# Monitoring Thrips (Thysanoptera: Thripidae) Presence in Flue-Cured Tobacco Using Yellow Sticky Traps[1]

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**Abstract** The thrips-borne tomato spotted wilt tospovirus is a serious economic threat to Georgia's flue-cured tobacco crop. Two thrips vectors, *Frankliniella fusca* (Hinds) and *F. occidentalis* (Pergande), are commonly encountered on tobacco foliage and blooms, respectively. Yellow sticky traps were monitored after a 48-h field exposure from March through June in 2003-2005 to assess thrips movement and species composition in the tobacco farmscape. During March each year there were similar numbers of *F. fusca* and the flower thrips complex [*F.occidentalis*, *F. tritici* (Fitch) and *F. bispinosa* (Morgan), combined] captured on sticky cards. During April, May and June, the flower thrips complex steadily became more abundant comprising around 60, 70, and 95% of the trap capture, respectively. Thrips vector species were captured throughout the entire sampling period. In April and May, *F. fusca* captures on stick traps related to *F. fusca* population densities on tobacco foliage. Some sampling periods had differences in thrips captures relative to a north, south, east, or west orientation, with each direction having the highest thrips numbers at least once each season. However, the overall seasonal mean capture was higher on the eastward direction all 3 yrs and on the westward direction on 2 of the 3 yrs, compared to the southern and northern directions. In a time-of-day study, very few thrips were captured between 1830 h and 0,700 h the following morning. Thrips movement increased in midmorning and peaked during midafternoon. It appears that sticky cards can be used to monitor early colonization of thrips species in tobacco fields plus monitor thrips movement throughout the day, thus providing information on when potential vectors arrive and move within the field. Sticky trap monitoring provides an alternative to direct plant observation for predicting thrips abundance on tobacco foliage and the need for thrips controls.

**Key Words** *Frankliniella fusca*, *Frankliniella occidentalis*, *Frankliniella tritici*, thrips sampling

Thrips (Thysanoptera: Thripidae) have steadily increased in economic importance as pests of flue-cured tobacco in Georgia during the past 10 yrs, due to their transmission of tomato spotted wilt Tospovirus (TSWV). In 1996, there was an average statewide tobacco stand reduction of 5-8% due to TSWV with no reported crop loss (Bertrand 1997), whereas in 2002 there was a 40% stand reduction and a crop loss in excess of $19 million due to TSWV (Bertrand 2003). TSWV is vectored exclusively by thrips (Wijkamp et al. 1995), and two known TSWV vectors are reported to be commonly observed on tobacco, the tobacco thrips, *Frankliniella fusca* (Hinds), and the western flower thrips, *F. occidentalis* (Pergande) (McPherson et al. 1999). *Fran-*

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*kliniella fusca* feeds on tobacco foliage and is present soon after the tobacco is transplanted and peaks in early to midMay, when the tobacco begins to flower (McPherson et al. 1992). *Frankliniella occidentalis* is present in tobacco blooms later in the season and is one of several species in the flower thrips complex that feeds on tobacco. *Frankliniella tritici* (Fitch) is the most common thrips in tobacco blooms; this species is not reported as a vector of TSWV (McPherson et al. 1992).

Currently, GA tobacco producers are treating transplants with imidacloprid (Admire 2F, Bayer Agrichemical Division, KS City, MO) either in the greenhouse prior to transplanting or in the transplant water at the time of transplanting to reduce the risks of TSWV (McPherson et al. 2005). Recent reports also have suggested that early-season foliar applications of acephate insecticide (Orthene 97PE, Valent USA Corp., Walnut Creek, CA) also can help to control thrips and suppress TSWV symptomatic plants (McPherson et al. 2005). However, neither of these management tactics use thrips sampling or population densities to justify the insecticide applications.

Sampling for thrips on tobacco is laborious, requiring the direct observation of tobacco foliage and carefully examining each leaf, both top and bottom surfaces, for these minute insects. Thrips sampling in early season is particularly time consuming because population densities during the first 3-4 wks after transplanting are very low, often less than 1 thrips per 10 plants (McPherson et al. 2005). Thus, a large number of plant samples is needed to detect thrips presence and to collect a small number for species identification and TSWV confirmation. Previous research has documented the seasonal abundance of thrips on flue-cured tobacco (McPherson et al. 1992, 1999), but alternative monitoring procedures to replace direct plant observation are needed for growers and field scouts to efficiently and effectively predict thrips presence. Sticky traps have been used to monitor thrips in several crops (Atakan and Canhilal 2004, Matos and Obrycki 2004, Brodsgaard 1989, Cho et al. 1995, Gillespie and Vernon 1990); however, information on their use in tobacco is limited. Thus, this study was conducted to evaluate yellow sticky traps for monitoring thrips movement and relative species abundance in flue-cured tobacco fields in Georgia.

## Materials and Methods

In midMarch (the entire month in 2005), around 1-2 wk before transplanting K-326 flue-cured tobacco, 10 yellow 7.6 × 12.7 cm sticky traps (Olson Products, Medina, OH 44,258) with sticky coating on both sides were randomly placed in the field at the Coastal Plain Experiment Station Bowen Farm in Tift Co., GA, during the 2003-2005 seasons. Traps were secured with a spring clip to a 2.5-cm diam plastic pole 2.7 m long that was pushed about 30 cm into the soil. The traps were positioned above the top of the tobacco plant canopy on each date. At each of five trap sites one trap was placed in a North/South orientation, and a second trap placed in an East/West orientation, yielding 2 traps per site (10 traps total). Traps were placed in the field between 0,800-0,900 h and retrieved 48 h later. After field exposure, the traps were placed into 15.2 × 20.3 cm clear plastic bags (Automated Packaging Systems, Streetsboro, OH 44,241), labeled, and returned to the laboratory. Daily weather information for Tift Co. was obtained from the National Weather Service (2005) to monitor predicted daily temperatures and rainfall patterns.

Thrips were counted, with the aid of a dissecting microscope, on each side of the trap indicating the direction from which the thrips arrived at the trap (N, S, E, or W). Thrips monitoring with traps continued until late June, after tobacco harvesting had

begun. During May of 2003, three additional trap locations were placed in the field using two traps per site as previously described. These six traps were placed in the field at 0700h and then collected and replaced after the following field exposure time periods (daylight savings time): 0,700-1100 h, 1100-1600 h, 1600-2100 h, 2100-0,700 h the next morning. In 2004, five additional trap locations (2 traps per location) were established, and the following field exposure periods were used: 0,700-0,900 h, 0,900-1100 h, 1100-1330 h, 1330-1600 h, 1600-1830 h, 1830-2100 h, and 2100-0,700 h the next morning. There were five 24-h observation periods each year, thus $n = 15$ for each trap direction in 2003 and $n = 25$ in 2004. Thrips were counted as previously described. Because the thrips specimens were embedded in the sticky trap surface, most of the thrips were not mounted on microscope slides for examination. Thus, thrips identifications were limited to three broad categories: *F. fusca* (those that fit the customary size, color, and morphological characters), flower thrips (*F. occidentalis*, *F. tritici*, and *F. bispinosa* (Morgan), combined), and 'other thrips' species, which included Tubulifera, *Chirothrips* spp., *Limothrips cerealium* (Haliday), and other *Frankliniella* spp. Because accurate thrips identification requires each specimen to be mounted and observed under magnification, our thrips count data were categorized into these three categories. On a few trap samples each month of each year, the tobacco and flower thrips were carefully removed from the trap with a modified dissecting pin, then mounted on microscope slides and examined with a dissecting microscope and identified to species (Beshear 1973). Thrips identifications were verified by Ramona Beshear (retired) and Stan Diffie (University of Georgia).

Cultivar K-326 flue-cured tobacco was transplanted between 15-20 March in 2003-2005 at the field site where the sticky traps were being monitored. Production practices followed Georgia Cooperative Extension Service recommendations (Moore 2004). Beginning 1 wk after transplanting and continuing until topping (tobacco blooms removed) adult thrips were counted on the tobacco foliage on four alternating plants at each of the five sticky trap sites in the field (20 total plants sampled each date). All leaves, both top and bottom surface, were visually examined on each plant. No insecticides were applied in the thrips sampling areas during any of the 3 yrs of this study. On alternate sampling dates, thrips were randomly collected from the tobacco foliage, placed in 70% ethyl alcohol, and returned to the laboratory to be identified.

Thrips capture data were analyzed by species category and total numbers by month each year, by direction each date and over all dates each year, and by time-of-day using an analysis of variance ($P = 0.05$; SAS Institute 1990). Significant means were separated using the Waller-Duncan K ratio test (SAS Institute 1990). The percentages of tobacco thrips, flower thrips, and other thrips species in the complex were calculated for total 48 h thrips captures and time-of-day captures each year.

## Results and Discussion

The yearly total numbers of thrips captured on yellow sticky traps are presented in Table 1. The mean thrips per 10 traps was relatively low during March of all 3 yrs, and the flower thrips species comprised around 40-60% of the thrips complex. Thrips captures rapidly increased during April and May, then declined somewhat in June. In June, the flower thrips species accounted for >93% of the total thrips captured for all 3 yrs. The tobacco thrips, a known vector of tomato spotted wilt virus (Sakimura 1963) and the most common foliage thrips on tobacco in Georgia (McPherson et al. 1999),

**Table 1. Thrips captured on 7.6 × 12.7 cm yellow sticky traps after a 48-hour exposure in a flue-cured tobacco field in Tift Co., GA, 2003-2005**

| Sampling month (No. 48 h obs.) | Monthly total thrips captured on traps | | | Mean per 10 traps | Percent flower |
|---|---|---|---|---|---|
| | Tobacco | Flower | Other spp. | | |
| | | | 2003 | | |
| March (5) | 24 | 47 | 5 | 15.2 | 61.8 |
| April (10) | 585 | 1,272 | 89 | 194.6 | 65.4 |
| May (10) | 674 | 2,780 | 80 | 353.4 | 78.7 |
| June (10) | 129 | 2,582 | 44 | 275.5 | 93.7 |
| | | | 2004 | | |
| March (7) | 198 | 140 | 5 | 49.0 | 40.8 |
| April (8) | 1,121 | 839 | 80 | 255.0 | 41.1 |
| May (8) | 1,170 | 1,644 | 90 | 363.0 | 56.6 |
| June (8) | 100 | 2,294 | 27 | 302.6 | 94.8 |
| | | | 2005 | | |
| March (13) | 292 | 460 | 44 | 61.2 | 57.8 |
| April (13) | 635 | 835 | 68 | 118.3 | 54.3 |
| May (12) | 1,745 | 6,731 | 141 | 718.1 | 78.2 |
| June (12) | 254 | 5,617 | 39 | 492.5 | 95.0 |

Tobacco thrips are *Frankliniella fusca* and flower thrips are *F. occidentalis*, *F. tritici*, and *F. bispinosa*, combined. Each 48 h observation period had a total of ten traps.

was captured on sticky cards every month of the sampling period in all 3 yrs of this study. *Frankliniella occidentalis*, also a known vector of spotted wilt virus (Sakimura 1962), was commonly collected on the sticky traps. However, based on mounted specimens identified throughout the season, *F. tritici* and *F. bispinosa* were more common flower thrips in the tobacco farmscape than *F. occidentalis*. Overall trap captures were similar in 2003 and 2004, but much higher in 2005, especially during May (Table 1). Mean *F. fusca* ($F = 8.85$; df = 3,6; $P = 0.012$) and 'other thrips' species ($F = 11.38$; df = 3,6; $P = 0.007$) were more numerous on sticky traps in April and May compared with March and June, whereas flower thrips ($F = 8.37$; df = 3,6; $P = 0.014$) were more abundant on traps in May and June (Table 2). Total thrips captures ($F = 7.87$; df = 3,6; $P = 0.017$) were highest in May (mean of 478.2 per 10 traps) and lowest in March (41.8 per 10 traps) (Table 2). When comparing monthly mean thrips captures between the three thrips categories, flower thrips were more numerous than the 'other thrips' on all four sampling months, and *F. fusca* were more abundant than the 'other thrips' species in 3 of the 4 months (March: $F = 6.98$; df = 2,4; $P = 0.049$; April: $F = 7.11$, df = 2,4; $P = 0.048$; May: $F = 7.77$; df = 2,4; $P = 0.041$; June: $F = 25.90$, df = 2,4; $P = 0.005$). Also, flower thrips were more abundant than *F. fusca* during May and June (Table 2).

**Table 2. Mean (±SEM) thrips per 10 sticky traps per month in a flue-cured tobacco field in Tift Co., GA, 2003-2005**

| Sampling month | Mean thrips per 10 traps | | | |
|---|---|---|---|---|
| | *F. fusca* | Flower thrips | Other spp. | Total |
| | Thrips category by month | | | |
| March | 18.5 ± 10.8 b | 21.6 ± 18.0 b | 1.7 ± 0.9 b | 41.8 ± 20.5 c |
| April | 82.5 ± 23.4 a | 98.8 ± 15.0 b | 8.0 ± 2.6 a | 189.3 ± 32.4 bc |
| May | 119.7 ± 21.6 a | 348.1 ± 94.2 a | 10.3 ± 1.1 a | 478.2 ± 97.7 a |
| June | 15.5 ± 2.8 b | 337.7 ± 53.7 a | 3.7 ± 0.4 b | 356.9 ± 55.8 ab |
| | Monthly comparisons between categories | | | |
| March | 18.5 ± 10.8 a | 21.6 ± 18.0 a | 1.7 ± 0.9 b | |
| April | 82.5 ± 23.4 a | 98.8 ± 15.0 a | 8.0 ± 2.6 b | |
| May | 119.7 ± 21.6 b | 348.1 ± 94.2 a | 10.3 ± 1.1 c | |
| June | 15.5 ± 2.8 b | 337.7 ± 53.7 a | 3.7 ± 0.4 b | |

Sticky trap counts after a 48 h field exposure. Flower thrips included *F. occidentalis*, *F. tritici*, and *F. bispinosa*, combined. Other thrips species included *Chirothrips* spp., other *Frankliniella* spp., *Limothrips cerealium*, and suborder Tubulifera. Column means for thrips category by month and row means for monthly comparisons between thrips categories followed by the same letter are not significantly different (Waller-Duncan's K ratio test, $P = 0.05$).

Foliage thrips densities (predominately *F. fusca*) were essentially nonexistent on tobacco foliage until around the second wk of April. Then, populations steadily increase and peaked around midMay (Fig. 1). In 2004, the higher densities of *F. fusca* on tobacco foliage during April related to the higher numbers of *F. fusca* collected on the sticky traps during this same time period (Table 1). The higher May 2005 sticky trap captures of *F. fusca* also related well with the highest 15 May peak of *F. fusca* on tobacco foliage in 2005. Thus, it appears that sticky trap captures might be useful in predicting foliage thrips abundance on tobacco foliage. The flower thrips captures on sticky traps are not a good indicator of thrips presence on tobacco foliage because around 90% of the thrips species on tobacco foliage are *F. fusca* (McPherson et al. 1999). In this study, 85, 91, and 88% of the foliage thrips were *F. fusca* in 2003-2005, respectively. The other thrips on tobacco foliage included *Limothrips cerealium*, *Chirothrips* spp., other *Frankliniella* spp., and the suborder Tubulifera. The flower thrips species are present on tobacco blooms in early June to early July; however, tobacco blooms are removed (topping of the tobacco plant) soon after the flowers are present. Thus, flower thrips are on tobacco blooms for only a short time, usually no more than a couple of weeks.

The seasonal mean total thrips captures were higher on the eastward side of the sticky traps than on the southern side in all 3 yrs of this study, and higher than the northern side on 2 of the 3 yrs (2003: $F = 3.11$; df = 3,692; $P = 0.025$; 2004: $F = 4.80$; df = 3,612; $P < 0.01$; 2005: $F = 2.88$; df = 3,992; $P = 0.035$) (Table 3). The overall captures on the westward side also were higher than on the southern side in 2003 and

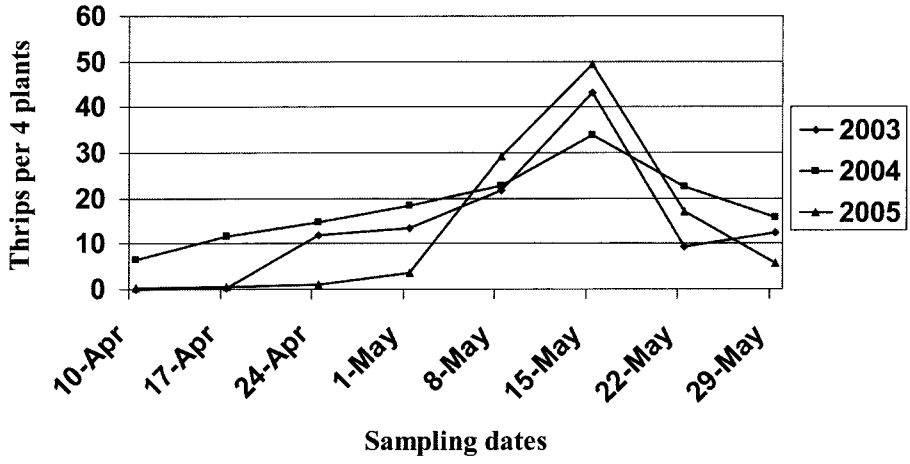


Fig. 1. Seasonal abundance of thrips (primarily *Frankliniella fusca*) on tobacco foliage, Tift Co., GA 2003-2005.

**Table 3. Seasonal mean (±SEM) thrips captured (March-June) on each 7.6 × 12.7 cm yellow sticky trap surface oriented in one of four directional positions (N, S, E, W) in a flue-cured tobacco field in Tift Co., GA, 2003-2005**

| | Seasonal mean number of thrips per trap | | |
|---|---|---|---|
| Direction of trap surface | 2003 (N = 175) | 2004 (N = 155) | 2005 (N = 250) |
| North | 10.5 ± 1.0 b | 13.7 ± 1.8 a | 15.3 ± 2.6 b |
| South | 9.5 ± 1.2 b | 9.0 ± 1.6 b | 14.2 ± 2.8 b |
| East | 13.8 ± 2.2 a | 13.4 ± 2.1 a | 21.2 ± 3.1 a |
| West | 13.6 ± 1.7 a | 13.6 ± 1.9 a | 17.3 ± 1.9 ab |

N = total number of yellow sticky traps observed in each of the four directional positions in the field each year. Column means followed by the same letter are not significantly different (Waller-Duncan's K ratio test, $P = 0.05$).

2004, and higher on the northern side than on the southern side in 2004 (Table 3). These same directional differences also were noted specifically for *F. fusca* and the flower thrips complex for all 3 yrs of this study.

Trap captures for total thrips were significantly different between time-of-day exposures in 2003 ($F = 7.19$; df = 3,12; $P < 0.01$) (Table 4). More thrips were captured between 1100-1600 h than during the other three time periods during the 24 h field exposure period. These same significant differences between the time-of-day also were noted for the flower thrips complex ($F = 6.97$; df = 3,12; $P < 0.01$) and for *F. fusca* ($F = 3.76$; df = 3,12; $P = 0.045$), but not for 'other thrips' due to overall low numbers.

**Table 4. Mean thrips (±SEM) captured on 7.6 x 12.7 cm yellow sticky traps placed in a flue-cured tobacco field during specific time periods of the day, Tift Co., GA, 2003**

| Time of day (daylight savings) | Mean thrips per trap | Percentage of thrips species in complex | | |
|---|---|---|---|---|
| | | Tobacco | Flower | Other spp. |
| 0700-1100 h | 12.1 ± 8.2 b | 18.2 | 80.3 | 1.5 |
| 1100-1600 h | 33.3 ± 12.1 a | 21.4 | 77.4 | 1.2 |
| 1600-2100 h | 0.03 ± 0.01 b | 24.7 | 72.3 | 3.0 |
| 2100-0700 h | 0.8 ± 0.6 b | 0.0 | 100.0 | 0.0 |

Observations taken between 15 May and 22 May, with three trap locations (two traps per location) at the site during each of five 24 hour time periods. Thrips species include tobacco thrips (*F. fusca*), flower thrips (*F. occidentalis*, *F. tritici*, and *F. bispinosa*, combined), and other thrips species. Column means with the same letter are not significantly different (Waller-Duncan's K ratio test, $P = 0.05$).

Trap captures for total thrips also were significantly different between time-of-day exposures in 2004 ($F = 15.93$; df = 6,24; $P < 0.01$) (Table 5). The highest number of thrips captured occurred between 1330-1600 h; however, numbers between 0,900-1100 h, 1100-1330 h, and 1600-1830 h also were higher than thrips captured between 1830-2100 h and 2100-0,700 h the following morning. Similar significant differences also were noted for the flower thrips complex ($F = 21.26$; df = 6,24; $P < 0.01$) and for *F. fusca* ($F = 2.78$; df = 6,24; $F = 0.033$).

The lower numbers of thrips captured in March 2003 (only 15.2 per 10 traps over

**Table 5. Mean thrips (±SEM) captured on 7.6 x 12.7 cm yellow sticky traps placed in a flue-cured tobacco field during specific time periods of the day, Tift Co., GA, 2004**

| Time of day (daylight savings) | Mean thrips per trap | Percentage of thrips species in complex | | |
|---|---|---|---|---|
| | | Tobacco | Flower | Other spp. |
| 0700-0900 h | 2.5 ± 0.9 de | 27.0 | 69.8 | 3.2 |
| 0900-1100 h | 6.8 ± 1.7 bc | 25.9 | 73.5 | 0.6 |
| 1100-1330 h | 7.7 ± 1.3 b | 24.7 | 74.0 | 1.3 |
| 1330-1600 h | 10.8 ± 1.8 a | 20.3 | 78.5 | 1.5 |
| 1600-1830 h | 4.0 ± 1.6 cd | 18.2 | 75.0 | 6.8 |
| 1830-2100 h | 0.0 ± 0.0 e | 0.0 | 0.0 | 0.0 |
| 2100-0700 h | 0.3 ± 0.1 e | 14.3 | 85.7 | 0.0 |

Observations taken between 12 May and 27 May, with five trap locations (two traps per location) at the site during each of five 24-hour time periods. Thrips species include tobacco thrips (*F. fusca*), flower thrips (*F. occidentalis*, *F. tritici*, and *F. bispinosa*, combined), and other thrips species. Column means followed by the same letter are not significantly different (Waller-Duncan's K ratio test, $P = 0.05$).

5 dates during the last 2 wks of the month, Table 1) plus the fact that only 31.6% were the vector species *F. fusca* (24 of 76 captured), is probably a key factor to such a low reported incidence of TSWV and crop loss ($ 0.6 million) in tobacco in Georgia in 2003 (Bertrand 2004). Conversely, in 2004, thrips captures were higher in March (mean of 49 per trap), and *F. fusca* comprised over 57% of the thrips complex. Over $17 million were reported lost to the tobacco crop due to TSWV in 2004 (Bertrand 2005). Similarly, thrips numbers (Table 1) and heavy virus losses ($9.57 million) also occurred in Georgia's tobacco crop in 2005 (Bertrand 2006). Thus, it appears that sticky trap captures might be useful in predicting seasonal losses to spotted wilt virus based on March captures and the percentage of the thrips complex that is *F. fusca*.

Why overall seasonal mean captures of thrips are lower on trap surfaces facing the southern direction is not known. During early spring, March through midMay, many weather fronts approach Georgia from the north and west. However, from midMay through the summer a southern airflow is common. Winds from an eastern direction are not as common in south Georgia, although they occur occasionally. However, the trap catches were higher on the traps facing east on all 3 yrs. Clearly, thrips movement within the tobacco farmscape is not just associated with wind direction. At the Bowen Farm test site there were woods within 400 m of all four sides of the field; however, woods were within 100 m on both the east and west sides of the test plots. This proximity to woods, and potential overwintering sites and early spring habitat, is possibly more influential to short distance thrips movement than wind direction. Other factors such as rainfall, humidity, temperature and pollen deposition also could influence thrips movement.

It is interesting to note that thrips activity during late evening, night, and early morning is very limited. This movement is not just associated with lack of daylight, because very few thrips were captured between 1600-2100 h and 0,700-0,900 h when sunlight was present. Thrips movement during both years of the time-of-day study was most active during the hottest, and usually driest, time of the day, between 1100-1600 h. It is usually around 1100 h before the dew is dried from the tobacco foliage during the spring and summer. Nearly every night from March through June, from around 2200 h until around 0,800 h the next morning, the relative humidity is at or near 100% and the foliage is covered in moisture (hourly relative humidity at Tifton, GA, obtained at http://sacs.cpes.peachnet.edu/sewrl/weather/humid.htm). Undoubtedly, moisture, temperature, wind speed/direction, and proximity to other suitable thrips habitat all contribute to thrips activity and movement within the farmscape.

The findings reported herein support the conclusion that yellow sticky traps can be used to monitor thrips movement into the tobacco field soon after transplanting and may provide an indication of thrips vector presence during the early growing season. The relative numbers of *F. fusca* captured on sticky traps during April and May relates to *F. fusca* populations on tobacco foliage during these same months. Thus, producers and field scouts can use trap captures to predict thrips abundance on tobacco foliage. This information will be useful in developing early season thrips management options and possibly be incorporated into a tomato spotted wilt virus outbreak prediction forecast.

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