carpel wall in the boll contributed greatly to their high susceptibility and their decline in use (Cook and Doyle, 1927). Early, rapid fruiting lines of upland cotton were developed to escape the boll weevil.

In summary, five frego, four red, and several Sea Island cotton lines received less boll weevil oviposition than the commercial check line when tested under field conditions. Reduced oviposition under field conditions is a part of the preference mechanism of resistance but measures a different component of preference than our standard laboratory test for oviposition factors. In general, however, lines selected in our laboratory test for low oviposition also showed reduced oviposition in the field tests. A covariance analysis adjusted the number of oviposition damaged squares for the number available to the boll weevil for oviposition. Gains in precision ranged from 49 to 105% from the use of covariance.

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