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# Effects of Pilose, Pubescent, and Smooth Cottons on the Cotton Leafperforator[1]

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## ABSTRACT

**Strains of cotton (*Gossypium hirsutum* L.) deviating in both directions from the degree of pubescence typical of upland cotton, were more resistant than the latter to cotton leafperforator (*Bucculatrix thurberiella* Busck). Two densely hairy lines, TM-1($H_2$) and SA 166, harbored significantly fewer insects than any of the other lines tested. Nonpreference for oviposition is probably the main mechanism of resistance involved. A no-choice greenhouse feeding technique was devised that should be useful in screening cottons for resistance to cotton leafperforator.**


***Additional index words:*** **Host plant resistance, *Gossypium hirsutum* L., *Bucculatrix thurberiella* Busck.**

THE cotton leafperforator (CLP), *Bucculatrix thurberiella* Busck, is a secondary pest of cotton, *Gossypium hirsutum* L., in the southwestern United States. Sixty years ago it was recognized as a cotton pest in Arizona and southern California (Stevenson and Kauffman, 1954). During the past 20 to 30 years, control has not been a problem because populations were kept to a subeconomic level by the insecticide spray used against other cotton pest insects. However, the CLP, like many pest insects, has now developed resistance to organophosphate and organochlorine insecticides and to DDT (Anonymous, 1973). Because of this chemical resistance, CLP is becoming a more important pest in Arizona and the desert valleys of southern California.

Watson and Johnson (1972) studied the life cycle of CLP. They observed a 4.0-day pre-oviposition period, a 2.25-day egg stage, a leaf mining stage (first three instars) of 3.45 days, a fourth instar period of 2.1 days including a 1.1-day "horseshoe" (resting) stage, a fifth instar time of 2.6 days, and a pupal stadium of 7.1 days.

Resistant plant cultivars would offer an alternate form of control. Moreover, these cultivars would save the farmer the cost of chemical control and would lessen the use of insecticides. However, only one study has been made of host plant resistance to CLP. Rejesus (1968) showed that the larvae fed significantly less on hairy strains of cotton (specifically Texas 423 and Texas 542) than on others. He stated that "the density of the hairs interfered with egg deposition of the adults since the eggs must be directly attached to the leaf surface." He also noted that gossypol content did not affect the feeding preference or oviposition of the perforators.

This paper reports the results of two years of testing cotton genotypes that had varying degrees of hairiness for oviposition preference by CLP. Also, a greenhouse technique was devised for screening cotton strains for feeding preference or antibiosis to CLP.

## MATERIALS AND METHODS

### Cotton Strains Used

The 12 cotton strains used are listed in Table 1. Some of these lines are more glabrous and some are more pubescent than the normally hairy cultivars of upland cotton currently grown in the United States. Four genes are involved, as follows: i) $Sm_1^{st}$, $D_2$ Smooth, carried by TM-1 (Sm); ii) $Sm_2$, North Carolina Smooth, carried by 'Stoneville (Sm)'; iii) $H_1$, Pubescent, probably carried by SA 156, SA 166, and SA 223 (J. E. Jones, personal comm.); and iv) $H_2$, Pilose, carried by TM-1 ($H_2$) see Lee, (1964, 1968, 1971) for further discussion and references on the genetics of trichome distribution in cotton.

TM-1 and TM-1 ($H_2$) are isogenic; TM-1 (Sm) is nearly isogenic with its recurrent parent, TM-1. The only other isogenic pair in our study is M-8 glanded and M-8 glandless. Stoneville (Sm) was received from M. J. Lukefahr, who subsequently

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**Table 1. Strains of *G. hirsutum* and *G. thurberi* used.**

| Cotton | Description | Source or reference |
|---|---|---|
| Deltapine 16 | Commercial cultivar | Delta & Pine Land Co., Scott, Miss. |
| Stoneville 7A | Commercial cultivar | Stoneville Pedigreed Seed Co., Stoneville, Miss. |
| Stoneville(Sm) | (See text) | J. E. Jones, La Agric. Exp. Stn., Baton Rouge via M. J. Lukefahr, USDA, ARS, Brownsville, Texas |
| TM-1 (Texas Marker-1) | Inbred line from 'DPL-14' | Kohel and Richmond (1971) |
| TM-1($H_2$) | Pilose isoline of TM-1 | Kohel and Richmond (1971) |
| TM-1(Sm) | $BC_2$ of TM-1 to $D_2$ Smooth | F. D. Wilson |
| M-8 Glanded | Doubled haploid of 'DPL-14' | J. R. Meyer, Delta Branch Exp. Stn., Stoneville, Miss. |
| M-8 glandless | $BC_2$ from M-8 × McMichael 41-4 glandless | J. R. Meyer, Delta Branch Exp. Stn., Stoneville, Miss. |
| SA 156 | Perso American (pubescent) | R. R. Bridge, Delta Branch Exp. Stn., Stoneville, Miss. |
| SA 166 | Mu8B-UA744 (pubescent) | R. R. Bridge, Delta Branch Exp. Stn., Stoneville, Miss. |
| SA 223 | K3112, 915, Pioneer (pubescent) | R. R. Bridge, Delta Branch Exp. Stn., Stoneville, Miss. |
| G. thurberi | Arizona Wild Cotton | C. A. Benschoter, 12, Oct, 1972, Santa Catalina Mtns., Pima Co., Ariz. |

informed us (personal comm.) that this line came from open-pollinated seeds of La. 15213. J. E. Jones, who developed the line, stated (personal comm.) that La. 15213 is glabrous and nectariless and has 'Stoneville 7A'[3] in its pedigree but that it is not an isoline of the latter cultivar. Most of the plants of Stoneville (Sm) in our 1972 test were glabrous but possessed nectaries; we rogued the pubescent and nectariless plants.

'Arizona Wild Cotton', *G. thurberi* Todaro, is a lintless diploid relative of the lint-bearing tetraploid *G. hirsutum*.

## 1972 Field

Four lines: Stoneville 7A, Stoneville (Sm), TM-1 and TM-1 ($H_2$), were planted at the Ariz. State Univ. Field Lab., Tempe, Ariz., in single row (7.6 m long) plots replicated four times.

Eleven samples consisting of 10 full sized leaves/row were picked randomly from the top 20 cm of the plants beginning on August 28 and continuing until October 10. Since leaf size varied considerably between lines, the leaves were weighed (green wt), and the number of fourth-instar horseshoe larvae on each leaf was counted. Data were recorded as the number of CLP/g of leaf tissue. We depended upon natural infestations of CLP larvae for all field tests.

## 1973 Field

Six cotton lines: SA-156, SA-223, SA-166, TM-1, TM-1 ($H_2$), and TM-1 (Sm), were planted in 7.6 m × two-row plots at Tempe, Ariz. The plots were randomized and replicated four times. In this test, 13 samples consisted of 10 full-sized leaves/plot randomly picked from the top 20 cm of plants. Sampling began October 12 and continued until November 14. Data were recorded as the number of CLP/g leaf tissue. Also, 50 bolls/plot were harvested so ginning and fiber quality could be determined at the USDA Fiber Testing Lab., Phoenix, Ariz.

Also, TM-1 and TM-1 ($H_2$) were planted at the Univ. of Ariz. Agric. Exp. Stn., Yuma, Ariz. in plots four rows wide, 15.2 m long, replicated five times. Sampling began July 10 and ended October 24 for a total of 15 collections. Twenty five leaves/plot were picked, weighed, and examined for horseshoe larvae. Data were recorded as the number of CLP/g leaf tissue.

The ginning and fiber-quality data that were obtained at the testing laboratory were as follows: lint percentage, percentage of seed cotton that is lint; boll size, seed cotton in g/boll; 2.5% and 50% span length, length (in) at which the given percentage of fibers in an array are that long or longer; fiber strength ($T_1$), strength (g/tex) measured on the stelometer with the jaws of the machine separated by a 3.2-mm spacer; elongation ($E_1$), percentage elongation of fiber bundle before breakage; micronaire, fiber fineness expressed as $\mu$g/in.

## Greenhouse Test

Six cotton lines: 'Deltapine 16'[3], *G. thurberi*, M-8, M-8 glandless, Stoneville (Sm), and TM-1 ($H_2$), were planted in 3.8-liter pots in the greenhouse in 1973. When the plants were 6-weeks-old, four leaf cages were placed on each plant and each was infested with a CLP larva.

Since not much damage results from the feeding of the first four instars of the cotton leafperforator, we used fifth-instar larvae. However, the larvae were collected in the horseshoe period of the fourth instar by using a no. 5 cork borer to punch them out of an infested leaf on plants growing in another greenhouse. (The horseshoes were inspected to make certain that they were alive and suitable for the test.)

Four leaf discs each containing a single larva were placed in individual light-weight leaf cages as described by Hughes, Hunter, and Leigh (1966) and each secured to a clean, undamaged leaf on a greenhouse test plant.

Thus, when the fifth-instar larva emerged from the resting stage, it had an area of 314 mm² on which to feed. This procedure was repeated 10 times over a period of 2 months for a total of 40 larvae/plant.

When pupation occurred, the pupa was removed from the cage and held for adult emergence, and the leaf feeding area was removed from the plant, dried, and pressed for 2 days. The dried area was then mounted in a 5.08 × 5.08-cm slide along with a dot grid, (size 600-20, Zip-a-tone by Para-tone, Inc.[3], (Benjamin, Freeman, and Brown, 1968), and the number of dots were counted that are visible through the holes caused by feeding. The area of tissue removed was calculated. Also, a micrometer was used to measure the leaf thickness so we could measure the volume of tissue eaten by the larva.

[3] The use of trade names does not imply their endorsement by the USDA over similar products not mentioned.

## RESULTS

Table 2 summarizes CLP development in the field and greenhouse tests. In all three field tests, the number of CLP's/g of leaf tissue was significantly lower on the pilose TM-1 ($H_2$) than on the other entries except the pubescent lines SA 166 grown at Tempe in 1973.

In the 1973 field test, all four of the hairy cottons had fewer CLP's than TM-1. Also, the two lines that had the highest density of leaf trichomes, TM-1 ($H_2$) and SA 166, had the fewest number of CLP's. However, the next highest trichome count was found on leaves of SA 156, and the CLP count on this line was significantly higher than on the pilose line and on SA 166. The CLP count was not significantly different on SA 156 than on SA 223; the latter cotton is apparently no more hairy than TM-1.

Also, in both field tests at Tempe, the smooth lines had significantly fewer CLP's than the normally hirsute ones. However, they never had as few insects as the highly pubescent SA 166 or the pilose TM-1 ($H_2$).

In the 1973 greenhouse test, the larvae fed less on TM-1 ($H_2$) than on the DPL-16 check, but not statistically less than on the other four lines of *G. hirsutum*. Feeding on *G. thurberi* was less than on the five lines of *G. hirsutum*, but not significantly less than on TM-1 ($H_2$). There were no significant differences in adult emergence among any of the six lines tested.

Table 3 presents ginning and fiber data for the six lines grown at Tempe during 1973. The results from TM-1($H_2$) were generally consistent with previous data (Kohel and Richmond, 1971) though there were some exceptions. In both studies, the Pilose TM-1 ($H_2$) had higher lint percentage and micronaire and shorter fiber than its isoline. In our study, fiber strength was about the same in both lines, but elongation was reduced in the pilose isoline. Kohel and Richmond, however, reported that strength was lower in TM-1 ($H_2$), though elongation was about the same in both lines.

The three hairy SA lines had low lint percentages, small bolls, and short, fine, and relatively weak fiber. TM-1 (Sm) also had a low lint percentage, but was in every other way comparable to the normal TM-1.

## DISCUSSION

The $H_2$ allele for pilosity is pleiotropic in that it also shortens fiber length and increases micronaire (Simpson, 1947; Kohel and Richmond, 1971). The pubescence of SA 166 appears to be influenced by a gene or genes other than $H_2$, presumably $H_1$ because it is a derivative of the strain Mu8-B, known to carry $H_1$ (Lee, 1968), since its trichome density is much lower than that of TM-1 ($H_2$) and it has finer fiber. However, SA 166 is not desirable agronomically because its lint percentage, fiber length, fiber strength, elongation, and boll size are low compared with the TM-1 check. Then if, in fact, SA 166 does carry only $H_1$ for hairiness, it should be possible to upgrade the fiber

**Table 2. Effects of hairy and smooth cottons on cotton leafperforator development.**

| Cotton† | Leaf trichomes/cm² ‡ | Field tests | | | Greenhouse test 1973 |
|---|---|---|---|---|---|
| | | Tempe 1972 | Tempe 1973 | Yuma 1973 | mm³ tissue consumed |
| | | CLP/g leaf tissue | | | |
| St-7A (Sm) | 6 | 2.04 b* | -- | -- | 12.86 ab* |
| TM-1 (Sm) | 6(GH) | -- | 2.22 b* | -- | -- |
| DPL-16 | 8 | -- | -- | -- | 13.46 a |
| G. thurberi | 12(GH) | -- | -- | -- | 9.75 c |
| St-7A | 40 | 2.76 a | -- | -- | -- |
| M-8 glanded | 75(GH) | -- | -- | -- | 11.84 ab |
| M-8 glandless | 75(GH) | -- | -- | -- | 12.15 ab |
| SA 223 | 106 | -- | 1.92 c | -- | -- |
| TM-1 | 125 | 2.02 b | 3.34 a | 1.52 a* | -- |
| SA 156 | 331 | -- | 2.15 bc | -- | -- |
| SA 166 | 438 | -- | 0.61 d | -- | -- |
| TM-1($H_2$) | 1100 | 0.71 c | 0.51 d | 0.26 b | 10.85 bc |

* Means followed by same letter are not significantly different at the 5% level, according to L. S. D. test. † Data are means of four replications. ‡ GH-trichome counts were made on greenhouse grown plants.

**Table 3. Ginning and fiber data for cotton with varying pubescence grown at Tempe, Ariz., 1973.**

| Cotton† | Lint | Fiber length | | Fiber strength $T_1$ | Fiber elongation $E_1$ | Micronaire | Boll size |
|---|---|---|---|---|---|---|---|
| | | 2.5% span | 50% span | | | | |
| | % | in. | | g/tex | % | μg/in. | g seed cotton/boll |
| TM-1 | 32.59 a* | 1.05 a* | 0.53 a* | 17.65 ab* | 6.28 b* | 4.21 b* | 4.21 a* |
| TM-1 (sm) | 29.65 b | 1.06 a | 0.53 a | 19.20 a | 7.05 a | 4.10 bc | 4.33 a |
| TM-1($H_2$) | 34.52 a | 0.90 c | 0.47 b | 17.48 ab | 5.73 c | 5.11 a | 3.89 ab |
| SA 156 | 28.30 b | 0.93 c | 0.46 b | 15.90 b | 4.38 d | 2.99 d | 3.00 c |
| SA 166 | 24.85 c | 0.84 d | 0.45 b | 16.68 b | 4.38 d | 3.87 bc | 2.61 c |
| SA 223 | 25.23 c | 0.98 b | 0.47 b | 15.78 b | 3.25 3 | 3.58 c | 3.24 bc |

* Means followed by same letter are not significantly different at the 5% level, according to LSD test. † Data are means of four replications.

quality without losing the leaf pubescence because this gene has no obvious pleiotropic effects (Lee, 1964).

Leaf hair density and number of CLP/g leaf tissue were correlated at the 10% level of significance. In the 1972 test of four lines, r was equal to —0.92; in the 1973 test of six lines, r = —0.74. In these tests, a trichome density somewhere between 331 and 438 trichomes/cm² appeared to be critical for significantly reducing CLP numbers.

In the field tests, the female moths could have been selective in ovipositing, and the density of hairs seemed to be the main nonpreference mechanism. However, larval behavior on a pilose line no doubt influenced survival. Small larvae observed on a pilose leaf seemed to be confused by the vast number of hairs. They climbed randomly over and under the hairs and had difficulty orienting themselves to the leaf.

In the greenhouse test, the larvae had no choice of hosts so the presence or absence of antibiosis or nonpreference could be determined. However, behavior on pilose leaves probably also influenced feeding. Results were not as dramatic as in the field tests, but differences did occur that indicated a preference of the larvae for one cotton strain over another.

Several facts emerged. First, deviations in both directions from normally hirsute cottons reduced CLP populations, even though the two densely hairy lines had significantly fewer insects than any of the other lines. Second, the genetic source of hairiness did not matter as much as the hairiness itself. Third, factors other than hairiness apparently affect CLP populations because SA 223 is apparently no more hairy than normal cotton, but it harbored fewer insects.

At present, we do not know the effects of different populations of CLP on the yield and quality of cotton. The *a priori* assumption that more insects will cause greater losses in yield is usually, but not inevitably, valid. However, if it is valid, then our results are encouraging because we have more flexibility than usual in developing cottons that could fit into integrated control programs. For example, a cotton resistant to CLP because of its dense pubescence would probably not be of much value unless this character also imparted resistance to the pink bollworm, *Pectinophora gossypiella* (Saunders), the most important cotton pest in the southwestern United States.

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