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Research Article

Efficacy of one botanical and three synthetic insecticides against silverleaf whitefly, *Bemisia tabaci* (Hem.: Aleyrodidae) on cucumber plants in the field

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Abstract: The silverleaf whitefly, *Bemisia tabaci* (Hem.: Aleyrodidae), is a key pest of greenhouse crops. Nymphs and adults feed on plant sap and excrete honeydew, resulting in reduction of yield and quality. This pest has a high potential for developing resistant biotypes against different insecticides. Therefore, it is necessary to study the efficacy of different categories of insecticides against *B. tabaci*. In this research, efficacy of imidacloprid (0.5 l/ha), thiacloprid + deltamethrin (0.75 l/ha), pyrethrum (4 l/ha) and thiamethoxam + lambda-cyhalothrin (0.3 and 0.4 l/ha) with four replications were studied in a completely randomized block design in Yazd and Bushehr provinces of Iran. Mean (± SE) efficacy of imidacloprid, thiacloprid + deltamethrin, pyrethrum and thiamethoxam + lambda-cyhalothrin (0.3 and 0.4 l/ha) were 73.42 ± 3.41, 89.57 ± 2.86, 90.29 ± 2.79, 68.13 ± 3.37 and 75.62 ± 3.76% against *B. tabaci* nymphs 7 days after treatment in Yazd, respectively; while in Bushehr, they were 57.30 ± 3.37, 68.45 ± 4.65, 64.17 ± 2.87, 30.0 ± 4.56 and 53.0 ± 3.35%, respectively. Thiacloprid + deltamethrin, pyrethrum and thiamethoxam + lambda-cyhalothrin (at 0.4 l/ha) can be suitable candidates in IPM programs of *B. tabaci*.

Keywords: *Bemisia tabaci*, insecticide, efficacy, cucumber

Introduction

The silverleaf whitefly, *Bemisia tabaci* (Hem.: Aleyrodidae), is a key pest of field and greenhouse cucumber. Nymphs and adults feed on plant sap and excrete honeydew. Due to its multi-voltinism and short generation-time, it has high potential for developing biotypes resistant to insecticides. One of the methods to decrease the rate of emergence of resistant biotypes is application of insecticides with different modes of actions. Therefore, it is necessary to study the efficacy of different types of insecticides against *B. tabaci*. Effective control of *B. tabaci* by new insecticides can decrease the side effects from overusing non-effective insecticides.

Resistance of *B. tabaci* to different types of insecticides has been reported (Ellswortha and Martinez-Carrillo, 2001; Toscano, 2003). Research on efficacy of insecticides against *B. tabaci* goes back to 1986 by Razeghi and Omati (1986), who studied the efficacy of pirimiphos-methyl, dimethoate, dimicron, fenpropathrin and Dimicron + carbaryl. In a field research (Bacci *et al.,* 2007), cartop, imidacloprid and abamectin

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caused 80% mortality; while, fenitrothion, fenthion, phenthoate malathion, bifenthrin, cypermethrin, esfenvalerate and fenpropathrin were not effective, and also caused high mortality on natural enemies. Deltametrin and dimetoat were effective against *B. tabaci* on faba bean, *Vicia faba* (Ahmad *et al.*, 2002). Li *et al.* (2000) reported cross-resistance when they treated *B. tabaci* with imidacloprid, thiamethoxam and acetamiprid. Application of imidacloprid may increase yield by 20% in addition to an effective control of *B. tabaci* (Horowitz *et al.,* 1998). Application of acetamiprid or thiamethoxam on 22 consecutive generations of *B. tabaci* resulted in a 30-50-fold increase in resistance of *B. tabaci* to these insecticides. However, there was not a cross-resistance between these insecticides and IGR compounds (Ishaaya *et al.,* 2003). Treatment of bean seeds with imidacloprid followed by four times of foliage spraying resulted in 83%, 92% and 70% mortalities of eggs, nymphs and adults of *B. tabaci*, respectively (Barbosa *et al.,* 2002). Imidacloprid, buprofezin and pyriproxyfen were effective against *B. tabaci* on cotton (Palumbo *et al.,* 2001). Wang *et al.* (2008) studied the efficacy of abamectin, acetamiprid, azadirachtin, oxymatrine, imidacloprid, chlorpyrifos, cyhalothrin, buprofezin and rotenone against *B. tabaci* by dipping method. Based on their result, abamectin was the most efficacious followed by acetamiprid, azadirachtin, oxymatrine, imidacloprid, chlorpyrifos, cyhalothrin and rotenone. The efficacy of azadirachtin against *B. tabaci* was studied by Jazzar and Abou-Fakhr (2003) and Abou-Fakhr and McAuslane (2006).

Anti-feeding, repellency, and insecticidal effects of extracts obtained from different plant species, e.g. *Azadirachta indica*, *Salvia bracteata*, *Nerium oleander*, *Lavandula officinalis* and *Ferula assafoetida* have been studied (Marouf *et al.,* 2002; Moharamipour *et al.,* 2003; Mansouri-Jajaiiand Marouf, 2004). Azadirachtin (Neem®) at 20 mg/cm^2 effectively repelled the red flour beetle (*Tribolium castaneum* (Col.: Tenebrionidae) (Chander *et al.,* 1999).

The objective of this research was to evaluate the efficacy of four different insecticides against *B. tabaci* in the field. The results can be useful in application of insecticides against *B. tabaci* in IPM programs.

Materials and Methods

This research was conducted on cucumber fields in Yazd (Yazd, Iran) and Dashtestan (Bushehr, Iran) in 2011 in a completely randomized block design with six treatments and four replications. The treatments were: 1) imidacloprid (Confidor® SC 35 at 0.5 l/ha, Bayer Crop Science LP, Research Triangle Park, NC), 2) thiacloprid+deltamethrin (Proteus® OD 110, Bayer Crop Science LP) at 0.750 l/ha, 3) pyrethrum (Pyrethrum® EC 5 at 4 l/ha, Agropharm Chemical Company, Buckinghamshire, UK), 4 & 5) thiamethoxam + lambda-cyhalothrin (Eforia® SC 247 at 0.4 & 0.3 l/ha, Syngenta Crop Protection, Greensboro, NC), and 6) control (treated with water). The experimental plots were 30 m^2 and 2 m apart. The blocks were 3 m apart. Since, adult whiteflies were very mobile and might enter into the treated plots, the control plots were located 70 m apart from treated plots. 'Mirsoltan' cucumber variety was planted in the fields. An atomizer sprayer (Model: 102063, Tecnoma Company, France) was calibrated (at 1000 l/ha), before running the experiment. The sprayer was washed with water and detergent before applying each treatment. Samplings were done once before treatment; and 3, 7 and 14 days after treatment. The samples were taken early in the morning, when the weather was cool. In each plot, 10 plants were randomly selected from which one leaf/plant (at the top third of the plant canopy) was excised and transferred to the laboratory inside plastic bags. The number of adult whiteflies under these leaves was recorded. To sample for eggs and nymphs, 10 leaves per plot were removed from different plants and transferred to the laboratory in plastic bags. To record the number of eggs and nymphs On the abaxial surface of leaves, two 1-cm^2 sampling units were chosen under the leaves, such

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that the units included the main vein. Counting was done using a stereo-microscope at X40.

The efficacy was estimated based on the Henderson-Tilton formula (Henderson and Tilton, 1955):

Efficacy (%) = 100 × [1 - (*Ta* × *Cb*)/(*Tb* × *Ca*)]

where, *Ta* is the number of insects in treated plot after treatment, *Cb* is the number of insects in control plot before treatment, *Tb* is the number of insects in treated plot before treatment, and *Ca* is the number of insects in control plot after treatment.

Data were analyzed using procedures of SAS® (SAS Institute Inc., 2002). The normality of the untransformed and transformed data and also normality of residuals after analysis of variance were checked using stem-leaf and normal probability plots. Homoscedasticity was checked by observing graphical distribution plots of variance by mean (PROC PLOT). A General Linear Model (PROC GLM) was used to compare the efficacy of the treatments as well as the number of insects at different growth stages in the treatments ($\alpha = 0.05$). Comparisons between the treatments were made using the Duncan's test, where analysis of variance showed significant differences among the means.

Results and Discussion

Yazd province: The efficacy against the nymphs and adults at different days after treatment were significantly different among treatments (Nymphs: 3 days after treatment: $F_{4,8} = 4.25$, $P = 0.024$; 7 days after treatment: $F_{4,8} = 9.17$, $P = 0.001$; 14 days after treatment: $F_{4,8} = 6.16$, $P = 0.001$ – Adults: 3 days after treatment: $F_{4,8} = 6.10$, $P = 0.001$; 7 days after treatment: $F_{4,8} = 3.21$, $P = 0.042$; 14 days after treatment: $F_{4,8} = 3.58$, $P = 0.039$). Three days after treatment, only thiacloprid+deltamethrin had an acceptable (i.e. more than 70%) efficacy against the nymphs (Table 1). However, despite significant differences in efficacy of the treatments against the nymphs on the 7th and 14th days after treatment, none of the insecticides controlled the nymphs at an acceptable level. The adults (Table 1) were controlled at acceptable levels on the 3rd and 7th days after treatment (≥ 70%). pyrethrum and thiacloprid+deltamethrin kept their high efficacy (i.e. ≥ 90%) against adults up to the 7th day after treatment, and ranked the most efficacious treatments (more than 70% efficacy) on the 14th day after treatment (Table 1). Imidacloprid and both doses of thiamethoxam + lambda-cyhalothrin (0.4 and 0.3 l/ha) resulted in an acceptable level of adult control (ca. 70%) up to the 7th day after treatment.

Bushehr province: The efficacy against the nymphs and adults at different days after treatment were significantly different among treatments (Nymphs: 3 days after treatment: $F_{4,8} = 11.99$, $P = 0.0001$; 7 days after treatment: $F_{4,8} = 6.08$, $P = 0.001$; 14 days after treatment: $F_{4,8} = 5.16$, $P = 023$ – Adults: 3 days after treatment: $F_{4,8} = 3.74$, $P = 0.041$; 7 days after treatment: $F_{4,8} = 4.86$, $P = 0.036$; 14 days after treatment: not-available due to technical problems). Three days after treatment, none of the treatments resulted in an acceptable level of control against the nymphs. However, on the 7th day after treatment, the treatments resulted in an acceptable control of nymphs except imidacloprid, which caused 51% mortality (Table 2). Fourteen days after treatment, only thiacloprid + deltamethrin and pyrethrum effectively controlled the nymphs. Despite significantly different efficacies among treatments against the adults, none could effectively control the adults of *B. tabaci.*

Despite fast acting nature of imidacloprid, its low efficacy in both provinces may indicate the emergence of resistant biotypes. Imidacloprid has been used for quite a long time against sucking insects, which may corroborate the possibility of emergence of resistant biotypes. Previously, resistance of whiteflies to imidacloprid was reported (Sheikhi, 2008). Studies of Bi and Tosccano (2007) on biotypes of whiteflies resistant to imidacloprid, showed that these biotypes were susceptible to insecticides with other modes of action such as chlorinated insecticides (e.g. endosulfan), pyrethroids (e.g. fenpropathrin, deltamethrin), organophosphorus insecticides (e.g. malathion, Chlorpyrifos), and carbamates (e.g. methomyl).

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This may corroborate our results on efficacy of treatments against nymphs.

Study on efficacy of imidacloprid, thiamethoxam and dinotefuran against nymph and adult whiteflies (Pirmoradi *et al*., 2010) showed that thiamethoxam and imidacloprid were the most and least effective against adults, respectively. The low efficacy of imidacloprid against adult whiteflies was reported to be due to emergence of resistant biotypes of whiteflies (Pirmoradi *et al*., 2010). They also reported higher mortality rate in nymphs compared with adults, which confirm our results.

Table 1 Efficacy of different insecticides against nymphs and adults of silverleaf whitefly, *Bemisia tabaci* on cucumbers in the field in Yazd province.

Insecticides	Dose (l/ha)	% efficacy on nymphs (Mean ± SE) Days after treatment[1]			% efficacy on adults (Mean ± SE) Days after treatment[1]		
		+ 3	+ 7	+ 14	+ 3	+ 7	+ 14
Imidacloprid	0.50	26.26 ± 3.27c	38.55 ± 3.12b	27.44 ± 4.25ab	79.22 ± 4.65b*	73.42 ± 3.41b	60.31 ± 4.23b
Thiacloprid + Deltamethrin	0.75	76.81 ± 5.67a	63.85 ± 4.35a	22.12 ± 3.75b	92.34 ± 4.35ab	89.57 ± 2.86a	82.68 ± 4.11a
Pyrethrum	4.00	42.61 ± 4.82b	65.92 ± 4.27a	4.11 ± 4.35c	95.65 ± 3.74a	90.29 ± 2.79a	71.1 ± 3.95ab
Thiamethoxam + Lambda-cyhalothrin	0.40	50.77 ± 4.39b	40.05 ± 3.62b	11.27 ± 4.31bc	81.64 ± 2.95b	75.62 ± 3.76b	32.58 ± 3.45c
Thiamethoxam + Lambda-cyhalothrin	0.30	40.09 ± 2.58b	33.36 ± 2.41b	40.86 ± 3.29a	75.07 ± 2.55b	68.13 ± 3.37b	31.35 ± 2.78c

[1] Means followed by the same letters in a column are not significantly different (Duncan's test, $\alpha = 0.05$).

Table 2 Efficacy of different insecticides against nymph and adult silverleaf whitefly, *Bemisia tabaci* on cucumber in the field in Bushehr province.

Insecticides	Dose (l/ha)	% efficacy on nymphs (Mean ± SE) Days after treatment[1]			% efficacy on adults (Mean ± SE) Days after treatment[1]		
		+ 3	+ 7	+ 14	+ 3	+ 7	+ 14[2]
Imidacloprid	0.50	45.65 ± 2.35a	51.12 ± 4.74b	50.07 ± 3.85b	53.45 ± 2.58a	57.30 ± 3.37ab	NA
Thiacloprid + Deltamethrin	0.75	25.0 ± 2.55b	70.0 ± 4.56a	89.40 ± 6.52a	55.17 ± 2.21a	68.45 ± 4.65a	NA
Pyrethrum	4.00	21.1 ± 3.23b	79.42 ± 3.39a	72.37 ± 5.32a	51.55 ± 3.36a	64.17 ± 2.87a	NA
Thiamethoxam + Lambda-Cyhalothrin	0.40	49.62 ± 3.23a	84.25 ± 5.32a	53.75 ± 4.87b	34.10 ± 2.59b	53.0 ± 3.35b	NA
Thiamethoxam + Lambda-cyhalothrin	0.30	38.65 ± 4.65a	75.6 ± 4.57a	60.30 ± 3.69b	23.67 ± 3.71c	30.0 ± 4.56c	NA

[1] Means followed by the same letters in a column are not significantly different (Duncan's test, $\alpha = 0.05$).
[2] Not-available data due to technical problems.

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In our study, pyrethrum resulted in an acceptable level of whitefly control and was more effective than other treatments. Studies of Jazzar and Abou-Fakhr (2003) and Abou-Fakhr and McAuslane (2006) showed effective control of *B. tabaci* with azadirachtin, resulting in 9.4 ± 3.6 nymphs on treated leaves compared to 24.3 ± 7 nymphs on untreated leaves.

Some research on efficacy of plant extracts against insects has also reported high mortality rates of insects treated with these compounds. Ahmad *et al.* (1999) reported 100% mortality rate of adult Pulse beetle, *Callosobruchus chinensisi* (Col.: Bruchidae), 3 days after release on seeds treated with extracts of Sesamex and Neem.

Higher efficacy of treatments against adults in Yazd compared with Bushehr, might be due to genetic difference between the two populations, which needs more research. Higher efficacy of pyrethrum on nymphs, 14 days after treatment, in Yazd compared with Bushehr might be due to difference in weather conditions, resulting in faster degradation of pyrethrum in Yazd. The efficacy of thiacloprid + deltamethrin on nymphs had an increasing trend during the evaluated period in Bushehr, while in Yazd, it had a decreasing trend; more research is needed to clarify this difference.

In conclusion, we recommend application of thiacloprid + deltamethrin and pyrethrum, (at 0.75 and 4 l/ha, respectively) for controlling *B. tabaci* nymphs for up to 7 days after treatment. thiamethoxam + lambda-cyhalothrin at 0.3 l/ha may also be used in rotation with thiacloprid + deltamethrin and pyrethrum.

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مطالعه کارایی چند حشره‌کش سنتتیک و یک حشره‌کش گیاهی علیه سفیدبالک *Bemisia tabaci* (Hem.: Aleyrodidae) روی خیار در مزرعه

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چکیده: سفیدبالک (*Bimisia tabaci*) یکی از آفات مهم محصولات گلخانه‌ای به‌ویژه خیار است. حشرات کامل و پوره‌ها با تغذیه از شیره گیاهی و ترشحات عسلک سبب خسارت و کاهش عملکرد می‌گردند. این افت دارای پتانسیل بالایی برای توسعه و بروز مقاومت در برابر حشره‌کش‌ها می‌باشد، بنابراین مطالعه کارایی حشره‌کش‌های جدید و با نحوه اثر متفاوت برای کنترل آفت ضروری است. در این تحقیق کارایی حشره‌کش‌های ایمیداکلوپرید (به نسبت ۰/۵ لیتر در هکتار)، تیاکلوپرید + دلتامترین (به نسبت ۰/۷۵ لیتر در هکتار)، پیرتروم (به نسبت ۴ لیتر در هکتار)، تیامتوکسام + لمبداسی‌هالوترین (به نسبت ۰/۳ و ۰/۴ لیتر در هکتار) و شاهد مطالعه شدند. آزمایش‌ها در قالب طرح بلوک‌های کامل تصادفی با ۴ تکرار در استان‌های یزد و بوشهر انجام شدند. در استان یزد هفت روز پس از سمپاشی میانگین کارایی تیمارهای ایمیداکلوپرید، تیاکلوپرید + دلتامترین، پیرتروم، تیامتوکسام + لمبداسی‌هالوترین (به نسبت ۰/۳ و ۰/۴ لیتر در هکتار) به‌ترتیب برابر ۳/۴۱ ± ۷۳/۴۲، ۲/۸۶ ± ۸۹/۵۷، ۲/۷۹ ± ۹۰/۲۹، ۳/۳۷ ± ۶۸/۱۳ و ۳/۷۶ ± ۷۵/۶۲ درصد برآورد شد، درحالی‌که در استان بوشهر کارایی حشره‌کش‌ها به‌ترتیب برابر ۳/۳۷ ± ۵۷/۳۰، ۴/۶۵ ± ۶۸/۴۵، ۲,۸۷ ± ۶۴/۱۷، ۴/۵۶ ± ۳۰/۰ و ۳/۳۵ ± ۵۳/۰ درصد بودند. بنابر نتایج حشره‌کش‌های تیاکلوپرید + دلتامترین، پیرتروم، تیامتوکسام + لمبداسی‌هالوترین (۰/۴ لیتر در هکتار) می‌توانند کاندیدای مناسبی برای مدیریت تلفیقی سفیدبالک باشند.

واژگان کلیدی: *Bimisia tabaci*، حشره‌کش‌ها، کارایی و خیار

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