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Fluctuation and Distribution of *Frankliniella occidentalis* (Pergande) and *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) Populations in Greenhouse Cucumber and Tomato

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Abstract: The seasonal fluctuation and distribution of *Frankliniella occidentalis* (Pergande) and *Thrips tabaci* Lindeman populations in various developmental stages (larvae I, II and adults) was studied in two crops: cucumber (*Cucumis sativus* L., F_1 Kamaron) and tomato (*Lycopersicon esculentum* M., F_1 Arletta) during April-August 2000. Samples of leaves and flowers were collected from the upper and lower half part of the plants. The population peak of *F. occidentalis* and *T. tabaci* in cucumber and tomato crops was observed between 20/5/2000 and 30/5/2000. The distribution data for both Thrips species showed that they prefer cucumber to tomato. Both Thrips species prefer leaves than flowers and the upper half than the lower half part of the plants. Additional laboratory research was conducted to determine the predatory effect of *Coccinella septempunctata* on both Thrips species. According to number of thrips found on cucumber and tomato leaves, the predatory effect of the ladybird was also determined indicating that, when pest density is high, then predation may be ineffective.

Key words: Ladybird population fluctuation, distribution, *F. occidentalis*, *T. tabaci*, cucumber, tomato

INTRODUCTION

The polyphagous Thrips species, *Frankliniella occidentalis* (Pergande) and *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) are major pests which cause serious damages in greenhouse crops worldwide[1-3]. Thrips feed on host plants and may cause great damage during the adult and larval I-II stage. Activity stops when the thrips enter the diapause period or pupate. When larvae II complete their development, they seek sheltered places in order to develop into prepupal and pupal stages when they do not feed and remain mainly immobile[4,5].

The two Thrips species (*F. occidentalis* and *T. tabaci*) behavior requires further investigation in greenhouses because: 1) they are vectors of Tomato Spotted Wilt Virus (TSWV)[2,6-11], they are not readily controlled by commercially available biological control agents or insecticides[3,12,13] insecticides used for this purpose disrupt the establishment of naturally occurring predators and the use of biological control programs for other greenhouse pests such as aphids, mites and white flies[13-16].

The purpose of this study was to monitor the seasonal fluctuation and distribution of *F. occidentalis* (Pergande) and *T. tabaci* Lindeman populations during main developmental stages (larvae I, II and adults) in two crops: cucumber and tomato grown in greenhouses, as little data are available. These data are considered useful for biological control of thrips in greenhouses.

MATERIALS AND METHODS

The study was carried out in a glass greenhouse of an area 80 m^2. There were used 32 cucumber plants (*Cucumis sativus* L., F_1 Kamaron) and 32 tomato plants (*Lycopersicon esculentum* M., F_1 Arletta).

The greenhouse soil was enriched with 100 L of commercial substrate (type Humosoil 801, pH: 5.2-6.0, salt 0.7-1.7 g L^{-1}, N: 90-210 mg L^{-1}, P_2O_5: 140-230 mg L^{-1}, K_2O: 190-310 mg L^{-1}, about 70:30 white/black peat, fine structure) followed by sterilization. Plants were grown in small pots treated with soil fungicides Ridomyl MZ 63.5 WP and Benlate (15 and 6 g per 10 L of water, respectively). The plants were transplanted on 4 March 2000 in four rows (8 plants per row) for each plant species, in distances of 0.5 X 1 m. The irrigation and fertilization with Complesal were applied simultaneously depending on the plant demands.

From 19 March 2000, Antracol-Bayleton 67 WP was applied at a rate of 200 g per 100 L of water against fungal diseases (downy mildew, powdery mildew) once a week and for the three following weeks. The natural

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colonization of thrips in greenhouse was supplemented by 300 female adults from both species *F. occidentalis* and *T. tabaci* released on 25 March 2000 (150 on each plant species), which had been collected by rearing on cucumber kept in the laboratory.

The sampling started on 20 April 2000 and samples were taken every 10 days. Twenty leaves and flowers (2 flowers and 2 leaves from each plant) were collected separately from 10 cucumber and 10 tomato plants (in random), during each sampling. One leaf and one flower were taken from the upper half part of the plant and one leaf and one flower were taken from the lower half part. Each sample was put into plastic bags, the flowers separately from the leaves of each plant and they were carried to the laboratory for examination. The sampling of the plants (cucumber-tomato) lasted until 29 July 2000 (total samples n=11). During the study, the temperature and the relative humidity of the greenhouse were recorded by a thermohydrograph. At 20 May 2000, the greenhouse was covered with a slacked lime coating [$ca(oH_2)$] in order to reduce temperature. Population fluctuation and distribution of the thrips stages (larvae I-II and adults) were calculated separately for the leaves and flowers, taken from the upper and lower half part of each plant species.

Additional sampling for predatory effect estimation was conducted on both cucumber and tomato leaves at 20 May. Twenty leaves (2 leaves from each plant) were collected separately from 10 cucumber and 10 tomato plants, during sampling. One leaf was taken from the upper half part of the plant and one from the lower half part. Each sample consisted of one upper and one lower leaf of the same plant and then it was put into a 20X15X10 cm clear plastic cage. All the cages were carried to the laboratory for examination. Cucumber leaf dimensions were approximately 11 cm in diameter with slight differences between upper and lower (bigger) leaves. Because leaves were not of the same size, although similar, data were adjusted at an average of 100 cm^2. Tomato leaves were selected to be close to 80 to 100 cm^2 but data were adjusted at an average of 100 cm^2. The total (initial) number of thrips of both species was counted in all cages.

One beetle of two-day old females of *C. septempunctata* (collected from original rearing kept in the laboratory for 9 months at 25±1°C) was introduced into each cage and those beetles were starved for 24 h before use (leaves introduction). After introduction of *C. septempunctata*, cages were held in controlled environment chambers for 24 h, at a temperature of 24±0.2°C, 60±2% Relative Humidity (RH), with a 16 h light; 8 h dark photoperiod and intensity of light 9000 Lux, after which survivor of thrips (of both species) was calculated.

ANOVA was based on separate parameter analysis, since these parameters are considered (and found) independent, according to methods described by Snedecor and Cochran[17].

RESULTS

The conditions (temperature and relative humidity) of greenhouse, under which the population fluctuation and distribution of *F. occidentalis* and *T. tabaci*, on cucumber and tomato plants were studied (Fig. 1).

The present study (Table 1) recorded the total population of the stages (larvae I-II and adults) of *F. occidentalis* and *T. tabaci* which have been collected on cucumber and tomato plants in greenhouse during the seasonal period 4/3/2000 to 29/7/2000. For each thrips species also is reported particularly the mean number of collected individuals on the leaves, flowers, upper and lower half part of cucumber and tomato plants, respectively. The variance and distribution of both thrips species within plants were markedly similar. Greater numbers of *F. occidentalis* and *T. tabaci* were collected on cucumber (Table 1). Differences in population density of thrips was observed between flowers and leaves of the plants, with the greatest aggregation of

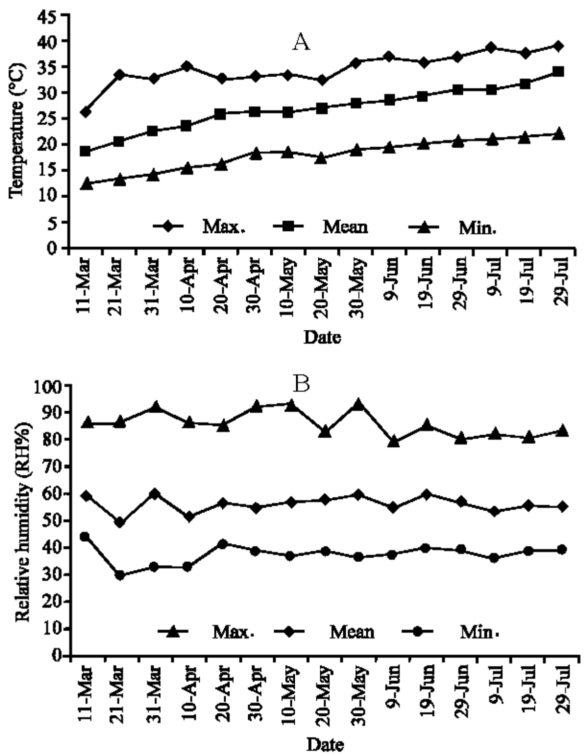

Fig. 1: Variability of the mean temperatures (A) per 10 days (max, mean, min) and relative humidity (B) of the greenhouse from 11/3/2000 until 29/7/2000

Table 1: Mean±SE of both larvae (I-II) and adults of *F. occidentalis* and *T. tabaci* found on cucumber and tomato

(A) *Frankliniella occidentalis*

Cucumber				Tomato			
Leaves		Flowers		Leaves		Flowers	
Lower half	Upper half	Lower half	Upper half	Lower half	Upper half	Lower half	Upper half
5.85±0.71a	8.65±0.95b	5.79±0.85a	7.39±0.99b	3.2±0.5a	5.24±0.75b	2.08±0.42a	2.88±0.48b

(B) *Thrips tabaci*

Cucumber				Tomato			
Leaves		Flowers		Leaves		Flowers	
Lower half	Upper half	Lower half	Upper half	Lower half	Upper half	Lower half	Upper half
3.38±0.57a	5.87±0.86b	2.61±0.48a	3.52±0.62a	2.92±0.39a	4.42±0.65b	0.97±0.2a	1.63±0.31b

Average values followed by the same letter within each parameter are not significantly different (p<0.05) according to DMRT

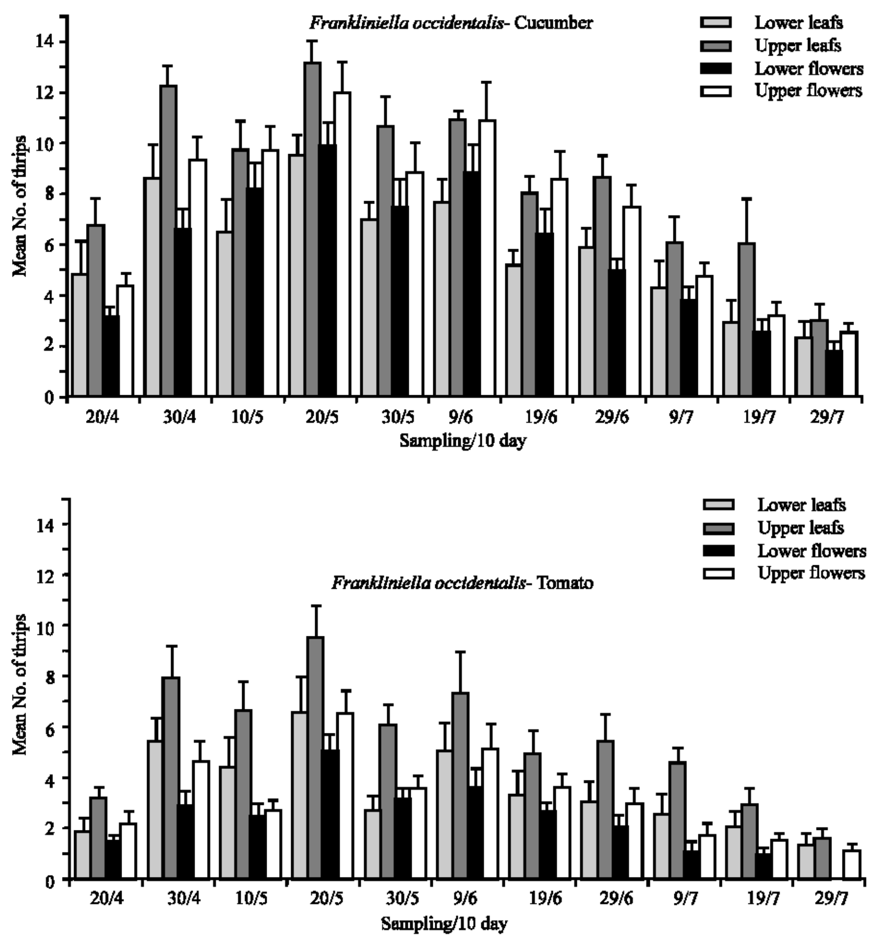

Fig. 2: Fluctuation of the population (±SE) of *F. occidentalis* (larvae I-II and adults) on leaves and flowers, lower and upper half part of cucumber and tomato plants per sampling

thrips on the leaves of cucumber and tomato, respectively. The population of thrips species was affected by location on the plants, where there was a preference for the upper half part of the plants in relation

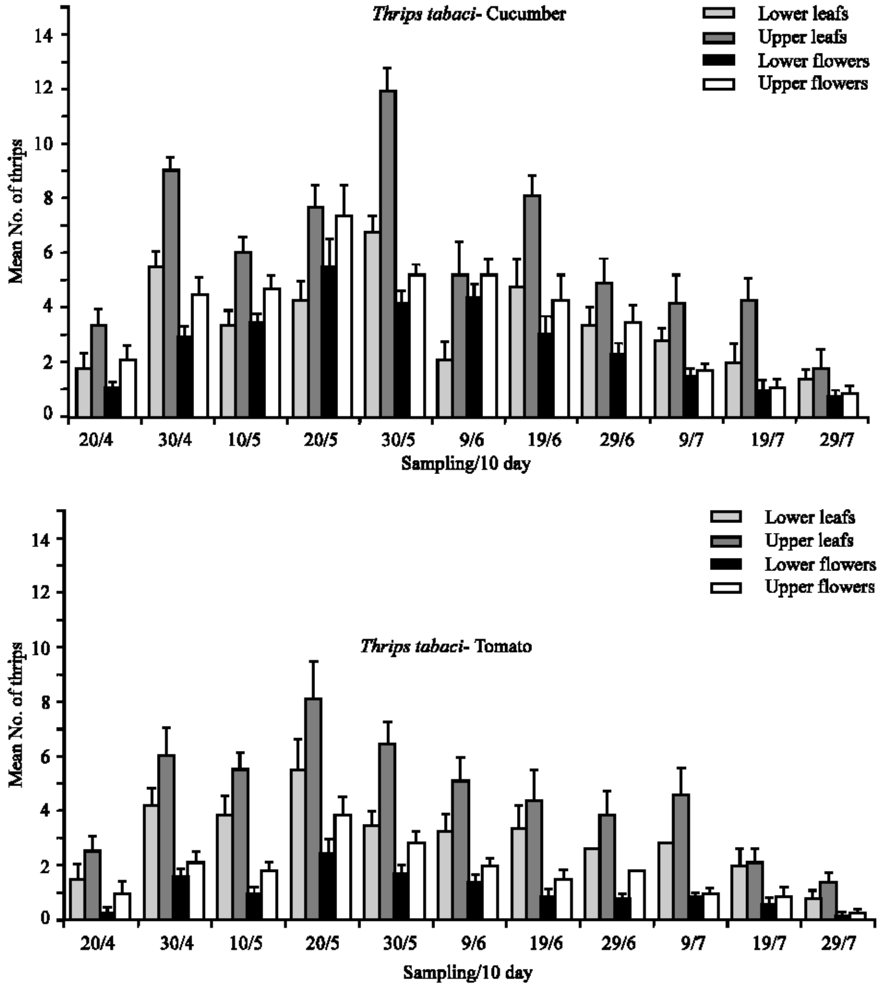

Fig. 3: Fluctuation of the population (±SE) of *T. tabaci* (larvae I-II and adults) on leaves and flowers, lower and upper half part of cucumber and tomato plants per sampling

Table 2: Effects of the plant species (cucumber-tomato), plant organs (leaves-flowers) and the location on the plant (upper and lower half part) on seasonal distribution (±SE) of *F. occidentalis* and *T. tabaci* stages (larvae I-II and adults)

Factors	*F. occidentalis*	*T. tabaci*
A_1 Cucumber	6.92±0.45a	3.85±0.35a
A_2 Tomato	3.35±0.31b	2.48±0.28b
B_1 Leaves	5.73±0.46a	4.15±0.34a
B_2 Flowers	4.54±0.47b	2.18±0.25b
C_1 Upper Half	6.04±0.51a	3.86±0.38a
C_2 Lower Half	4.23±0.39b	2.47±0.24b

Average values in the same column followed by the same letter within each parameter (A, B and C) are not significantly different ($p<0.05$) according to DMRT

to the lower half part. Seasonal fluctuation of population of the immature stages (larvae I-II) and adults of *F. occidentalis* (Fig. 2) and *T. tabaci* (Fig. 3) on leaves and flowers, for the upper and lower half part of cucumber and tomato plants from 20/4/2000 until 29/7/2000 in the greenhouse shows that the mean number of thrips per sampling (*F. occidentalis* and *T. tabaci* larvae I-II and adults) on cucumber and tomato, increased and then declined at the final samplings. The peak of *F. occidentalis* population in cucumber and tomato found during the 4th sampling (30/5/200). The same happened with *T. tabaci* in tomato. The monitoring of *T. tabaci* population on cucumber leaves revealed that highest population density was achieved during the 5th sampling(30/5/200).

Table 2 shows the seasonal distribution of the population (larvae I-II and adults) of *F. occidentalis* and *T. tabaci* over cucumber and tomato plants, on leaves and flowers and the upper-lower half part of the plants. The comparisons between average values (Table 2) of the population distribution of *F. occidentalis* and *T. tabaci* (larvae I-II and adults) showed that thrips prefer cucumber than tomato plants and leaves than flowers. According to the present results, the highest population density of

Table 3: Mean percentage (%) of escapes, mean of total insects counted for both thrips species on cucumber and tomato (n = 10, for each species)

Plant species	Cucumber		Tomato	
Thrips species	Total insects	(%) escapes	Total insects	(%) escapes
F. occidentalis	35.8	67.5	24.1	33.3
T. tabaci	21.8	30.6	20.5	30.1

Data were compared to theoretical model adapted from *Deligeorgidis et al.* [18,34]

F. occidentalis and *T. tabaci* (for all stages) was found on the upper half part of the plants.

The mean percentage (%) of escapes[18] in comparison to the mean number of insects counted for both thrips species in the presence of the predator on cucumber and tomato leaves are presented in Table 3.

DISCUSSION

Thrips population in early season was increasing followed by a decrease at the final samplings of this study on the leaves and flowers both of the upper and the lower half part of the host-plants. The population density of *F. occidentalis* and *T. tabaci* was high, mainly during May, followed by a reduction during the following months of samplings. The progressive reduction of the population may be due to the reduced reproduction and survival of the thrips because of the rising temperature in the glasshouse and the gradual drying of the host-plants. Webb *et al.*[19] reported that flower thrips typically occur in large numbers for a relatively short period during the year and that, this period occurs earlier in the southern United States than in the North. Seasonal patterns of abundance of *F. occidentalis* and *T. tabaci* on cucumber and tomato in the present study were similar to seasonal patterns of abundance reported in tomato[20]. Economically damaging populations of Thrips Species that are capable of transmitting tomato spotted wilt virus (i.e. *F. occidentalis* and *T. tabaci*) or causing fruit damage occurred usually in May. Therefore, detection and management efforts can be predictably focused on this period in spring. Temperature affects significantly total biological cycle of *F. occidentalis* and *T. tabaci* and other parameters such us preoviposition-oviposition-postoviposition periods, reproduction dynamic and reproduction rate, especially when measurements our out of normal temperature range[21].

The total population (larvae I-II and adults) of *F. occidentalis* and *T. tabaci* was significantly ($p<0.05$) greater in cucumber than in tomato. The thrips preference for a specific host-plant, probably is due to the attractiveness of colour, smell, taste, leaf construction, as well as the low resistance of the plant (and of course, the experimental conditions). Relative studies have also shown the preference of *F. occidentalis* in cucumber than in tomato and pepper[13,22,23]. The thrips preference is also shown among varieties of the same plant. Lall and Singh[24] ascertained that *T. tabaci* prefers varieties of onion which are less resistant. Similar behavior of thrips was reported for varieties of cotton[25]. Studies on the resistance of the cucumber varieties against *F. occidentalis* have shown satisfactory results. Varieties selected for their resistant capabilities had up to 50% less damage than a cucumber variety sensitive in thrips[26]. During the present study, greater numbers of individuals (larvae I-II and adults) of *F. occidentalis* and *T. tabaci* was collected on cucumber and tomato leaves than on the flowers of the same plant. The bigger area and longevity of the leaves probably ensure better protection for the thrips from adverse conditions and predators. Despite the fact that the flowers have an ephemeral nature, thrips migrate there because of the colour attractiveness[27]. Thrips migrate mainly for particular feeding preferences (pollen, nectar)[13,28]. Kirk[28] found that only 1% of the eggs laid by *Thrips imaginis* Bagnall were in parts lost after flowering. Rosenheim *et al.*[29] reported that the adults of *F. occidentalis* were found in higher densities in flowers of cucumber maybe because of their mobility, while *Thrips palmi* Karny in leaves of the same plant. These results concern exclusively the adults of the two Thrips Species, while samplings for immature stages were not undertaken. Higgins[13] reported similar results for adult females of *F. occidentalis* that appeared to prefer the flowers of cucumber and pepper, than the leaves. However, the immature stages (larvae I-II) of thrips showed a preference for the leaves of these plants. The present study also showed that the stages (larvae I-II and adults) of *F. occidentalis* and *T. tabaci* are found mostly on the leaves and flowers of the upper half part of cucumber and tomato. This distribution could occur due to the gradual maturation and aging of the lower plant organs than the upper, which are more tender and preferred by thrips. Similar results were reported by Steiner[30]. In other studies, *F. occidentalis* population density from sticky traps was greater for traps placed just above the crop canopy[31,32]. Based on these findings, Gillespie and Vernon[32] hypothesized that mobility of *F. occidentalis* within a crop field occurs just above the top of the crop. This hypothesis may explain why absolute population density of *F. occidentalis* and *T. tabaci* in this study was greater on leaves and flowers located on the upper half part of the plants compared to the lower half part of the plants. Binns *et al.*[33] ascertained that the greatest numbers of *T. tabaci* occurred on the tender leaves of cucumber, which were found on the upper half part of the plant. Gillespie[15] reported similar results for this preference for the species of *F. occidentalis* and *T. tabaci* on cucumber leaves. According to Navas *et al.*[20] the greatest adult population of *F. occidentalis* and *Frankliniella tritici* (Fitch) was found on flowers of the upper half part of tomato plants compared with flowers on the lower half part of plants. *Frankliniella fusca* (Hinds) was not influenced from the location of the flowers on the plants. In contrast, the immature stages of thrips were found in greater numbers on the flowers of the lower rather than the upper half part of plants. According to the above-mentioned researchers, the survival of the immature stages on the lower flowers may have been improved because of poorer coverage by insecticides.

Pest population is essential for biological control programs[18,21,23]. Although insecticides can be used for controlling thrips in greenhouses, *C. septempunctata* may be an effective predator to reduce thrips population below damage levels and overcome problems because of poorer coverage by insecticides. These researchers claim that, when the proportion of predator/pest is around 1:30-1:35, then the predation may considered effective. Data from Table 3 in this study, are in agreement to the models proposed by Deligeorgidis *et al.*[18,34], indicating that when pest density is high, then predation may be ineffective.

Determining the appearance, population density and distribution of thrips in greenhouse crops may be able to define the timing and proper control of the insects before the population increase is realised and cause serious damages. The preference of thrips for certain plant species, organs (flowers-leaves) and location (upper-lower half part) allows the selection of resistant plants, proper insecticides and proper control techniques.

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