The Great Lakes Entomologist

Volume 39
Numbers 1 & 2 - Spring/Summer 2006 *Numbers 1 & 2 - Spring/Summer 2006*

Article 4

April 2006

Seasonal Abundance; Damage; and Comparison of Different Heights, Orientations, and Directions of Yellow Sticky Traps for Sampling of *Liriomyza Trifolii* (Diptera: Agromyzidae) in Cotton

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SEASONAL ABUNDANCE; DAMAGE; AND COMPARISON OF DIFFERENT HEIGHTS, ORIENTATIONS, AND DIRECTIONS OF YELLOW STICKY TRAPS FOR SAMPLING OF LIRIOMYZA TRIFOLII (DIPTERA: AGROMYZIDAE) IN COTTON

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ABSTRACT

This study was done to determine the optimum height, orientation, and direction of yellow sticky traps for sampling of *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) in cotton fields. Leaf infestation rates for the whole plants, as well as for each of three plant regions, and number of mines per infested leaf were also determined. Traps were placed at 25 cm above the plant canopy and 30 cm above the ground at two orientations (horizontal and vertical) and two directions (east-to-west and north-to-south) for each height and orientation in Aydin province, Turkey. Horizontally oriented traps captured more flies than vertically oriented traps. More flies were captured 25 cm above the plant canopy than 30 cm above the ground. The upper sides of horizontally oriented traps had the highest capture rates. Direction of traps did not significantly affect capture rate. The infestation rate of leaves was highest (14.1%) the first week of August and generally higher lower on the plant (79.4-100%). No mines were found in the upper region (top third) of the plants. No adults emerged from reared mines. These results are useful in development of sampling protocols to aid growers in making decisions and could be used as an additional component in Integrated Pest Management against *L. trifolii* in cotton fields.

Liriomyza trifolii (Burgess) (Diptera: Agromyzidae) is an important pest insect on tomato, celery, chrysanthemum and other commercially valuable plants in several countries (Parrella and Robb 1982, Parrella 1987, Zoebisch and Schuster 1987), including Turkey (Akbulut and Zumreoglu 1996, Yasarakinci and Hincal 1999, Civelek 2004). In addition to vegetables and ornamental plants, *L. trifolii* damaged cotton in Arizona (USA) (Palumbo 1992), India (Jeyakumar and Uthamasamy 1996), and Israel (Yathom 1989). Sohi et al. (1994) reported that *L. trifolii* was feeding and breeding on cotton from the cotyledon stage to the vegetative phase until mid-August in India. Larval feeding and adult oviposition in leaves may facilitate entry of fungi and bacteria. Leaf mining reduces rates of photosynthesis, transpiration, and stomatal and mesophyllic conductance causing premature leaf drop (Chandler and Gilstrap 1987, Foster and Sanchez 1988).

Gencsoylu (2003) first found *L. trifolii* in Buyuk Menderes Valley, Turkey, in 1998, and reported that the largest number of infested leaves was observed in Aydin, where 18.8% and 17.7% of the sampled leaves were infested in 1999 and 2000, respectively. These infestation rates were higher than the 2-4% rates found in India (Jeyakumar and Uthamasamy 1996).

Some management measures are necessary to control *Liriomyza* spp. (Parrella 1982, Palumbo et al. 1994). Sticky card traps attract and capture flying adults (hereafter: flies) and can help growers detect early pest activity more effectively than intensive plant sampling and may help to determine the proper time for implementation of control measures. Yellow sticky card traps (hereafter:

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traps) were more attractive to flies than were those of yellow-green, orange, green, and blue (Tryon et al. 1980, Yudin et al. 1987, Park et al. 2001).

Heinz et al. (1992) reported on modifications of size and shape of traps and the height and orientation of trap placement that increased the traps' effectiveness. Trumble and Nakakihara (1983), Zehnder and Trumble (1984), and Zoebisch and Schuster (1990) reported that trap height had a significant influence on the number of flies captured in celery and tomato. Yathom (1989), studying in gerbera greenhouses, found that more flies were caught at 30 cm than at 70 cm above the plant tops and that horizontal and 45^0 angle traps caught more flies on their upper sides. Weintraub and Horowitz (1996) studied four heights and two orientations of traps in potato fields, where traps placed at the plant height caught significantly more flies than traps placed near the ground or 20 cm or more above plants, but significant differences were not found in the numbers of flies caught on traps placed either horizontally or vertically.

As *L. trifolii* is a new pest in cotton in Turkey, little is known about it except an average infestation rate of cotton leaves (Gencsoylu 2003) — no other studies relating to this pest in cotton in Turkey have been published. This study was done to test the use of traps as a monitoring tool in cotton, and to find the optimum height, orientation, and direction of trap placement.

MATERIALS AND METHODS

This work was done at the Agricultural Research Center of Adnan Menderes University, Aydin province, in 2004 and 2005. The Nazilli 84-S cotton variety was planted in rows with a north-to-south orientation on 3 May 2004 and 12 May 2005, in the same 0.5 ha field. Standard cultural practices of irrigation and fertilization were followed but no pesticides were applied. The seasonal abundance of *L. trifolii,* heights, orientations, and directions of traps were studied in one half (0.25 ha) of the field while damage and rates of infestation were studied in the other half (0.25 ha). Plots in the first half were set up in randomized complete block design with three replicates. Each treatment within blocks consisted of 60 rows of 160 m.

Traps were in the field over 11 June - 17 September 2004, and 17 June - 23 September 2005. These were yellow plastic cards (15 × 10 cm) with >90% reflectance in visible wave length spectrum of 540-600 nm that were placed in the center of each plot and uniformly coated with a thin layer of an adhesive compound mixture of synthetic hydrocarbon polymers (Kapar Organik Tarim Sanayi, Ankara, Turkey) on both sides. Each trap was held in a wooden frame on a wooden rod. Traps at 30 cm above the ground were fixed on the rod, while those at 25 cm above plant canopy could be moved up the rod at each sampling to keep them just above the plant canopy. Traps were oriented vertically and horizontally in both north-to-south and east-to-west directions. East-to-west direction was perpendicular to the rows. Traps were replaced weekly. Traps were brought into the laboratory where flies stuck on each surface were counted under a microscope. These counts were recorded as numbers per side of trap per week. No effort was made to sex the flies trapped.

Each week, on the same dates as traps were replaced on one half of the experimental plot, data relating to leaf infestation were collected on the other half of the plot. At each sampling, plant height was measured and divided into three — lower, middle and upper — regions. From 180 plants, 1080 leaves were sampled each week by randomly selecting two leaves from the lower, middle and upper regions of each plant and percentage infestation by plant region was calculated. The infested leaves were put in paper bags and taken to the laboratory where they were examined under a microscope and their mines counted. Mines were not separated into active, dead, or empty. Leaves bearing mines were enclosed in an attempt to rear out flies.

Data relating to trap height, orientation and direction were analyzed using three-way analysis of variance (ANOVA) including all two-way and three-way interactions. Means were separated by TUKEY'S adjustment for multiple comparisons of the means (P <0.05). Data were transformed using log(x+1) before analysis of variance to correct for heterogeneity of variance. Weekly mean for infestation rate (%) of leaves by plant region and percent of mined leaves with different numbers of mine were analyzed by using paired-samples test. All analyses were performed using SPSS version 9.0.1 (1999).

RESULTS

There being no significant interaction between the two years' data, they were combined. The first fly was captured at Week 2. Average counts of flies captured at two heights for both horizontal and vertical orientations showed that the traps caught more flies at 25 cm above plant canopy (18.7 ± 4.4) than at 30 cm above the ground (4.9 ± 1.4), a statistically significant difference (F = 9.748, df = 1, P < 0.05).

The orientation of the trap affected the mean numbers of flies captured at both heights. At 25 cm above the plant canopy, horizontal traps (34.9 ± 6.3) captured more flies than vertical traps (2.6 ± 0.4) (F = 19.374, df = 1, P < 0.05). At 30 cm above the ground, horizontal traps (8.5 ± 1.3) captured more flies than vertical traps (1.45 ± 0.3) (F = 8.435, df = 1, P < 0.05). Total flies captured varied significantly by height: at 25 cm above the plant canopy, more flies were captured than at 30 cm above the ground. In each orientation, at both heights, direction did not significantly affected the numbers captured (F = 1.274, df = 1, P > 0.05) (Table 1).

At 25 cm above the plant canopy (Fig. 1), in horizontal orientation, the highest numbers taken were 122/trap at Week 12, and 117.3/trap at Week 10. In vertical orientation, mean numbers trapped peaked at only 11.3/trap.

At 30 cm above the ground (Fig. 2), in horizontal orientation, mean numbers were highest with 27/trap at Week 5, 16.7/trap at Week 8, and 26/trap at Week 12. In vertical orientation, mean numbers peaked at only 9.3/trap.

Average counts of flies captured varied on different sides of the traps (Table 1). Fly numbers on the upper sides were significantly higher at 25 cm above the plant canopy than at 30 cm above the ground (F = 8.435, df = 1, P < 0.05). At each height more flies were captured on the upper sides of the traps than on the lower sides. Capture rates by sides of vertically oriented traps at different directions were not significantly different (Table 1 & 2).

The infestation of the leaves (Fig. 3) was higher in the lower region of plants, being 100% at the first two samplings and not falling below 81.8% by the end of sampling period; whereas, in the middle region, infestation rate peaked at 18.2% at Weeks 10, 11, and 12. In the upper region of the plants, leaf mines were never found. Infestation rate was significantly important (F = 24.127, df =1, P < 0.05).

Mine numbers varied from one to four on the leaves (Fig.4). The one mine category was highest with 100% at the first sampling week and decreased by the end of season to 45% and was statistically significant (F = 18.431, df = 3, P < 0.05). The two mine category peaked at 36.2% at the beginning of August. The three mine category peaked at 16.3% at Week 8. The four mine category peaked at 19.4% at Week 12. No flies were produced by the rearing efforts in this study.

DISCUSSION

Gencsoylu (2003) reported *L. trifolii* in Turkish cotton fields over 1998 - 2000, with similar infestation rates, over 1999 and 2000, as were found in this study. This study shows that more flies were captured on traps at 25 cm above

Table 1. Seasonal mean numbers (± SE) of *L. trifolii* captured on the yellow sticky card traps at different heights and positions. Means followed by same lowercase letter within columns are not significantly different ($P < 0.05$). Means followed by same uppercase letter within rows are not significantly different ($P < 0.05$). EW: east-to-west; NS: north-to-south.

Heights	Orientations	Directions	Side		Total
			West	East	
25 cm above plant canopy	Vertical	EW	2.3 ± 0.5bA	1.8 ± 0.5bA	4.1 ± 0.5b
	Vertical	NS	0.7 ± 0.2bA	0.4 ± 0.1bA	1.1 ± 0.2b
			Upper	Lower	
	Horizontal	EW	30.6 ± 9.1aA	4.4 ± 1.0aB	35.1 ± 9.6a
	Horizontal	NS	30.8 ± 6.1aA	3.9 ± 0.9aB	34.7 ± 3.5a
			West	East	
30 cm above the ground	Vertical	EW	0.7 ± 0.3bA	0.5 ± 0.1bA	1.2 ± 0.2b
	Vertical	NS	1.0 ± 0.4bA	0.7 ± 0.3bA	1.7 ± 0.4b
			Upper	Lower	
	Horizontal	EW	8.8 ± 2.1bA	1.3 ± 0.4bB	10.1 ± 1.2b
	Horizontal	NS	6.1 ± 1.9bA	0.8 ± 0.4bB	6.9 ± 1.1b

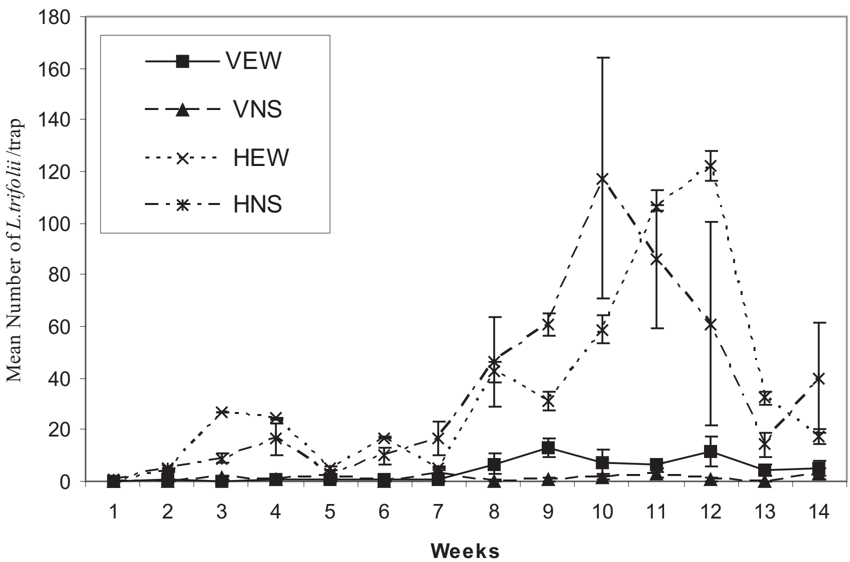

Figure 1. Mean number of *L. trifolii* captured on the yellow sticky card traps at 25 cm above the plant canopy during the sampling period (bars indicate SEM; $P < 0.05$). VEW: Vertical east-to-west., VNS: vertical north-to-south, HEW: horizontal east-to-west, HNS: horizontal north-to-south.

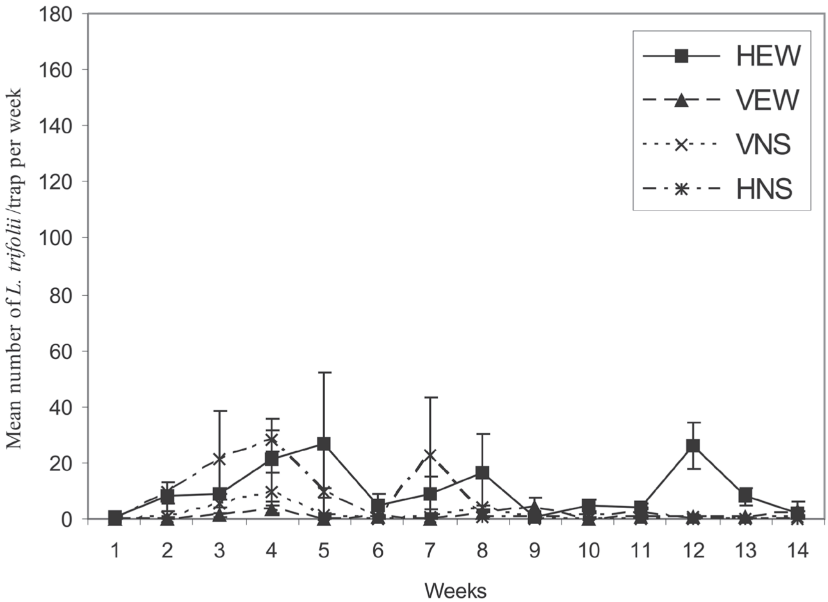

Figure 2. Mean number of *L. trifolii* captured on the yellow sticky card traps at 30 cm above the ground during the sampling period (bars indicate SEM; $P < 0.05$). VEW: Vertical east-to-west., VNS: vertical north-to-south, HEW: horizontal east-to-west, HNS: horizontal north-to-south.

Table 2. Analysis of variance tables.

Source	**df**	**Sum of squares**	***F***	***P***
Height	1	3.34	9.75	<0.05
Orientation	1	4.24	12.37	<0.05
Orientation × height	1	0.50	1.46	>0.05
Direction	1	0.53	1.57	>0.05
Orientation × direction	1	0.75	2.19	>0.05
Height × direction	1	0.70	2.04	>0.05
Orientation × height × direction	1	3.85	11.23	<0.05
Error		16	5.49	
Corrected total		23	16.23	

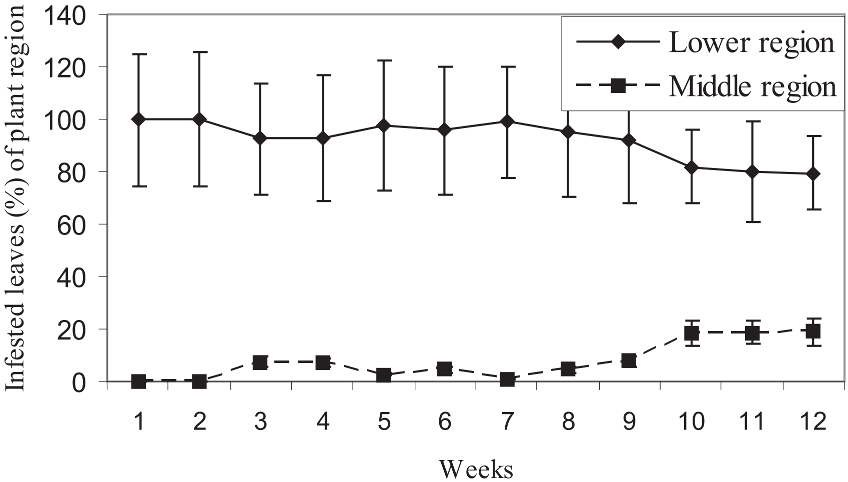

Figure 3. The percentage of those sampled leaves bearing *L. trifolii* mines from the lower and middle plant regions; leaf mines were never found in the upper region.

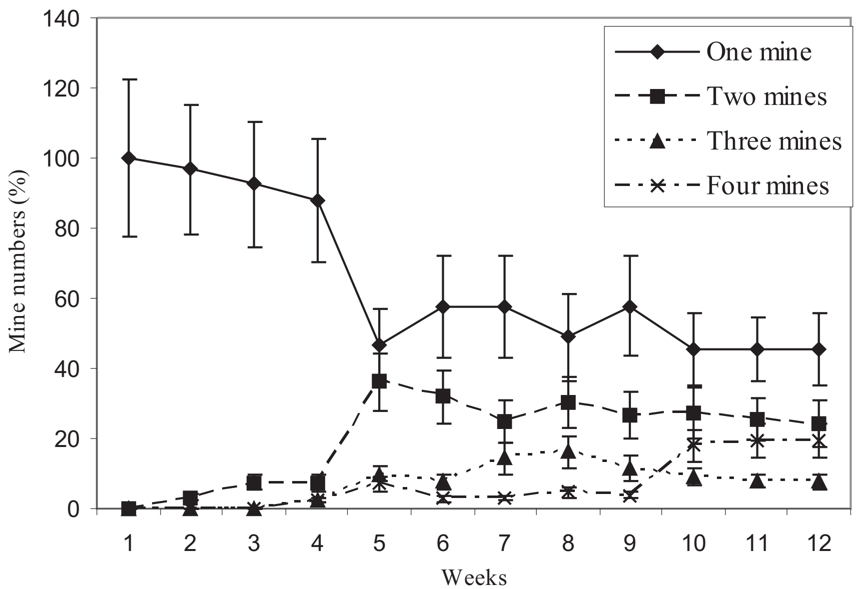

Figure 4. The percentage of those sampled leaves bearing *L. trifolii* mines having different numbers of mines.

the plant canopy than at 30 cm above the ground. Yathom (1989) reported more flies captured at 30 cm above the plant tops than at 70 cm above the plant tops, in gerbera greenhouses. Weintraub and Horowitz (1996) found that traps placed at plant height caught more flies than traps placed near the ground or 20 cm or more above the plant tops, in potato fields.

Orientation of traps significantly affected capture rates. Horizontally oriented traps at 25 cm above the plant canopy captured the most flies. In contrast, Herbert et al. (1984) trapped fewer flies on horizontally oriented traps than on vertically oriented traps in chrysanthemum greenhouses. Parrella and Jones (1985) reported high capture rates on vertically oriented traps in chrysanthemum where direction of the traps did not significantly affect capture rates, which data support Herbert et al. (1984).

Significantly higher capture rates on the upper sides of the horizontally oriented traps at both heights were found in this study. Yathom (1989) also found highest capture rates of flies on the upper sides of traps.

This study shows that the percentage of leaves infested was highest during the first week of August and that most mines were in the lower region of the plants. Sohi et al. (1994) reported that *L. trifolii* fed and bred on cotton from the cotyledon stage to the vegetative phase up to mid-August in India, preferred old plants for oviposition, and attacked lower canopy leaves. In this study, even though capture rates were highest at 25 cm above the plant tops, most mines were low on the plants, which shows that flies prefer old leaves for oviposition in cotton.

Yathom (1989) reported that *L. trifolii* failed to pupate and cannot complete its life cycle in cotton. In this study, the rearing effort failed to produce flies, supporting Yathom's claim.

Number of mines per leaf on the leaves infested varied over the sampling period. Initially, leaves bore a single mine or none. As time passed, two, three, or even four mines were in some leaves low on the plants. Mines never were found in the leaves high on the plants. This shows that the plant region is of more importance to ovipositing flies than the presence of other mines in a given leaf. These results contribute to the development of a sampling protocol to aid cotton growers and can be used as an additional component in an Integrated Pest Management against *L. trifolii* in cotton fields. Further studies should be conducted on the yield effect.

ACKNOWLEDGMENTS

I thank Phyllis Weintraub, a *Liriomyza* specialist at the Entomology Unit at Gilat Research Center in Israel, and three anonymous reviewers of my manuscript.

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