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Control of *Frankliniella occidentalis* on glasshouse-grown cucumbers: an efficacy comparison of foliar application of *Steinernema feltiae* and spraying with abamectin

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Summary. In a glasshouse experiment, the effectiveness of the entomopathogenic nematode *Steinernema feltiae* (Filipjev) (Rhabditida: Steinernematidae) was compared with abamectin for the control of western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) on slicer cucumbers. In a period from mid June to the end of August, cucumbers were grown in four different growth substrates: expanded perlite, expanded vermiculite, light expanded clay aggregate and peat. A suspension of entomopathogenic nematodes (2500 infective juveniles ml^{-1}) was applied to cucumber leaves nine times in one growing season, whilst insecticide at recommended dose (22.5 g a.i. ha^{-1}) was used three times. A significant effect of the extent of pest damage to the leaves (assessed by a six grade scale) was determined only for treatment type (nematodes, insecticide and untreated control), but not for the type of growth substrate or the damage evaluation date (16 July, 3 August, and 23 August). The leaves of cucumbers treated with nematodes and insecticide were significantly less damaged than untreated plants, with damage never exceeding 10% of the leaf surface. Nevertheless, type of growth substrate showed a significant effect on the number of fruits as well as on the mean mass of fruits. Light expanded clay aggregate was seen to be the least appropriate growth substrate, whilst the other three substrates can all be recommended for cucumber growing. The mean mass of fruits was also significantly influenced by type of suppression, with the mean mass of fruits in treated plants being significantly higher (from 37 up to 51%) than in untreated plants. The mean number of fruits per plant did not differ significantly between different types of pest suppression. Spraying nine times with nematodes and three times with abamectin gave similar efficacy against western flower thrips on glasshouse-grown slicer cucumbers.

Key words: biological control, cucumbers, entomopathogenic nematodes, greenhouse, insecticide, Rhabditida, Steinernematidae, Thysanoptera, Thripidae, western flower thrips.

More than twenty years after its introduction to Europe, western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae), is still one of the most important glasshouse pest in many countries of Old Continent (zur Strassen, 1986, Karnkowski & Trdan, 2002). In some southern European countries, its mass occurrence in the open has been reported (Deligeorgidis *et al.*, 2002). This polyphagous insect presents both direct and indirect threats to plants, with the result of their direct activity often leading to silvering of attacked plant organs, deformation and weak plant growth (de Jager *et al.*, 1997). Indirect damage can also be caused as western flower thrips has been noted as a vector of tospoviruses (Inoue *et al.*, 2004).

Intensive use of insecticides in controlling western flower thrips in some parts of the world has led to chemical resistance of thrips to many standard insecticides (Espinosa *et al.*, 2002; Loughner *et al.*, 2005). A solution to this problem may lie in the development of modern, environmentally friendly methods of pest control (Shipp & Wang, 2003; Sengonca *et al.*, 2006), and optimization and implementation of such methods into the food production systems is a continuous process.

Amongst the biological agents that have been studied to date with the aim of controlling western flower thrips are entomopathogenic nematodes. Entomopathogenic nematodes (EPNs) have been tested on a wide range of plant pests under laboratory conditions (Shapiro & McCoy, 2000) and in the field (Abbas *et al.*, 2001). At first they were mostly known as parasites of soil pests, but in recent years many investigations have demonstrated that they can also be used against foliar pests (Arthurs *et al.*, 2004).

EPNs have already been tested under glasshouse conditions for control of western flower thrips, against both soil-dwelling (Ebssa *et al.*, 2004) and above-ground life stages (Buitenhuis & Shipp, 2005). Although in many plant species, a positive correlation has been established between the concentration of aromatic amino acids in the plant proteins and the extent of western flower thrips damage (Mollema & Cole, 1996), nevertheless this species shows a greater preference for slicer cucumbers then to many other hosts (Shipp *et al.*, 2000; Hao *et al.*, 2002).

The use of growth substrates is an increasingly important method for cucumber production in glasshouses (Parks *et al.*, 2004). The advantage of this type of production in comparison with conventional (soil) production is that beside a controlled nutrient supply, there is also a replacement of inappropriate substrate, particularly in cases where pest organisms occur naturally in the substrate (Schnitzler, 2005). The usage of EPNs in these kinds of production systems can be through foliar application, which provides rapid activity of these biological agents.

Previous research on foliar application of *Steinernema feltiae* (Filipjev) (Rhabditida: Steinernematidae) suspension showed its high efficacy in controling leafminers on vegetables (Williams & Walters, 2000), and the larvae of the sweetpotato whitefly (*Bemisia tabaci* [Gennadius]) and *Thrips palmi* Karny was effectivelly controlled with mixed suspensions of *S. feltiae* and some insecticides (Cuthberston *et al.*, 2003, 2005). In previous research with single foliar application of *S. feltiae*, no positive results were attained in controlling larvae and adults of western flower thrips on chrysanthemums (Buitenhuis & Shipp, 2005). However, we wanted to study the efficacy of numerous applications of this species against thrips on glasshouse-grown cucumbers and to compare the results with the efficacy of the insecticide abamectin. Abamectin has been shown to have high efficacy against western flower thrips (Raspudić *et al.*, 1998) and some other glasshouse insect pests (Broadbent & Olthof, 1995). Furthermore, abamectin belongs to a group of insecticides to which thrips have not yet developed resistance, as far as is known (Kontsedalov *et al.*, 1998; Herron & James, 2005). We decided not to combine applications of the EPNs and insecticide, as in a previous study abamectin (Head *et al.*, 2000) – like chlorpyrifos (Chen *et al.*, 2003) - showed no satisfactory campatibility with *S. feltiae*, in spite of its relatively high environmental acceptibility (Cai *et al.*, 1997).

MATERIAL AND METHODS

In 2004, a glasshouse experiment was conducted at the experimental field of the Biotechnical Faculty in Ljubljana, Slovenia. The study was conducted in a quarantine part of the glasshouse where massive occurrence of western flower thrips on different hosts (cucumber, eggplant, tomato, bean) had been recorded in the previous years (Trdan & Jenser, 2003).

Seeds of the slicer cucumber, cv. Jazzer F1, were sown in 92 seedling trays filled with fertilized peat. After seedling emergence, the transplants were irrigated overhead as needed. When the seedlings had three fully expanded leaves, 50 mg l^{-1} of soluble fertilizer ($15N$-$15P_2O_5$-$15K_2O$) was added weekly. After the nursery period, the plants were transferred to the high-roof passive-ventilated glasshouse (width 18 m, length 24 m, east-west orientation) on June 10. Plants were set into 10 m long by 0.4 m wide by 0.3 m tall black plastic sleeves (plots), then placed 0.8 m apart in rows to give a population of 4 plants m^{-2}. To allow drainage, ten holes about 1.5 cm in diameter were drilled about 5 cm from the bottom of the containers.

The sleeves were filled with one of four different growth substrates: expanded perlite (bulk density: 160 kg m^{-3}), expanded vermiculite (medium granulation, pH 7.4), light expanded clay aggregate (grain size 8-16 mm) and peat (Humin substrate N2 Neuhaus). All plants were fertilized with the same (drip irrigation) system and same rate of nutrients, consisting of 8-18-26 soluble fertilizer, calcium nitrate and magnesium sulphate. The amount of added water in addition to the fertilizer (there was no irrigation) derived from substrate moisture and was measured with tensiometer. The city water source showed a pH of 6.8 and so was adjusted to 7.2 with nitric acid. A trellis system and high tensile fencing wire was used to support the cucumbers to a height of 3 m. The glasshouse temperature was 24-32°C (day) and 16-22°C (night), with relative humidity of 65-75 %.

Glasshouse experiment. The treatments in the experiment (2-factorial design) were allocated at random within each of the four replicated blocks. Each block included four sleeves with different growth substrates. All sleeves (plots) were composed of twelve cucumber plants, which were divided into three subplots. Four plants in each sleeve (sub-plot) were sprayed with a suspension of *S. feltiae* (the biopreparation Entonem, manufacturer: Koppert B.V., Berkel en Rodenrijs, The Netherlands; supplier: Zeleni hit d.o.o., Ljubljana, Slovenia), four plants were sprayed with abamectin (18 g l^{-1}; 0.125 % Vertimec 1.8 % EC; manufacturer: Syngenta Crop Production AG, Basel, Switzerland; supplier: Syngenta Agro d.o.o., Ljubljana, Slovenia), and the four control plants were sprayed with water. Before spraying each suspension of nematodes, 0.05% of the surfactant Nu-Film-17 (a.i. di-1-p-methene, 96%; manufacturer: Lances Links SA, Geneva, Switzerland; supplier: Karsia Dutovlje d.o.o., Ljubljana, Slovenia) was added to the sprayer to enable the suspension to move more effectively across the leaf surface and enhance thrips location. The choice of surfactant was based on the fact that it is registered in Slovenia and that in previous research it enhanced the persistance of entomopathogenic nematodes applied to control the diamond-back moth, *Plutella xylostella* (L.) (Baur et al., 1997).

The first application of the biological agents and insecticide (June 24) occurred when the first western flower thrips adults were seen on the light blue sticky boards, which are one of the most widely-used methods of thrips monitoring (Trdan & Jenser, 2003). Weekly applications thereafter (1, 2, 3, 4, 5, 6, 7 and 8 weeks after first application [AFA]) of entomopathogenic nematodes suspension (at glasshouse temperature) were made by an injector hollow cone nozzle TVI 80 02 attached to motor operated backpack sprayer (filter and screens were removed) with piston pump, usually in the early evening to minimise rapid drying of the spray on the crop. Sprays were applied as an overhead 'rain' as opposed to a thorough HV spray, at 1000 l ha^{-1}. A standard rate of 2500 IJ of *S. feltiae* per ml of water was used. Sprays with abamectin (June 24, 2 and 6 weeks AFA) were applied at the same time of day using a backpack sprayer with an injector flat fan nozzle ID 90 02. The output liquid pressure in both cases was 1.0 MPa, and the flow rate was between 1.42 and 1.46 l min^{-1}. The droplet size after the application of entomopathogenic nematodes suspension was 400 μm, while after the apllication of abamectin the same parameter was 300 μm.

No pests, other than the thrips studied here, were seen on the cucumbers to any substantial degree during the course of the study. The only other infection of note was cucumber powdery mildew (*Sphaerotheca fuliginea* [Schlecht.] Pollacci), which was controlled efficiently in the early stages of infection with two sprayings (2 and 3 weeks AFA) with the fungicide azoxystrobin (250 g l^{-1}; 0.075 % Quadris; manufacturer: Syngenta Limited AG, Fernhurst, UK; supplier: Syngenta Agro d.o.o., Ljubljana, Slovenia).

Observations and evaluations. Evaluations were taken at three time-points during the growing season: 3, 6 and 8 weeks AFA. At each time-point, three randomly selected plants of about the same height in each sub-plot were assessed for the percentage of leaf damage caused by sucking of *Frankliniella occidentalis* larvae and adults. Three leaves (lower, middle and upper part) from each chosen plant were evaluated. As no standard scale exists for rating the damage done by western flower thrips in cucumbers, a slightly modified version of the Stoner & Shelton (1988) method was used. Their method had been developed for assessing the damage by onion thrips (*Thrips tabaci* Lindeman) on cabbage leaves (Trdan *et al.*, 2005). The scale is as follows: 1 = no damage, 2 = up to 1%, 3 = 1-10%, 4 = 11-25%, 5= 26-50%, and 6= more than 50%. This scale was chosen because a relatively small amount of damage occurred on all plants.

Cucumber fruits were harvested when their diameters were 3-4 cm. Harvesting began 2 weeks after first application and continued up to the 8th week after first application, when all remaining marketable fruit was harvested. The yield was classified into three groups according to harvest time (up to 4 weeks AFA, between 4 and 6 weeks AFA, and between 6 and 8 weeks AFA). The cucumber yield was determined in two ways: 1) mass of fruits per plant, and 2) number of fruits per plant.

Data analyses. Differences in number of fruits, and mass of fruits with three different pest treatments (EPN, insecticide and control) and between four different growth substrates were analysed individually at each time of fruit picking using ANOVA. Prior to analysis, each variable was tested for homogeneity of variance, and those data found to be non-homogeneous were transformed to log(Y) before ANOVA. Significant differences ($P \leq 0.05$) between mean values were identified using Student-Newman-Keuls's multiple range test. Data of the feeding damage on the cucumber leaves had a nonparametric distribution and so was analyzed using the Kruskal-Wallis test. As in the case of the first two parameters, means were determined to be significantly different when there was no overlap of the 95% confidence intervals. All statistical analyses were done using Statgraphics Plus for Windows 4.0 (Statistical Graphics Corp., Manugistics, Inc.). The data are presented as untransformated means ± SE.

RESULTS

Damage on cucumber leaves. The type of substrate had no significant influence on the extent of leaf damage at any of the evaluation dates (3 weeks AFA: H = 4.70; df = 3; n = 96; P = 0.1951, 6 weeks AFA: H = 3.41; df = 3; n = 96; P = 0.3322, 8 weeks AFA: H = 0.57; df = 3; n = 96; P = 0.9023) (Fig. 1A). At all evaluation dates, thrips on average caused damage to about 10 % of the leaf surface.

The extent of pest damage to leaves was significantly different in relation to the control methods, irrespective of the date of damage evaluation (3 weeks AFA: H = 11.61; df = 2; n = 96; P = 0.0030, 6 weeks AFA: H = 7.79; df = 2; n = 96; P = 0.0204, 8 weeks AFA: H = 10.72; df = 2; n = 96; P = 0.0047) (Fig 1B). At all evaluation dates untreated plants were significantly more damaged than the treated plants. There was one exception to this; 3 weeks AFA no significant differences were seen between the abamectin-sprayed plants and control plants. The extent of damage did not exceed a value of 25% of the total leaf surface, even with untreated plants.

Mass of fruits per plant. Significant differences in the mean mass of fruits were found between substrate types in the first two fruit harvesting periods (< 4 weeks AFA: F = 2.30; df = 3, 103; P = 0.0425, 4-6 weeks AFA: F = 3.38; df = 3, 71; P = 0.0229) but this was not the case for the third period (6-8 weeks AFA: F = 1.23; df = 3, 96; P = 0.3030) (Fig. 2A). In the first two periods, the significant difference in mean mass of fruits was seen only between plants grown on light expanded clay aggregate (< 4 weeks AFA: 258.55±50.17, 4-6 weeks AFA: 246.67±60.31) and plants grown on vermiculite (< 4 weeks AFA: 391.66±42.30, 4-6 weeks AFA: 410.87±31.28). In both these periods, expanded perlite and peat produced results between these two extremes but not significantly different from light expanded clay aggregate, or vermiculite, or each other.

In all three harvesting periods, the method for thrips control was seen to have a significant effect on the mean mass of fruits (< 4 weeks AFA: F = 10.10; df = 2, 103; P = 0.0001, 4-6 weeks AFA: F = 10.85; df = 2, 71; P = 0.0001, 6-8 weeks AFA: F = 12.78; df = 2, 96; P < 0.0001) (Fig. 2B). Untreated plants gave significantly lower mean mass of fruits compared to other treatments in all three harvesting periods (< 4 weeks AFA: 224.66±27.69, 4-6 weeks AFA: 215.6±23.32, 6-8 weeks AFA: 210.66±18.00). No significant differences in fruit mass were seen between EPN-treated plants and abamectin-treated plants in either the first (382.08 g ±28.86 vs. 373.79 g ± 24.34) or third (433.34 g ± 41.15 vs. 421.04 g ± 38.83) harvesting periods. However, in the second harvesting period, the abamectin-treated plants showed a significantly greater fruit mass than the EPN-treated plants (418.61 g ± 28.13). No significant interactions between substrate type and pest control method were seen for any of the three harvesting periods (< 4 weeks AFA: F = 0.62; df = 6, 103; P = 0.7123, 4-6 weeks AFA: F = 0.55; df = 6, 71; P = 0.7696, 6-8 weeks AFA: F = 2.28; df = 6, 96; P = 0.0551).

Number of fruits per plant. In all three harvesting periods, the type of substrate significantly influenced the mean number of fruits per plant (< 4 weeks AFA: F = 9.49; df = 3, 23; P = 0.0003, 4-6 weeks AFA: F = 3.92; df = 3, 20; P = 0.0238, 6-8 weeks AFA: F = 12.00; df = 3, 22; P = 0.0001) (Fig. 3A). In all three periods, plants grown on light expanded clay aggregate developed significantly smaller mean number of fruits than plants grown on other substrates (< 4 weeks AFA: 6.08±0.83, 4-6 weeks AFA: 1.67±0.00, 6-8 weeks AFA: 5.67±1.05). In all three periods, plants grown on peat gave significantly more fruits per plant than plants grown on other substrates (< 4 weeks AFA: 14.67±0.33, 4-6 weeks AFA: 8.34±1.30, 6-8 weeks AFA: 14.01±0.70).

The pest-control method showed no significant influence on the mean number of fruits per plant in any of the three harvesting periods (< 4 weeks AFA: F = 1.24; df = 2, 23; P = 0.3085, 4-6 weeks AFA: F = 0.23; df = 2, 20; P = 0.7953, 6-8 weeks AFA: F = 0.84; df = 2, 22; P = 0.4432) (Fig. 3B). The mean number of fruits per plant ranged between 7.5±1.33 (4-6 weeks AFA, sprayed three times with abamectin) and 14.67±1.60 (< 4 weeks AFA: untreated control). No interaction between substrate type and control method was found within any harvesting period (< 4 weeks AFA: F = 1.61; df = 6, 23; P = 0.1894, 4-6 weeks AFA: F = 0.92; df = 6, 20; P = 0.5005, 6-8 weeks AFA: F = 1.84; df = 6, 22; P = 0.1373).

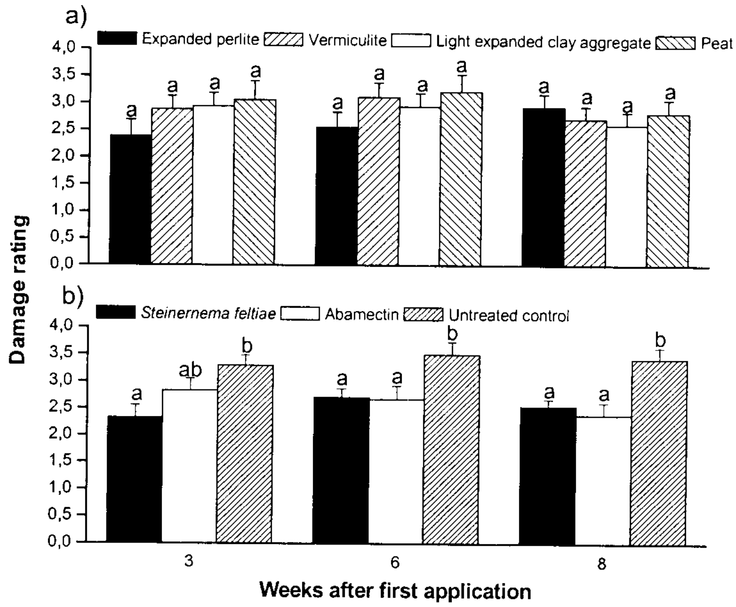

Fig. 1. Mean damage rating for *Frankliniella occidentalis* (Pergande) feeding on the leaves of cucumbers, cv. 'Jazzer Fl', produced on plants, a) grown in four different substrates, and b) subjected to two different control measures vs. untreated control. Bars headed by the same letter do not differ significantly ($P > 0.05$) according to Student-Newman-Keuls's multiple range test. The damage rating scale was as follows: 1 = no damage, 2 = up to 1%, 3 = 1-10%, 4 = 11-25%, 5= 26-50%, and 6= more than 50%.

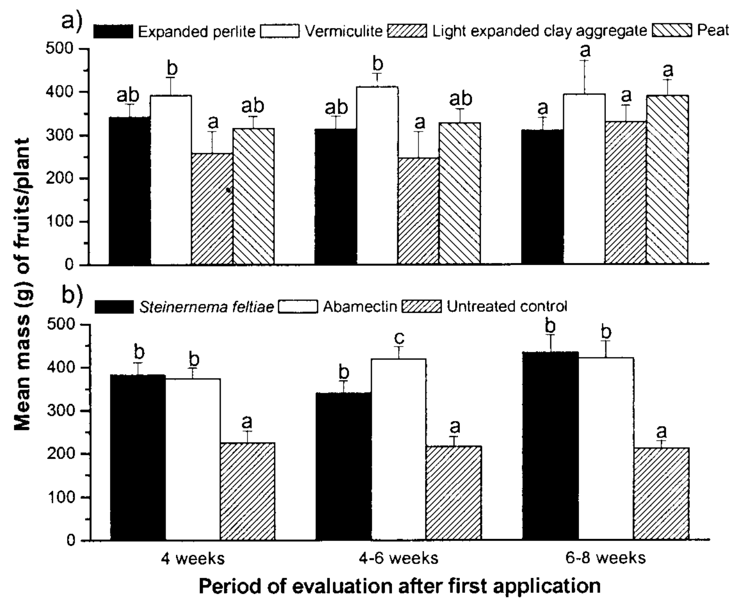

Fig. 2. Mean mass of cucumber, cv. 'Jazzer Fl', fruits produced on plants, a) grown in four different substrates, and b) subjected to two different control measures vs. untreated control. Bars headed by the same letter do not differ significantly ($P > 0.05$) according to Student-Newman-Keuls's multiple range test.

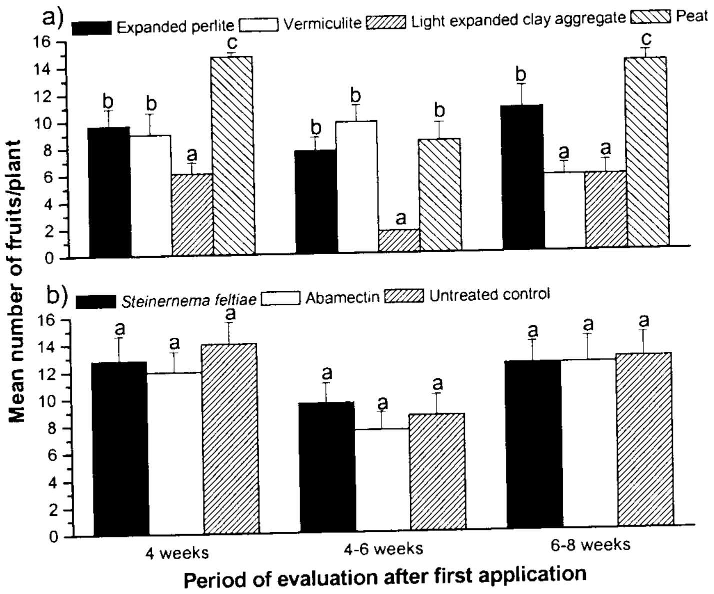

Fig. 3. Mean number of cucumber, cv. 'Jazzer F1', fruits produced on plants, a) grown in four different substrates, and b) subjected to two different control measures vs. untreated control. Bars headed by the same letter do not differ significantly ($P > 0.05$) according to Student-Newman-Keuls's multiple range test.

DISCUSSION

Western flower thrips is cosmopolitan pest (Kirk & Terry, 2003). As they cause considerable damage, they are also one of the most studied agricultural pests of the last twenty years. In our study, the thrips showed sensitivity to the attack of the entomopathogenic nematode *S. feltiae,* and also showed sensitivity to application of the insecticide abamectin. The efficacy of nematodes in our study appears greater than in other related studies where the same biological agents failed effectively to control western flower thrips on chrysanthemums (Buitenhuis & Shipp, 2005). We attribute this difference to our multifold application of nematodes and also to the size of the cucumbers leaves, to which a larger quantity of suspension and thus a higher number of nematodes can be applied. In a similar study, a higher concentration of EPNs was also seen to produce a greater mortality rate of western flower thrips (Ebssa *et al.*, 2004).

We also attribute the relative efficiency of *S. feltiae* against western flower thrips to of the early application of nematodes, adding the first suspension to cucumbers just two weeks after transferral to the glasshouse or immediately after the occurrence of the first thrips. The early start of entomopathogenic nematodes application is one of the key factors in their efficiency (Belay *et al.*, 2005).

Our research also added further support to the frequently-proven fact that abamectin is a very efficient insecticide for controlling this particular pest (Herron & James, 2005). This is why its usage against western flower thrips is recommended in conventional cucumber production, particularly because it belongs to a group of substances that have the shortest waiting period. For cucumbers, this period is only 3 days. However, the weakness of abamectin usage is its nontarget activity on natural enemies of western flower thrips. One study has reported such activity to predatory bugs (van de Veire *et al.*, 2002) and predatory mites (Bostanian & Mohhamed Akalach, 2006), thus implicating abamectin as less convenient for integrated cucumber production.

One of disadvantages of using entomopathogenic nematodes in biological control is their relatively high price compared with chemical insecticides (Georgis *et al.*, 2006). The cost of spraying for 9 times the area of 100 m^2 of cucumbers with 10 l of suspension of *S. feltiae* and excluding the labour cost of application was 130.5 EUR, whereas the cost of spraying the same area for 3 times with abamectin was rather low (15.1 EUR). The cost of 50 million infective juveniles in biopreparation Entonem is 29.0 EUR, whilst the cost of 10 ml of insecticide Vertimec is 4.0 EUR. Thus, the application of entomopathogenic nematodes is an expensive way of controlling western flower thrips on cucumber yet it is environmentaly more acceptable.

With both methods we successfully limited the extent of damage on cucumber leaves to under 10 % of the leaf surface. Although the extent of leaf damage on untreated cucumbers did not exceed an average of 25 % of the leaf surface, the average mass of fruits on those plants was significantly smaller than on sprayed plants. Fruits on untreated plants were lighter than the fruits on treated plants by between 37 and 51 %. Thus, these data demonstrate the direct activity of this pest on cucumber yield and confirm the results of a similar previous study (Hao *et al.*, 2002).

The type of growth substrate did not have a significant influence on the extent of damage caused by larvae and adults of western flower thrips to cucumbers leaves. In a study exploring the influence of growth substrates on pest damage to cucumbers, no evidence was found that the type of growth substrate impacted on the damage caused by tomato leafminer (*Liriomyza bryoniae* Kaltenbach). However, this might not be the case for all plants; as in the same study, the same insect caused significantly greater damage to tomato plants grown on peat (Szwejda & Nawrocka, 1999). It is probable that the type of growth substrate affected the susceptibility of tomato plants, as both tomato and cucumber are equally susceptible to leafminers (Tokumaru & Abe, 2005). If we wish to reduce the damage caused by western flower thrips to cucumbers, it is worth noting that in addition to considerations concerning the type of pest control, more attention should be given to the selection of appropriate cultivars. Leaf position and plant age are other factors known to influence the degree of resistance (de Kogel *et al.*, 1997), and differences in the aggressiveness of different thrips populations must also be taken into account when assessing all factors associated with cucumber sensitivity to this pest (de Kogel *et al.*, 1996).

In our research, light expanded clay aggregate appeared to be a less appropriate growth substrate as cucumbers grown on this type of substrate produced the lowest number of fruits per plant. In 2 out of 3 time-periods, the light expanded clay aggregate also produced the lowest total mass of fruits. In a similar research with different growth subtrates (coir, sawdust, rockwool, perlite and cucumber mix), no differences in the number of fruits per plant and average fruit mass were observed (Parks *et al.*, 2004). Similar conclusions were also reached in a study exploring the influences of medium perlite, coarse perlite and pine bark on cucumber yield (Cantliffe *et al.*, 2003). Although it is difficult to compare results across studies, it appears as though there is generally not a large influence of substrate type on the number or mass of cucumber fruits. However, our results indicate that in conditions similar to that of our study, the use of light expanded clay aggregate is not advisable as it was seen to produce poorer growth results. Our data indicate that expanded vermiculite and peat - both already demonstrated as suitable for cucumber production (Sawan *et al.*, 1999) - and expanded perlite in limited circumstances are appropriate substrates for growing this important vegetable.

Furthermore, for the control of western flower thrips on cucumber crops, biological control with EPN suspensions was seen to be equally as effective as the currently widely-used and highly recommended chemical insecticide abamectin. Thus, we believe that with proper optimization, the application of these biological agents represents a very promising alternative to the current chemical control methods.

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S. Trdan, D. Žnidarčič, M.Vidrih. Контроль трипсов *Frankliniella occidentalis* на тепличных огурцах: сравнение эффективности применения *Steinernema feltiae* на листьях и опрыскиваний абамектином.

Резюме. В проведенных в теплицах экспериментах сравнивали эффективность энтомопатогенных нематод *Steinernema feltiae* (Filipjev) (Rhabditida: Steinernematidae) с применением абамектина для биологического контроля трипса *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) на салатных огурцах. В период с середины июня по конец августа огурцы выращивали на различных субстратах: вздутый перлит, вздутый вермикулит, слабо-вздутые агрегации глины и торф. Взвесь энтомопатогенных нематод (2500 инвазионных личинок на мл) наносили на листья огурцов девять раз за период выращивания. Инсектицид вносили трижды в предложенной производителем дозе (22.5 g a.i. ha^{-1}). По показателям сокращения вреда от трипсов, оцененным по шестибальной шкале, наблюдались существенные различия в эффективности только между типами обработки (внесение нематод, обработка инсектицидом и необработанный контроль). Различий в результатах обработки между типами субстрата, датами проведения оценки вреда от трипсов (16 июля, 3 августа и 23 августа). Листья огурцов, обработанные нематодами и инсектицидом, были значительно менее поражены, чем необработанные листья. Уровень повреждения обработанных листьев не превышал 10% поверхности листа. Тем не менее, тип ростовых субстратов оказывал в данном эксперименте достоверное воздействие на число завязывающихся плодов и общий вес плодов. Слабо-вздутые агрегации глины оказались наименее пригодными, тогда как другие три субстрата могут быть рекомендованы для выращивания тепличных огурцов. Способ подавления вредителя оказывал также воздействие на среднюю массу огурцов, которая оказывалась на 37-51% больше чем на необработанных растений. Среднее число плодов на растение не различалось существенно при разных методах подавления вредителя. Девятикратное опрыскивание энтомопатогенными нематодами и трехкратное опрыскивание абамектином давали сходную эффективность в борьбе против трипса на тепличных огурцах.