Reproductive Success and Damage Potential of Tobacco Thrips and Western Flower Thrips on Cotton Seedlings in a Greenhouse Environment[1]

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ABSTRACT A greenhouse study was performed to assess the damage and reproductive potential of two thrips (Thysanoptera: Thripidae) species on cotton, *Gossypium hirsutum*, seedlings grown under relatively cool temperatures. The reproductive potential of tobacco thrips, *Frankliniella fusca* (Hinds), was greater than that of western flower thrips, *Frankliniella occidentalis* (Pergande), on two cotton varieties (Deltapine 436 RR® and Stoneville 474®). Plant biomass measurements and visual plant damage ratings performed on the last day of the study suggested that the damage potential of tobacco thrips was less than that of the western flower thrips. No differences in the reproductive potential of either thrips species were observed between the two cotton varieties used in the experiment. The results of this study confirm the importance of thrips identification because damage to cotton seedlings may be a function not only of population sizes, but also of the thrips species involved.

KEY WORDS Thysanoptera, Thripidae, *Frankliniella fusca*, *Frankliniella occidentalis*, *Gossypium hirsutum*, early-season injury

Thrips (Thysanoptera: Thripidae) are early season pests of cotton, *Gossypium hirsutum*, that typically infest seedlings immediately following emergence. Both adult and juvenile stages injure cotton seedlings by rasping the young, tender leaves and terminals, resulting in distortion of leaf shape, browning along leaf margins or over the entire leaf, and holes in the leaf margin. Thrips feeding injury to the cotyledon stage leaves is characterized by stippling that can ultimately result in loss of chlorophyll and, in severe cases, a torn, ragged appearance. Various thrips species may significantly impact both developmental and maturity parameters, including yields (Gaines 1934, Dunham & Clark 1937, Newsom et al. 1953, Herbert 1998, Van Duyn et al. 1998).

Numerous factors have been identified that contribute to variations in thrips damage to cotton seedlings observed annually. These factors include cotton variety, weather, and thrips density. Different cotton varieties have demonstrated varying levels of tolerance to thrips injury, and these variations have been attributed to plant characteristics such as trichome density, gossypol production,

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and thickness of the epidermal tissue (Gawaad & Soliman 1972, Rummel & Quisenberry 1979, Bowman & McCarty 1997). Faircloth et al. (1998) concluded that a combination of cool, wet weather, coupled with moderate to high thrips populations during the seedling stage of cotton resulted in heavily damaged cotton and reduced yields in eastern North Carolina.

Another factor that potentially impacts the extent of thrips damage is the species composition of thrips populations that colonize cotton seedlings. The importance of species composition as it relates to the extent of damage is not well understood. J. G. Watts (1937) suggested the importance of knowing the species composition of thrips as it relates to their control. Hightower (1958) later reported the damage potential of the tobacco thrips, *Frankliniella fusca* (Hinds), on seedling cotton in a greenhouse study to be greater than that of the eastern flower thrips, *Frankliniella tritici* (Fitch).

Two of as many as six species commonly found infesting cotton seedlings are western flower thrips, *Frankliniella occidentalis* (Pergande), and tobacco thrips. The most prevalent species inhabiting cotton seedlings in numerous states including North Carolina is the tobacco thrips (Newsom et al. 1953, Burris 1980, All et al. 1993, Van Duyn et al. 1998). Past studies conducted in North Carolina reported western flower thrips as composing only a small proportion of the species complex (Van Duyn et al. 1998, Faircloth et al. 1999); however, unusually high proportions of western flower thrips were reported on seedling cotton in certain areas of North Carolina in 1999 (Bacheler 1999). Increased proportions of western flower thrips in seedling cotton are of great concern for two reasons: western flower thrips are more difficult to control with certain conventional insecticides (Bacheler 1999), and they also may vary from other species of thrips in their reproductive and damage potentials.

One objective of this study was to compare the reproductive success of western flower thrips and tobacco thrips on seedlings of two cotton varieties under controlled environmental conditions in a greenhouse. Another objective of this study was to compare the damage potentials of western flower thrips and tobacco thrips on seedlings of two cotton varieties under controlled environmental conditions.

Materials and Methods

This study was conducted in a greenhouse at North Carolina State University in Raleigh, North Carolina. The two cotton varieties used were Deltapine 436 RR® and Stoneville 474® because these varieties are commonly grown in North Carolina. The test was initiated and seeds were sown on 10 October 1999. Seeds were sown in black plastic, 3.78-liter pots containing Scotts Metro Mix 200 potting soil. Cylindrical, insect-proof containers (15 cm diameter × 30 cm height) constructed of 5-mm, clear Vivak plastic (AIN Plastics Corp., Greensboro, North Carolina) covered with Bed Bug 110 fine-mesh screening (Green Thumb Group, Inc., Dawners Grove, Illinois) were placed inside the outer rim of the pots gently seated below the soil line. From 15 October to 27 October, mean daily temperatures of 28:16°C (L:D) and a photoperiod of 14:10 h (L:D) were recorded. Beginning 28 October and continuing through the remainder of the experiment, mean daily temperatures were increased and held at temperatures of 32:20°C (L:D) and a photoperiod of 14:10 h (L:D). Mean temperatures were increased in this experiment to simulate the temperature typical at and shortly after planting cotton in eastern North Carolina in early to mid May.

Newly emerged seedlings of both varieties were individually infested with 10 newly eclosed adult thrips per plant on 15 October. Both thrips species used in the experiment were obtained from a laboratory colony maintained on green bean pods (*Phaseolus vulgaris* L.) in an enclosed chamber held at 24°C, 65% RH, and a photoperiod of 14:10 (L:D) h. Approximately 24–48 h following enclosure, adults were aspirated into 2.5-ml disposable Pasteur® pipettes (10 thrips/pipette), and the ends of the pipettes were sealed with Parafilm® to prevent escape.

The seedlings remained infested for 21 d, representing the period of time that thrips commonly infest North Carolina cotton seedlings at damaging population levels. This period of time was also selected to maximize thrips recovery based on documented life cycles (Robb 1988, Lewis 1997). To compare the reproductive success of the two species, the exclusion cages were lifted from each pot on 4 November while simultaneously severing the seedlings directly below the cotyledonary nodes. A plant washing procedure similar to that described by Irwin & Yeargan (1980) was used. Seedlings were placed in labeled mason jars containing a 0.1% detergent solution and were subsequently emptied over a #100 U.S.A. Standard Testing Sieve (150 μm). All residue remaining in the sieve was further rinsed into a 20-ml scintillation vial containing 70% EtOH. Each vial was later individually emptied into a petri dish under a dissecting scope where the number of juvenile thrips and adult thrips were counted and recorded.

On 29 October and 4 November, the cotton seedlings were visually rated to assess the relative damage potential of the two species of thrips. Ratings were based on the severity of thrips feeding damage to the newly emerging true leaves. The signs of thrips damage considered included distortion, discoloration, and tears or missing areas in the true leaves. The rating scale used ranged from 1 to 5 and is described as follows: 1, leaves with no visible damage; 2, slight damage (crinkling or browning of leaf with less than 25% leaf loss); 3, moderate damage (crinkling and browning with less than 50% leaf loss); 4, severe damage (leaf loss greater than 50% yet remains of the leaf present); and 5, complete loss of true leaves.

Immediately following thrips recovery on 4 November, the seedlings from each jar were dried for 24 h in a Thelco, Model 17 (Precision Scientific, Winchester, Virginia) drying oven at 65°C. At the end of the drying period, the plants were removed from the oven and weighed. Because thrips damage on cotton seedlings is usually more intense on the true leaves, and the cotyledons appeared to comprise a significant amount of the total seedling weight, cotyledons were then removed and all plants were reweighed. All weights were taken using a Precision Standard (OHAUS, Florham Park, New Jersey) scale.

The four treatments consisted of two cotton varieties (Stoneville 474® and Deltapine 436®) and two species of thrips (tobacco and western flower thrips) in all combinations. This two by two factorial design was set within a randomized complete block with three replicates. Each replicate was contained on a different bench within the greenhouse. Populations of thrips recovered were log transformed prior to analysis to normalize variance. The analysis of variance was performed using Pesticide Research Manager Software (Gyllings Data Management, Inc., Brooking, South Dakota). Reported means in tables and figures are all back-transformed. Data from the plant measurements were analyzed using the same analysis of variance but without transformation.

Results and Discussion

Thrips reproduction. Both thrips species used in these experiments reproduced successfully under the greenhouse environments utilized. Mean numbers of juvenile thrips per plant were 36.90 and 23.97 for tobacco thrips and western flower thrips, respectively, after 21 d, and averaged over both cotton varieties (Table 1). Populations of tobacco thrips juveniles were significantly higher ($F = 501.8$, df = 1 and 6, $P = 0.059$) than that of western flower thrips and there was not a significant thrips species by cotton variety interaction ($F = 0.550$, df = 1 and 6, $P = 0.4861$), suggesting that the reproductive potential was higher for tobacco thrips on both plant varieties. Adult numbers were relatively low upon termination of the test at 2.52 tobacco thrips per plant and 4.27 western flower thrips per plant. No significant differences ($F = 4.628$, df = 1 and 6, $P = 0.0750$) in adult counts were observed between thrips species averaged over both cotton varieties or with the thrips species by cotton variety interaction ($F = 0.638$, df = 1 and 6, $P = 0.4547$) (Table 1). Cotton variety did not appear to have a significant effect on reproduction in either thrips species as there were no significant main effects regarding juvenile ($F = 0.459$, df = 1 and 6, $P = 0.5234$) or adult ($F = 0.353$, df = 1 and 6, $P = 0.5741$) thrips, averaging over thrips species (Table 2).

Successful reproduction of both thrips species confirmed the validity of the greenhouse techniques employed to compare damage potential on seedling cotton. Furthermore, the adult-to-juvenile thrips ratios approximate those observed in field experiments (Faircloth et al. 1998).

Plant damage evaluation. The 29 October damage rating (14 d postinfestation) averaged 2.20 and 3.68 over both varieties for tobacco thrips and western flower thrips, respectively, implying that western flower thrips populations imparted significantly greater damage ($F = 274.14$, df = 1 and 6, $P = 0.0001$) (Table 1). Likewise, on 4 November (20 d postinfestation), seedlings infested with western flower thrips again averaged a significantly higher damage rating ($F = 91.125$, df = 1 and 6, $P = 0.0001$) of 3.7 compared with 2.8 for tobacco thrips populations. There were no significant effects of cotton variety averaged over thrips species on 29 October ($F = 1.69$, df = 1 and 6, $P = 2.413$) or on 4 November ($F = 1.125$, df = 1 and 6, $P = 0.3297$). The thrips species by cotton variety interaction was not significant on 29 October ($F = 0.034$, df = 1 and 6, $P = 0.8588$) or on 4 November ($F = 1.125$, df = 1 and 6, $P = 0.3297$). Damage did not increase proportionally between 29 October and 4 November, perhaps as a result of greenhouse temperatures being elevated during the experiment to simulate temperature increases typical of field conditions. Thus, cotton seedling growth and seedling tolerance to thrips infestations may have increased over the course of the experiment.

Dry weights of whole cotton seedlings after 21 d of western flower thrips infestation were significantly reduced relative to dry weights of whole cotton seedlings after 21 d of tobacco thrips infestation ($F = 64.483$, df = 1 and 6, $P = 0.0002$) (Table 1). Significant differences were also found regarding cotton variety averaged over thrips species ($F = 0.0258$, df = 1 and 6, $P = 12.53$) as Stoneville

TABLE 1. Mean number (± SEM) of adult and juvenile thrips, rating scale values, and seedling dry weights per plant at 21 d after infestation, averaged over two cotton varieties.

Thrips species	Juvenile thrips	Adult thrips	Rating scale value[a] (Oct. 29)	Rating scale value (Nov. 4)	Dry weight	Dry weight[b]
F. fusca	36.90 ± 4.85	2.52 ± 0.59	2.20 ± 0.11	2.80 ± 0.07	196.22 ± 13.6	78.17 ± 10.16
F. occidentalis	23.97 ± 2.44	4.27 ± 1.33	3.68 ± 0.16	3.70 ± 0.12	155.10 ± 14.62	40.97 ± 9.87

[a]Rating scale values ranged from 1 to 5 and is described as follows: 1, leaves with no visible damage; 2, slight damage (crinkling or browning of leaf with less than 25% leaf loss); 3, moderate damage (crinkling and browning with less than 50% leaf loss); 4, severe damage (leaf loss greater than 50% yet remains of the leaf present); and 5, complete loss of true leaves.
[b]Dry weight taken without cotyledons attached in grams.

TABLE 2. Mean number (± SEM) of adult and juvenile thrips, rating scale values, and seedling dry weights per plant at 21 d after infestation, averaged over two thrips species.

Cotton variety	Juvenile thrips	Adult thrips	Rating scale value[a] (Oct. 29)	Rating scale value (Nov. 4)	Dry weight	Dry weight[b]
Stoneville 474	29.38 ± 5.6	3.63 ± 1.35	2.88 ± 0.26	3.30 ± 0.49	183.2 ± 14.05	57.87 ± 12.94
Deltapine 436	31.48 ± 5.54	3.15 ± 0.77	3.00 ± 0.33	3.20 ± 0.48	168.12 ± 22.22	61.27 ± 17.54

[a]Rating scale values ranged from 1 to 5 and is described as follows: 1, leaves with no visible damage; 2, slight damage (crinkling or browning of leaf with less than 25% leaf loss); 3, moderate damage (crinkling and browning with less than 50% leaf loss); 4, severe damage (leaf loss greater than 50% yet remains of the leaf present); and 5, complete loss of true leaves.
[b]Dry weights taken without cotyledons attached in grams.

474® whole seedling weight was reduced less than that of Deltapine 436 RR® seedlings. There was not a significant thrips species by cotton variety interaction (F = 5.786, df = 1 and 6, P = 0.0529) with respect to the mean dry weights of whole cotton seedlings. By visual inspection, it appeared that the cotyledonary leaves of the seedlings sustained less damage relative to the terminals of the plants while the cotyledons comprised over 75% of the total biomass. Therefore, the seedlings were reweighed after removing the cotyledonary leaves. The effect of thrips species on seedling weight after removal of cotyledon leaves averaged across varieties was significant (F = 143.102, df = 1 and 6, P = 0.0001) (Table 1). Cotton variety averaged across thrips species had no significant effect on the seedling weights after removal of cotyledons (F = 1.195, df = 1 and 6, P = 0.3162) (Table 2), and there was not a significant thrips species by cotton variety interaction (F = 3.243, df = 1 and 6, P = 1218).

In summary, the reproductive potential of tobacco thrips was greater than that of western flower thrips on cotton seedlings in this greenhouse study; however, the damage potential of western flower thrips was greater than that of tobacco thrips. Thus, although population size of thrips infesting cotton is important, the species composition of thrips populations may also markedly impact damage potential. The results of this study confirmed the importance of thrips species identification in studies that evaluate thrips management tactics and strategies.

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