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Thrips Injury to Upland Cotton (*Gossypium hirsutum* L.) Varieties[1]

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ABSTRACT

The purpose of this study was to obtain thrips injury data on Upland cotton varieties currently planted in the Southeast and to associate the effects of the injury with yield. Yield and thrips injury data were obtained on 16 varieties at Experiment, Georgia, in 1960, and thrips injury data on 12 varieties at Jackson, Georgia, in 1961. In 1960, a highly significant (P=.01) negative correlation (-0.52) between yield and injury-index was obtained. The linear regression showed a decrease of 392 pounds seed cotton per acre for each unit increase in thrips injury-index. A highly significant correlation (0.73) between the 1960 and 1961 thrips injury-index data was obtained.

The order of rank of thrips resistance for varieties tested was 'Empire,' 'DeKalb 108,' 'Dixie King,' 'Rex,' 'Auburn 56,' 'Plains,' 'Stoneville 7,' 'Coker 100A,' and 'Deltapine 15.'

Empire and varieties having Empire in their genetic background exhibited more resistance to thrips injury than did other varieties.

The value of Empire genes in a cotton breeding program for thrips resistance is pointed out.

THRIPS have been recognized as cotton pests for many years; however, the amount of damage caused by the various species of this insect is not fully known. Thrips obtain their food by sucking juice of the plant. They mutilate leaves, often destroy the terminal bud, and may even cause death of the entire plant. If thrips are not controlled the resulting damage may retard plant growth and reduce stands, and cause delayed fruiting, maturity, and harvest. The stunted plants are also more susceptible to disease than normal plants.

The economic importance of thrips control is twofold. First, applications of insecticides must be made specifically for control of this pest, and second, if thrips are not controlled, the resulting delay in maturity makes extra insecticide applications necessary for the control of boll weevil (*Anthonomus grandis* Boheman), boll worm [*Heliothis zea* (Boddie)], and other late season cotton insects.

Variation in resistance to thrips injury among Upland cotton varieties was reported from the Georgia Experiment Station in 1951 (1). This paper presents thrips injury data on current varieties and associates the effects of the injury with yield.

LITERATURE REVIEW

Many species of thrips have been found on cotton. Watts (17) reported that 13 species belonging to 10 genera of 3 families and 2 sub-orders attack cotton. He stated that the four species probably causing injury to cotton were the flower thrips, *Frankliniella tritici* (Fitch); the tobacco thrips, *F. fusca* (Hinds); the onion thrips, *Thrips tabaci* Lindeman; and *Sericothrips variabilis* (Beach). Eddy and Livingstone (6) reported tobacco thrips on cotton, and Eddy and Clarke (5) called attention to onion thrips as pests of cotton. Smith (14) reported the western flower thrips, *F. occidentalis* (Pergande), and the bean thrips, *Caliothrips fasciatus* (Pergande), as cotton pests.

Beckham and Morgan (2) collected nine species from Georgia in a study conducted in 1955. In order of abundance the four species found by Beckham and Morgan (2) at Experiment were *F. fusca* (Hinds), *T. tabaci* Lindeman, *F. exigua* Hood, and *F. tritici* (Fitch).

Ballard (1) obtained data that showed highly significant differences among varieties in resistance to thrips injury. 'Empire,' 'Collins Stoneville,' 'Coker 100,' and 'Coker 100 Wilt' showed consistently high resistance to thrips injury. 'Hi-Bred' and several strains of Stoneville and Deltapine cottons were highly susceptible. The same study showed that density of pubescence of terminal leaves was associated with resistance to thrips. Empire, which had the heaviest pubescence on young leaves, was highest in thrips resistance, while Hi-Bred, with its nearly glabrous leaves, was highest in susceptibility. However, certain varieties with intermediate pubescence varied widely in resistance to thrips, suggesting that varietal resistance might be due to undetermined chemical or morphological factors.

Watts (18) reported delayed fruiting and reduced yield in thrips injured cotton, but gave no data on different varieties. In recent trials with various thrips insecticides, Race (13) found at least two insecticides that increased yields of seed cotton more than one-third bale per acre. Untreated plants had up to ten times as many thrips as treated plants of the same variety. Fletcher and Gaines (7) showed delays up to 2 weeks in boll production due to thrips injury.

Owen (11) found that control of thrips and fleahoppers resulted in a lower percentage of plant deformity than no control and increased the number of blooms. He also showed that yields were increased 676 pounds seed cotton per acre when 2 applications of effective insecticides were used, and 830 pounds when 3 applications were used.

In a study of flower and boll production in two varieties of cotton, Ballard (1) concluded that fruiting was delayed and yields were progressively reduced on plants having successively higher thrips injury. Even on plants with apparently slight thrips injury, yields were appreciably reduced in both varieties.

Brook (3) showed untreated plots had from 3 to 36 times as many thrips per plant as treated plots. Check plots had 22 to 64% thrips-injured plants, while treated plots had 1 to 24% injured plants. Three-year records show the yield of treated plots to be significantly higher than check plots. Kauffman and Stevenson (8) showed that early applications of insecticides reduced the thrips population and held it far below the levels occurring in the untreated check plots for at least ten days. They also presented data which showed that plots which received an early-season ap-

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plication of insecticide for thrips control plus 2 or 3 late applications yielded more than plots which received only the 2 or 3 late applications. The average increases of seed cotton per acre over comparable untreated check plots during the 3-year period were: 1 early application only, 311 pounds; 2 or 3 late applications only, 273 pounds; and, 1 early followed by 2 or 3 late applications, 584 pounds.

Not all studies, however, have shown thrips control increases yields. Newsom et al. (10) found that tobacco thrips caused different degrees of visible injury to six commercial varieties of cotton in the seedling stage, but subsequent growth and final yield were not affected. Watson (16) presented data which indicated that thrips control did not necessarily guarantee an increase in yield. He concluded that the disadvantages arising from increased production costs and destruction of beneficial insects far outweighed any advantages gained by thrips control.

The exact relationship of thrips injury to yield is a matter of conjecture. Usually by the time cotton plants are 6 or 7 weeks old, they have outgrown any visible differences due to thrips injury. This makes it difficult, if not impossible, to assess definite yield losses due to thrips injury alone. However, most reports show that thrips control tends to increase yields.

EXPERIMENTAL PROCEDURE

Heavy thrips infestations were evident in many cotton fields during 1960 and 1961. In the cotton variety tests at Experiment, Georgia, in 1960 and at Jackson, Georgia, in 1961, severe damage was visible on the seedling plants. We rated the damage by thrips on 4 replications of the test each year, when the plants were approximately 5 weeks old and retarded in growth. We used a scale of 1 to 5, representing slight to heavy damage, to rate 50 consecutive plants in 1 row of each variety in each of 4 replications of the test. All rating was done without knowledge of varietal identity. Ratings were recorded on an individual plant basis. Class 1 plants showed no injury or slight injury to 1 or more leaves, while Class 5 plants exhibited severe leaf damage and usually had aborted terminal buds. We calculated an injury-index for each variety in each replication by multiplying the number of plants falling into each rating-class by the class number, then adding the product for each class and dividing the sum by the number of plants rated. The ratings for the four replications were averaged to obtain a mean index rating for the entire test. Indices were analyzed for statistical significance of difference among varieties. Duncan's Multiple Range Test was applied to yield data and to the average injury-index according to the method outlined by LeClerg (9).

Neither the number of thrips per plant nor the species of thrips causing the damage was determined.

RESULTS AND DISCUSSION

1960 Test

Effects of injury on yield. Data on yield and thrips injury for 16 varieties of cotton grown at Experiment, Georgia, are presented in Table 1. 'Auburn 56' produced 2,151 pounds seed cotton per acre to lead all varieties tested. 'Lankart 57' was the lowest yielding variety with 1,565 pounds per acre.

Thrips-injury ratings by plots varied from 2.44 for 'DeKalb 108' to 4.06 for 'Deltapine 15.' The mean injury-index ranged from 2.69 for 'Wannamaker's All-in-One' to 3.68 for Lankart 57.

In an attempt to measure the influence of thrips injury on seed cotton yield, the correlation coefficient and linear regression of yield on injury were computed. A highly significant (P=.01) negative correlation (—0.52) was obtained (Figure 1). Each unit increase in thrips injury-index was associated with a decrease of 392 pounds seed cotton per acre ($\hat{Y} = 3023-392X$). The computed r^2 value (0.2663) indicated that 27% of the difference in yield could be attributed to thrips injury.

1961 Test

Injury-index ratings. Data on thrips injury-index for 12 varieties of cotton grown at Jackson, Georgia, are presented in Table 2. These data show that the damage by thrips was greater at Jackson in 1961 than at Experiment in 1960. Although no injury ratings

Table 1. Yield and thrips injury-index. Experiment, Georgia, 1960.

Variety	Seed cotton, lb/acre	Mean injury-index
Auburn 56	2151 a*	2.76 ab*
All-in-One	1981 ab	2.69 a
Empire WR 61	1893 bc	2.84 abc
DeKalb 108	1890 bc	2.84 abc
Coker 100A	1886 bc	3.19 bcd
Coker 124C	1883 bc	3.22 bcd
Dixie King	1831 bcd	2.94 abc
Empire WR	1808 bcd	2.88 abc
Rex	1808 bcd	3.12 abcd
Fox 4	1782 bcde	3.45 de
Deltapine 15	1759 bcde	3.44 de
Plains	1755 bcde	3.26 cde
Stoneville 7	1716 cde	3.14 abcd
Acala 4-42	1615 de	3.18 bcd
Stardel	1601 de	3.08 abcd
Lankart 57	1565 e	3.68 e

* Duncan's Multiple Range Test. Varieties with the same letter in common are not significantly different at the 5% level.

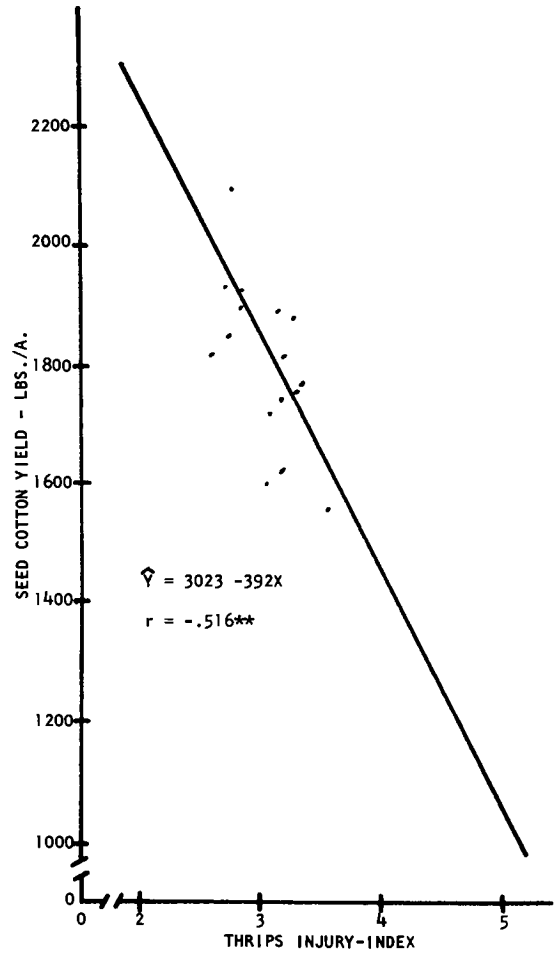

Figure 1. Regression of seed cotton yield on thrips injury-index, Experiment, Georgia, 1960.

Table 2. Thrips injury-index. Jackson, Georgia, 1961.

Variety	Mean injury-index
Empire WR	3.50 a*
Empire WR 61	3.60 ab
Rex	3.79 bc
DeKalb 108	3.82 bc
Dixie King	3.86 bc
Plains	3.95 cd
Stoneville 7	4.14 de
Acala 4-42	4.14 de
Deltapine 15	4.20 de
Auburn 56	4.21 de
Coker 100A	4.24 e
Lankart 57	4.72 f

* Duncan's Multiple Range Test. Varieties with the same letter in common are not significantly different in thrips injury at the 5% level.

were made in a similar variety test at Experiment in 1961, observations showed thrips damage was severe in 1961. At Jackson, the lowest injury-index for individual plots was 3.20 on 'Empire WR' while the highest was 4.88 on Lankart 57. The mean injury-index ranged from 3.50 for Empire WR to 4.72 for Lankart 57. The varieties were generally in the same order of injury-index ranking in both 1960 and 1961 with the exceptions of Auburn 56 and 'Coker 100A' which were relatively more severely damaged in 1961 than in 1960 both in relation to the other varieties, and according to injury-indices recorded. Yield data were not obtained because of poor stand. A highly significant (P=.01) correlation (r=0.73) between the 1960 and 1961 thrips-injury indices indicated that the 12 varieties common to the test both years were reacting to thrips injury in a similar manner.

Yield data from the 1960 test agrees substantially with results reported by several others. Ballard (1) reported that plants of one variety with grade 7 injury were 2 weeks later and produced only 48% as much cotton as the uninjured plants of the same variety. Another variety in his tests with grade 10 injury (most severe) flowered later and produced less than 20% as much cotton as plants of the same variety with grades 2 and 3 injury.

Dunnam and Clark (4) reported the effect of thrips injury on 40 cotton varieties, strains, or selections. Thrips injury delayed boll set 10 to 14 days, reduced average boll set 7.7%, and reduced yield 13%. However, no differences in varietal resistance to thrips injury were reported. Fletcher and Gaines (7) concluded that yield in 12 bottomland fields was reduced an estimated average 107 pounds seed cotton per acre. Owen (12) reported that the control of thrips and fleahoppers increased yield 310 to 602 pounds seed cotton per acre, and that the average gross value of these increases was $50.44 per acre.

Evaluation of Empire genetic background. In addition to the Empire entries, several varieties in the tests have Empire in their genetic make-up. The average mean injury-index for these Empire-type varieties is much less than for the varieties without Empire in their genetic background. Ratings were 2.92 for Empire-type and 3.24 for non-Empire-type in 1960, and 3.71 and 4.23, respectively, in 1961. These results substantiate the findings of Ballard (1) that Empire was damaged less than other varieties. Tugwell and Waddle (15) reported similar results in which 'Rex' (Empire-type) and Deltapine 15 (non-Empire-type) were tested. Rex showed slight thrips damage while Deltapine 15 showed medium to heavy damage even though the counts of thrips were the same on both varieties. They also found that the heavy damage to Deltapine 15 delayed fruit development 7 to 10 days.

Results show that the varieties tested fall into three general categories of thrips-injury. Empire and related varieties were injured the least. Deltapine 15 and 'Fox' were the most severely injured, and the other varieties were intermediate. 'Acala 4-42' and Lankart 57 ranked high in thrips injury but are not adapted to the Southeast area of cotton production.

Although yield differences associated with thrips injury are real, as shown by these tests, it should be pointed out that yield genes could be correlated also with thrips tolerance or resistance. This possibility remains unevaluated since the varieties used in the study were not grown in this environment without thrips injury. In addition, varietal differences could reflect preference by the insect rather than actual resistance by the variety. In either case, the thrips injury-index is a good tool for evaluation of varietal resistance to thrips and should be valuable in a breeding program. Results also show the apparent value of Empire genes for thrips resistance. This resistance, along with the outstanding combining ability of Empire (which has long been recognized by breeders) enhances the value of Empire genes in a breeding program.

LITERATURE CITED

1. BALLARD, W. W. 1951. Varietal differences in susceptibility to thrips injury in Upland cotton. Agron. J. 43:37-44.
2. BECKHAM, C. M., and MORGAN, L. W. 1955. Results of field tests with compound 3911 for control of cotton insects during 1955. Georgia Agr. Exp. Sta. Mimeo Series N. S. 15.
3. BROOK, T. S. 1961. Yields increased by thrips control in station tests. Mississippi Farm Research. 24(5):1, 5.
4. DUNNAM, E. W., and CLARK, J. C. 1937. Thrips damage to cotton. J. Econ. Entoml. 30:855-857.
5. EDDY, C. O., and CLARKE, W. H. 1930. The onion thrips on seedling cotton, with a season's record of parthenogenetic development. J. Econ. Entomol. 23:704-708.
6. ———, and LIVINGSTONE, E. M. 1931. *Frankliniella fusca* Hinds (thrips) on seedling cotton. South Carolina Agr. Exp. Sta. Bull. 271.
7. FLETCHER, R. K., and GAINES, J. C. 1939. The effect of thrips injury on production in cotton. J. Econ. Entomol. 32:78-80.
8. KAUFFMAN, WILLIAM, and STEVENSON, W. A. 1953. Value of early-season control of thrips on cotton in the Santa Cruz valley of Arizona. J. Econ. Entomol. 46:1111-1112.
9. LECLERG, E. L. 1957. Mean separation by the functional analysis of variance and multiple comparisons. USDA, ARS-20-3:23.
10. NEWSOM, L. D., ROUSSEL, J. S., and SMITH, C. E. 1953. The tobacco thrips; its seasonal history and status as a cotton pest. Louisiana Tech. Bull. 474.
11. OWEN, W. L., Jr. 1955. Early-season control of thrips and cotton fleahoppers on the High Plains. Texas Agr. Exp. Sta. Progress Rep. 1781.
12. ———. 1956. Thrips and cotton fleahopper control on the High Plains, 1955. Texas Agr. Exp. Sta. Progress Rep. 1859.
13. RACE, S. R. 1961. Early-season thrips control on cotton in New Mexico. J. Econ. Entomol. 54:974-976.
14. SMITH, G. L. 1942. California cotton insects. California Agr. Exp. Sta. Bull. 660.
15. TUGWELL, N. P., and WADDLE, B. A. 1964. Yield and lint quality of cotton as affected by varying production practices. Arkansas Agr. Exp. Sta. Bull. 682.
16. WATSON, T. F. 1965. Cotton yields—Thrips control vs. none. Highlights of Agricultural Research. Agr. Exp. Sta., Auburn, Alabama. Vol. 12. No. 1.
17. WATTS, J. G. 1937. Species of thrips found on cotton in South Carolina. J. Econ. Entomol. 30:857-860.
18. ———. 1937. Reduction of cotton yield by thrips. J. Econ. Entomol. 30:860-863.