Thrips control on protected sweet pepper crops: enhancement by means of Orius laevigatus releases

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Abstract: The efficacy of the pirate bug *Orius laevigatus* for controlling thrips on sweet pepper in a protected crop in tunnels was investigated in Northern Italy (Po Valley) during two years. Two thrips species were found: *Frankliniella occidentalis*, the most harmful one, and *Thrips tabaci*. Seasonal inoculative releases of *O. laevigatus* effectively reduced thrips infestation on the crop. In some tunnels the natural control by wild *Orius* species, *O. laevigatus, O. niger* and *O. majusculus*, was enough to reduce the thrips population. When chemical control against other insect pest species was applied, side effects were observed such as increase of thrips infestation. Only later in the season were wild *Orius* species able to reduce thrips populations.

Introduction

Since Western flower thrips (WFT) *Frankliniella occidentalis* appeared in Europe it has become one of the most serious pest species of sweet pepper (*Capsicum* spp.) both in greenhouses and in open fields (Arzone et al., 1989; Tavella et al., 1991; Tommasini and Maini, 1995; van Driesche et al., 1998). Damage caused by *F. occidentalis* on sweet pepper is typical of thrips, including discoloration of leaves and fruit, necrosis of the attacked area, and deformation. In some Italian regions, such as Liguria and in the South, as well as in south-east Spain, Tomato Spotted Wilt (TSWV) and, less frequently, Impatiens Necrotic Spot (INSV), both transmitted by *F. occidentalis,* were detected (German et al., 1992; Peters et al., 1996). The sweet pepper too was damaged (Lisa et al., 1990; Vaira et al., 1993; Vovlas et al., 1993; Sànchez et al., 2000), increasing the problem due to thrips. In north-eastern Italy where these experiments were carried out no TSWV nor INSV were present on sweet pepper, but now it is known that these viruses are already found on ornamental plants (Bellardi and Vicchi, 1998; Vicchi and Bellardi, 2000), on tomato (Vicchi et al., 2001) and on pepper (Vicchi, pers. comm.).

F. occidentalis control with chemical treatments is difficult because this pest is characterized by a high reproductive rate, low sensitivity to a number of commercial available insecticides allowed on vegetable crops (Immaraju et al., 1992; Brødsgaard, 1994; Robb et al., 1995; Zhao et al., 1995). Ethological traits such as endophytic egg laying and protection due to vegetable tissue typical of flowers inside which they are used to live avoid thrips from insecticides sprays. The possibility to apply a biological control system against thrips is needed. So, in the last years, many were the studies aimed to demonstrate the use and the efficacy of macrobials to control WFT: Gilkenson et al., 1990; van den Meiracker and Ramakers, 1991; Chambers et al., 1993; Vacante and Tropea Garzia, 1993; Bertaux, 1993; Gonzales Zamora et al., 1994; van Houten and van Stratum, 1995; Grasselly et al., 1995; Loomans et al., 1995; Rubin et al., 1996; Tavella et al., 1996; Degheele et al., 1997; Mifsud, 1997; Sabelis and van Rijn, 1997; van Driesche et al., 1998; Tommasini et al., 2001.

Among the natural enemies of *F. occidentalis*, *Orius* spp. have received more careful studies on thrips control on sweet pepper, including *O. tristicolor* (White) in Canada (Gilkenson et al., 1990; Higgings, 1992), *O. insidiosus* (Say), *O. majusculus* (Reuter) and *O. niger* (Wolff) in Europe (van den Meiracker and Ramakers, 1991; van de Veire and Degheele, 1992; Disselvet et al., 1995), *O. laevigatus* (Fieber) in Europe (Chambers et al., 1993; Vacante and Tropea Garzia, 1993; Disselvet et al., 1995; Tavella et al., 1996; van de Veire and Degheele, 1997; van der Blom et al., 1997; van Schelt, 1999; Sànchez et al., 2000) and *O. albidipennis* (Reuter) in Israel (Rubin et al., 1996) and Spain (Sànchez et al., 2000).

Material and Methods

During two years, 1994 and 1995, the thrips infestation and the population of *O. laevigatus* were checked in commercial greenhouses (unheated plastic tunnels) in Italy. A total of 11 tunnels, ca. 300 m^2 each, were sampled. The tunnels were located near Rimini (north-eastern Italy), close to the Adriatic Sea coast, in a large greenhouse area.

The cultivar Valdor was mostly used, in few cases cultivar Bullor was transplanted in a double row of plants with 50 cm spacing between and within rows. Hoses placed on the soil supplied water.

The transplanting of pepper started at the end of April-early May and plants were usually cut at the end of August-beginning of September. Before transplanting, the soil was fumigated by methylbromide.

Conventional chemical control was applied in 2 tunnels in 1994 and in other 2 in 1995 (chemical tunnels). The release of *O. laevigatus* was tested in 2 tunnels in 1994 and in 5 tunnels in 1995 (IPM tunnels).

In the IPM tunnels some mass-reared natural enemies were also applied to control infestation of other pest species such as *Phytoseiulus persimilis* Athias-Henriot against *Tetranychus urticae* Koch, *Encarsia formosa* Gah. against whiteflies, *Chrysoperla carnea* (Steph.), *Aphidius colemani* Viereck and *Aphidoletes aphidimyza* (Rond.) against aphids. Damages by European corn borer were not detected.

Weekly samplings were carried out during the sweet pepper cycle, counting nymphs and adults of both thrips species and *Orius* spp. on 200 leaves (50% at the top and 50% at the bottom of the plants) and on 100 flowers randomly chosen from 100 plants per tunnel. The number of thrips and predators on the flowers was recorded by gently shaking each flower in a small transparent plastic cylinder (ca. 1 dl).

The density of adult thrips was also sampled weekly by counting the catches in blue sticky traps (10x20 cm each) placed about 20 cm over the top of the plants. Initially 10 traps per tunnel were placed, and then reduced to two traps per tunnel as soon as more than 10 thrips per trap a week were caught.

In the IPM tunnels, a blend of nymphs and adults of *O. laevigatus* (ca. 3:2 respectively) were released scattering 1-3 predators per m^2 on the leaves, when thrips appeared on the plants. In some tunnels only one release of *O. laevigatus* was done, but generally two following releases were carried out. *O. laevigatus* applied, came from a southern Italy and then mass-reared at the rearing facilities of Biolab (now Bioplanet) (van Lenteren and Tommasini, 1999).

Samplings to check relative abundance of wild *Orius* species on three protected vegetable crops was carried out in July 1994 in north-eastern Italy.

Results and Discussion

Thrips species survey

Two main thrips species were found infesting the crop in both 1994 and 1995, *Thrips tabaci* and *F. occidentalis*, as recorded on eggplant in the same period and in the same area (Tommasini et al., 1997). As it was observed on eggplant, also on sweet pepper the relative abundance of the two thrips species was first higher for *T. tabaci*, but already in June-early July there was an inversion of the tendency with an increase of *F. occidentalis* which became the main species at the end of the crop cycle (Fig. 1).

All thrips instars were found on the plants, demonstrating that in our conditions, only occasionally thrips pupate into the soil.

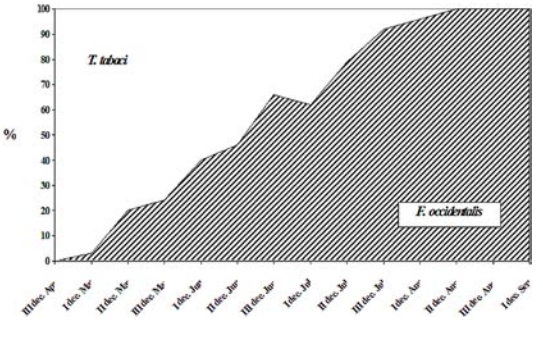

Fig. 1. Mean percentage during 1994 and 1995 of the infestation trends of two thrips species in sweet pepper tunnel at intervals of ca. 10 days (decade).

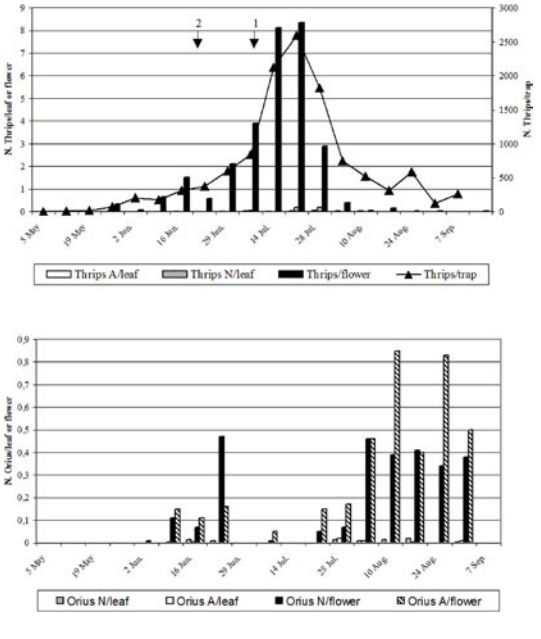

Fig. 2. Example of Tunnel in which Arthropods pests were controlled by insecticides. Legend of treatments: 1= Heptenophos; 2= Cyfluthrin; 3= Ciromazina.

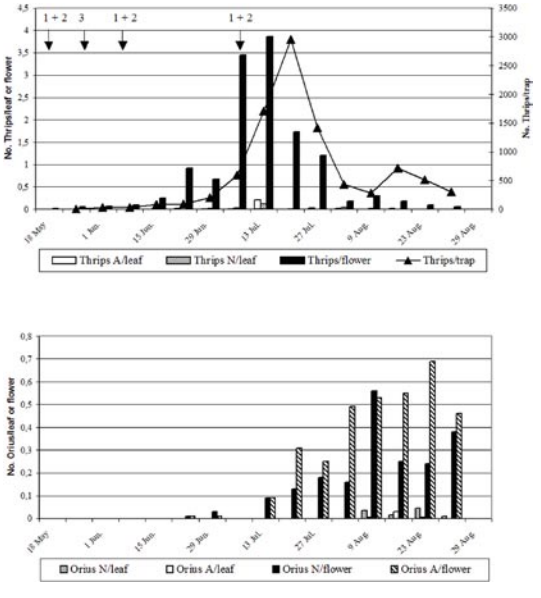

Fig. 3. Example of Tunnel in which Arthropods pests were controlled by insecticides. For treatments see figure 1.

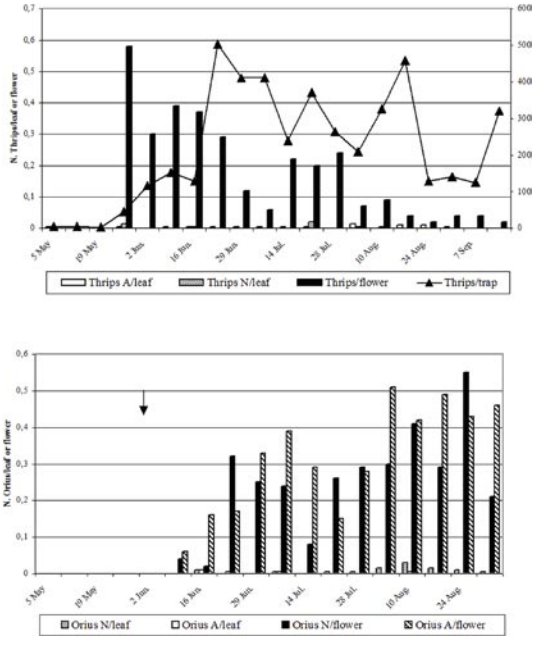

Fig. 4. Example of Tunnel in which *Orius laevigatus* was released (arrow indicates when) against thrips and other Arthropod pests were controlled by beneficial agents (IPM tunnel n.2).

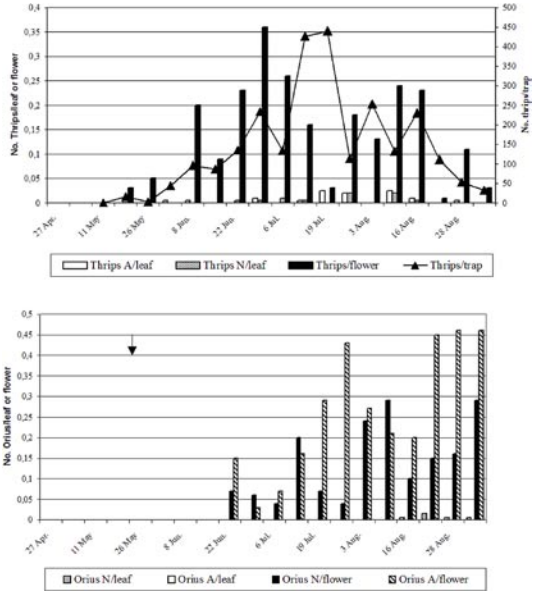

Fig. 5. Example of Tunnel in which *Orius laevigatus* was released (arrow indicates when) against thrips and other Arthropod pests were controlled by beneficial agents (IPM tunnel n.7).

Thrips started to be recorded on the plant during the second half of May-early June in both 1994 and 1995 (Figs. 2 to 5). Blue sticky traps started to capture thrips in average one week after their appearance on plants and the captures did not always reflect the population level of thrips on the plant, similarly to what observed by Berlinger et al. (1997) in Israel.

Thrips were found on leaves occasionally, confirming that sweet pepper flowers are more attractive for thrips, both adults and nymphs, than leaves, so we suggest to sample just the flowers to monitor thrips on sweet pepper. Also Berlinger et al. (1997) found that *F. occidentalis* is first attracted by flower than leaves. On the contrary, Higgins (1992) found in British Columbia (Canada) that more than 85% of nymphs of *F. occidentalis* were recorded on leaves of sweet pepper, while females preferred to stay within flowers (84-95%). Garcìa-Marì et al. (1994) found that both nymphs and adults of thrips have to be monitored in order to have a good estimation of the infesting population, and that an average of 100 flowers of a vegetable crop have to be observed to estimate pest population.

Chemical control

Generally the thrips infestation in chemical tunnels (Figs. 2 and 3) was higher than that in IPM tunnels (Figs. 4 and 5). Nevertheless no direct insecticides were sprayed against thrips due to low infestation level. On average the peak of thrips attack occurred in July. Chemicals were necessary to control aphids, particularly *Aphis gossypii* Glov., and leafminers of the genus *Liriomyza*. The sprays of chemicals did not allow the wild population of *Orius* spp. to establish into chemical tunnels and they appeared on the plants only late in the season contributing anyway to reduce effectively thrips population.

The wild *Orius* species recorded were *O. laevigatus* and *O. niger* mostly, only few *O. majusculus*. A survey carried out in July 1994 on three vegetable crops, sweet pepper, egg-plant and cucumber, showed a different relative natural abundance of *Orius* species in such protected crops (Tab. 1). Also in other Southern European countries these three *Orius* species showed to be the most common on vegetable crops (Riudavets et al., 1995; Tavella et al., 1996; Barbetaki et al., 1999).

Release of Orius laevigatus

As soon as thrips appeared on the crop an average of 1.0 and 1.2 *O. laevigatus*/m^2 were released in 1994 and 1995, respectively. In 1995, in 4 of the 5 IPM tunnels the release was repeated one week later with the same quantity of predators, in the other three tunnels (one in 1995 and 2 in 1994) only one release of predators was done. In table 2 the amount of *O. laevigatus* released in each IPM tunnel is detailed.

Crop	No.	*O. laevigatus*	*O. niger*	*O. majusculus*
Sweet pepper	600	64.2	30.2	5.6
Egg plant	250	36.0	45.2	18.8
Cucumber	100	28.6	0	71.4

Tab. 1. Relative abundance (%) of *Orius* species found on three protected vegetable crops in July 1994 in north-eastern Italy.

IPM tunnel	Total No. of *Orius* introduced/m^2
1 (1994)	1
2 (1994)	1
3 (1995)	3
4 (1995)	2.5
5 (1995)	2.5
6 (1995)	2.2
7 (1995)	1.8

Tab. 2. Number of *Orius laevigatus* released into sweet pepper tunnels.

After *O. laevigatus* release the predators were soon established on the crop, as confirmed by the presence of nymphs (Figs. 4 and 5). This condition avoided outbreaks of thrips. Thrips never exceeded one individual per flower weekly in IPM tunnels.

At the end of the crop cycle the number of *Orius* on plants was always higher than that of thrips, demonstrating the high capability of *O. laevigatus* to establish on sweet pepper in protected crop and its efficacy to control thrips infestation. A similar results was found on sweet pepper in protected crops by Sànchez et al. (2000) in south-east of Spain

Chamber et al. (1993) found that releasing a total of 1-2 predators per sweet pepper plant resulted in a good thrips control over several months on sweet pepper in United Kingdom greenhouses. In our conditions, where thrips infestations were not high, a much lower amount of *Orius* was necessary to obtain an effective control of thrips, with an average of 2 predator/m^2 in 1 or 2 releases (0.1 – 0.3 predator/plant). In the Netherlands, multiple releases of 1 *O. laevigatus*/m^2 combined with *Amblyseius cucumeris* (Oud.) introduction after transplanting, avoided thrips outbreaks (van Schelt, 1999).

In our conditions it cannot be excluded that the natural population of *Orius* spp. occurring in the surrounding environment enhanced the released predator's population. This can be guessed because a rather high population of *O. niger* was generally found at the end of the growing season in all IPM tunnels. Always on sweet pepper a similar result was found by van de Veire and Degheele (1992), they released the exotic species *O. insidiosus*, but later in the season they found only *O. niger* on plants. Also in Ligury it was observed that in sweet pepper greenhouses where IPM was applied, *O. laevigatus,* which naturally occurs, appears inside greenhouses late in the growing season controlling thrips infestation, together with a low number of *O. niger* and *O. majusculus* (Tavella et al., 1996).

Conclusion

Blue sticky traps could give a useful indication of thrips presence in greenhouses, but it is not the most reliable method to monitor thrips infestation on sweet pepper, whereas sampling flowers is more effective.

Early releases of *O. laevigatus* when thrips appear on flower and traps, allow a good and effective establishment of the predators and thrips control like van de Veire and Degheele (1997) found too. Despite the low thrips infestation level recorded in these experiments, the release of *O. laevigatus* demonstrated to contribute to reduce thrips population on sweet pepper.

When thrips infestation is not high and broad-spectrum insecticides are not used, the natural control of indigenous *Orius* species is very effective, preventing thrips outbreaks. Insecticide sprays disrupted any enhancement of natural control. When chemical treatments were stopped three natural *Orius* species soon appeared to colonize the crops and control thrips (*O. laevigatus, O. niger* and partially *O. majusculus*). This result was recorded also on other crops suck as on eggplant (Chiappini, 1993; Tommasini et al., 1997) and strawberry (Gonzàles-Zamora et al., 1992; 1994; Gambaro, 1995).

The use of *O. laevigatus* to control thrips showed to be effective and suitable to be released in combination with other natural enemies, as it was also shown by other authors (Brødsgaard and Enkegaard, 1995; Wittmann and Leather, 1997).

In Israel, Rubin et al. (1996) found *O. laevigatus* to be less effective to control thrips on sweet pepper compared to the phytoseid *Iphiseius* (*Amblyseius*) *degenerans* Berlese. However, in many European countries, *O. laevigatus* is was demonstrated as an effective natural enemy, which appears the most suitable candidate to be used and produced by biofactories for thrips control in general and in sweet pepper greenhouses, as confirmed by our trial and by several authors (Chamber et al., 1993; Dissevelt et al., 1995; Tavella et al., 1996; van de Veire and Degheele, 1997; Sànchez et al. 2000).

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