

Lethal and sublethal effects of ten insecticides, used in date palm production in Saudi Arabia, on the parasitoid *Trichogramma cacoeciae*

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Summary Lethal and sublethal effects of ten insecticides commonly used in date palm production in Saudi Arabia were assessed in the laboratory against adults of *Trichogramma cacoeciae*, an important egg parasitoid of the dried fruit moth *Ephestia calidella*. Bioassays were conducted according to the standard protocol of the International Organization for Biological Control IOBC/WPRS/Working Group 'Pesticides and Beneficial Organisms'. Our results showed that cypermethrin, deltamethrin, malathion, phenthoate, methomyl, and carbosulfan were moderately harmful (IOBC Class 3) to the parasitoid. The botanical insecticides azadirachtin and matrine were moderately harmful (IOBC Class 3) and slightly harmful (IOBC Class 2), respectively. The insect growth regulator pyriproxyfen was slightly harmful, whereas bistrifluron was harmless (IOBC Class 1). Regarding sublethal effects, the parasitism ratios compared to control were reduced by pyriproxyfen and azadirachtin to 49.0% and 58.0%, respectively; hence they are classified as slightly harmful insecticides (IOBC Class 2). Bistrifluron and matrine were harmless (IOBC Class 1) as parasitism ratios were reduced by 9.2% and 27.6%, respectively. Longevity of adults exposed to bistrifluron and matrine (3.6 and 3.3 days, respectively) and to pyriproxyfen and azadirachtin (1.7 and 1.3 days, respectively) was significantly lower than that in control (4.67 days). In semi-field tests, residues of most insecticides on leaves of tomato, a common host plant of lepidopteran pests parasitized by *T. cacoeciae*, were considered moderately harmful to harmful based on parasitoid mortality at 24 h post-treatment whereas they were slightly harmful at 7 and 14 days post-treatment.

Additional keywords: longevity, mortality, parasitism, sublethal effects, *Trichogramma cacoeciae*, viability

Introduction

Species of *Trichogramma* (Hymenoptera: Trichogrammatidae) are important parasitoids in natural and agricultural ecosystems and act as effective biocontrol agents of lepidopteran pests in important crops such as tomato, soybean and cruciferous plants (Godfray, 1994; Beserra and Parra 1994; Moezipour *et al.*, 2008; Polaszek, 2010).

The dried fruit moth *Ephestia calidella* (Guenée) (Pyralidae) is a pest of economic importance on date palm in Saudi Arabia, attacking dates during harvest, storage and packinghouse processing (El-Shafie *et al.*, 2017). Development of the pest and its dam-

aging impacts on date palms are restricted by the use of the parasitoid *Trichogramma cacoeciae* Marchal (Rubeai *et al.*, 2003; El-Shafie *et al.*, 2017), which is commercially available and the most commonly used natural enemy in biological control programs (Hassan, 1993; Hassan *et al.*, 2000).

Nevertheless, application of insecticides for the control of date palm pests cannot be excluded and sustainable use is foreseen in the frame of an Integrated Pest Management plan. Therefore, there is an urgent need to assess and quantify the risks of pesticides against natural enemies of date palm pests in order to minimize any adverse effects. Pesticides may cause lethal effects to non-target organisms in addition to sub-lethal behavioral and development effects, such as changes in rates of parasitism, longevity, sex ratio, and adult emergence (Desneux *et al.*, 2007; Firake and Khan, 2010; Firake *et al.*,

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2012; Blibech *et al.*, 2015).

Toxicity of different classes of insecticides to *Trichogramma* spp. vary. Synthetic pyrethroid insecticides appear to be the most harmful class (Youssef *et al.*, 2004; Abdulhay and Rathi, 2014; Sohrabi and Amini, 2015; Thubru *et al.*, 2016); Furthermore, the effect of deltamethrin on pupae of *Trichogramma oleae* (Voegele and Poitale), *T. cacoeciae*, and *T. bourarachae* Pintureau and Babault persisted for 30 days following exposure (Blibech *et al.*, 2015).

The neonicotinoid insecticide acetamiprid was harmful as regards adult emergence and rates of parasitism of *Trichogramma evanescens* Westwood (Jiu-Sheng *et al.*, 2010). Thiacloprid was harmful to *T. cacoeciae* adults but harmless to larvae and pupae (Schuld and Schmuck, 2000).

Organophosphate insecticides have been shown to be harmful to eggs of *T. evanescens* and *Trichogramma platneri* Nagaratti (Jiu-Sheng *et al.*, 2010; Brunner *et al.*, 2001) and moderately harmful to *T. cacoeciae* (Youssef *et al.*, 2004).

Insect growth regulators and insect growth inhibitors (fenoxycarb, diflubenuron and lufenuron) have been reported not to be harmful to adults, pupae or eggs of *T. cacoeciae* (Hassan *et al.*, 1998; Brunner *et al.*, 2001; Abaar *et al.*, 2010). Consoli *et al.* (2001) found that lufenuron and triflumuron did not affect parasitism efficiency in *T. galloi* Zucchi, although they were harmful when applied to larvae and caused 100% death rate in adults when applied to eggs.

Abdelgader and Hassan (2012) reported that azadirachtin was harmful to *T. cacoeciae* adults, which were exposed to residues on glass plates and slightly to moderately harmful regarding adult emergence when applied to parasitized host eggs at different time intervals.

Herein, we studied lethal, sublethal and persistence effects of ten insecticides, which are commonly used in date palm production in Saudi Arabia, on *T. cacoeciae*. Adults of the parasitoid were exposed to dry residues of the highest recommended rates of the test insecticides thus at very high risk (Hassan *et*

al., 2000), likely resulting in the greatest degree of harm. The outcome of lethal/sublethal effects together with the results on the insecticide persistence will contribute to the selection of insecticides that pose lower risk to the parasitoid and to determine the conditions of safe use in IPM programs in date palm plantations (Grutzmacher *et al.*, 2004).

Material and Methods

Trichogramma cacoeciae cultures

Trichogramma cacoeciae was selected among *Trichogramma* spp. for the bioassays as it is easy to rear and handle in the laboratory (Hassan 1998). *Trichogramma cacoeciae* was obtained from a colony maintained at the Excellence Research Center for palms and dates at the King Faisal University. The colony originated from parasitized Lepidopteran eggs on leaves of cruciferous, tomato and other Solanaceae plants cultivated at Al-Hasa fields, Eastern province of Saudi Arabia. Adults of *T. cacoeciae* were reared on eggs of *Ephestia cautella* (Walker) (Lepidoptera: Pyralidae) (Suh *et al.*, 2000), in an insect growth chamber maintained at 23 ± 2 °C and $75 \pm 5\%$ relative humidity (RH) with a 16:8 L:D cycle.

Insecticides

Lethal and sublethal effects on *T. cacoeciae* were assessed for 10 commonly used and commercially available insecticides in Saudi Arabia against pests of date palms. The insecticides are presented in Table 1 and contain active substances which belong to different chemical groups (pyrethroids, organophosphates, carbamates, Insect Growth Regulators and plant extracts).

Lethal effects of insecticides

Lethal effects of insecticides were assessed on *T. cacoeciae* adults after exposure to dry residues on glass plates using the highest recommended application rates (Hassan *et al.*, 2000). Glass tubes (2.5 x 20 cm) were treated by adding 5 ml of an aqueous insecticide solution which covered the inner surface; the tubes were then emptied and left to

Table 1. List of insecticides used in the study.

Insecticides	Class	Recommended application rate (ml/L)	Manufacturing company
Cypermethrin (Hi power 10% EC)	Pyrethroid	0.50	Sulphur mills limited- India
Deltamethrin (Flotron 2.5% EC)	Pyrethroid	0.35	Sulphur mills limited- India
Malathion (Sulmathion 57% EC)	Organic phosphorus	0.75	Sulphur mills limited- India
Phenthoate (Peston 50% EC)	Organic phosphorus	0.80	Astrachem - Saudi Arabia
Methomyl (Metho 900 SP)	Carbamate	0.20	BASF Corporation – Germany
Carbosulfan (Marshal 25% WP)	Carbamate	0.50	Astrachem - Saudi Arabia
Bistrifluron (Hanaro 10% EC)	(IGR)	1.00	Astrachem - Saudi Arabia
Pyriproxyfen (Muligan 10% EC)	(IGR)	0.75	Parabolan- Spain
Matrine (Kingbo 0.6% EC)	Plant Extract	2.00	Beijing Kingbo Biotech- China
Azadirachtin (Amen 1.0% EC)	Plant Extract	2.50	Ecopheosides – India

dry for 3 h. Control tubes were treated with distilled water. Five replicates of glass tubes per insecticide treatment were used. Twenty adults of *T. cacoeciae*, which were 24 hours old, were transferred to each treated tube after drying, using a fine feather. The tubes were then sealed using cotton previously dipped in 50% honey solution and were kept in an incubator at $26 \pm 2^\circ\text{C}$, RH $75 \pm 5\%$ RH and 16:8 L:D cycle. After 24 h of exposure to the dry insecticide residues, the effect on adult mortality was recorded. The classification system of the International Organization for Biological Control (IOBC) was used for the classification of the insecticide toxicity as: harmless (<30% mortality, Class 1); slightly harmful (30-79% mortality, Class 2); moderately harmful (80-99% mortality, Class 3); or harmful (>99% mortality) (Hassan *et al.*, 2000).

Sublethal effect on parasitism

Sublethal effect on parasitism were assessed on adult females of *T. cacoeciae*, which had survived the 24 h exposure to insecticide residues (bistrifluron 10% EC; pyriproxyfen 10% EC; matrine 0.6% EC; azadirachtin 1.0% EC, and control). Females were placed in glass tubes (2.5 x 20 cm), 6 individuals per tube, along with 100 ± 10 eggs of *E. cautella*, which were glued on cardboard tape (1cm²). The females were provided with food through a cotton wool, which had been dipped in 50% honey solution, and served also as a closure of the tubes.

Five tubes (replicates) were used per insecticide treatment and the control and were kept at $26 \pm 2^\circ\text{C}$, RH $75 \pm 5\%$ RH at a 16:8 L:D cycle. The eggs of *E. cautella* were removed from the glass tubes after 24 h exposure to the parasitoids and placed in labeled Petri dishes corresponding to the replicates, in the incubator. After 9 days of incubation, the number of parasitized eggs was counted and parasitism ratios of the insecticide treatments were compared with the control. The IOBC classification (Hassan *et al.*, 2000) was used for the classification of insecticide toxicity and the data were corrected using the Abbott's formula (Abbott 1925).

Sublethal effects on parasitoid longevity

Sublethal effect of insecticides on parasitoid longevity was also assessed on adult females which survived 24 h exposure to the insecticide treatments. Female individuals were placed individually in clean glass tubes sealed with cotton wool, which had been dipped in 50% honey solution, and were incubated as described before. Five tubes (replicates) per insecticide treatment and the control were used. Longevity of the parasitoid as number of days until death was recorded.

Persistence effects on parasitoid mortality

The persistence effect of insecticides, ap-

plied to tomato leaves, on *T. cacoeciae* adults was assessed. The experiment was conducted on tomato leaves because it is a common host for lepidopteran insects parasitized by *T. cacoeciae*. For this purpose, 75 tomato seedlings of the local cultivar Alhassawi were transplanted in five replicate plots, each measuring 2 x 3 m. Plants were grown in a mixture of peat moss (75% by vol.), native fine sand, perlite and vermiculite.

Each insecticide was applied to plants in four replicate plots, while the control (water) was applied to the fifth plot. Following treatment with insecticide or water, the plants were left to dry for three hours. Five tomato leaves, measuring 5-6 cm long, were randomly collected from the upper third of the plant in each plot of each insecticide treatment. Each set of five leaves, representing one replicate per treatment, was placed in a separate bag and transferred to the laboratory. Leaves were cut into 1 cm² pieces and placed in a test tube (5 x 1.5 cm) along with 20 x one day old adults of *T. cacoeciae* (Suh *et al.*, 2000). The tubes were then sealed with cotton wool and kept in an incubator for 24 h, before mortality was recorded at 1, 2, 3, 7,

14 days post-treatment. Mortality ratio data were corrected using the Abbott's formula (Abbott, 1925).

Statistical analysis

The experiment was designed as a randomized complete block design using five replicates per treatment in addition to the control. Corrected percent mortality was calculated (Abbott 1925) and data were analyzed using Analysis of Variance (ANOVA). Separation of the means was conducted using the Fisher's protected Least Significant Difference test (PLSD), ($P < 0.05$) (Steel *et al.*, 1997). The analyses were performed using SPSS 12.0 Windows (SPSS Inc., 2003).

Results and Discussion

Lethal Effects

Survival and corrected mortality of adult females of *T. cacoeciae* after 24 h exposure to dry insecticide residues differed among the insecticides (Table 2). Cypermethrin, deltamethrin, malathion, phenthoate, methomyl and carbosulfan, were moderately harmful

Table 2. Survival and corrected mortality of adult females of the egg parasitoid *Trichogramma cacoeciae*, when exposed to dry residues of insecticides on glass surfaces treated at the recommended application rates.

Treatment		Adult survival	Corrected mortality (E%)	IOBC Classification
Insecticide	Class			
Cypermethrin (Hi power)	Pyrethroid	2.00 ± 0.77 gh	98.00	3
Deltamethrin (Flotron 2.5%)		4.33 ± 0.26 efg	95.67	3
Malathion (Sulmathion 57%)	Organophosphate	1.00 ± 0.45 h	99.00	3
Phenthoate (Peston 50%)		3.33 ± 0.26 fgh	96.67	3
Methomyl (Metho900)	Carbamate	1.00 ± 0.45 h	99.00	3
Carbosulfan (Marshal 25%)		5.00 ± 0.45 ef	95.00	3
Bistrifluron (Hanaro 10%)	IGR	92.67 ± 0.7 b	7.33	1
Pyriproxyfen (Muligan 10%)		40.33 ± 0.68 d	59.76	2
Matrine (Kingbo 0.6%)	Plant Extract	50.00 ± 0.89 c	50.00	2
Azadirachtin (Amen 1.0%)		6.67 ± 1.37 e	93.33	3
Control		100.0 ± 0.00 a		-
LSD (P > 0.05) = 28.639				
F value = 0.041				

All values are means of 5 replicates ± SE. Means in the same column followed by the same letter are not significantly different (Fisher's test, $P > 0.05$). IOBC insecticide classification, where Class 1: harmless ($E < 30\%$); Class 2: slightly harmful ($30\% < E < 79\%$); Class 3: moderately harmful ($80\% < E < 99\%$); and Class 4: harmful ($E > 99\%$).

(IOBC class 2) to the parasitoid *T. cacoeciae*, according to the IOBC classification system (Hassan *et al.*, 2000). Similar moderate to high toxicities of organophosphorus and synthetic pyrethroid compounds to adults of *T. cacoeciae* and other *Trichogramma* spp. have also been reported in other studies (Brunner *et al.*, 2001; Youssef *et al.*, 2004; Jiu-Sheng *et al.*, 2010; Zhu *et al.*, 2009; Abaar *et al.*, 2011; Sohrabi and Amini, 2015; Thubru *et al.*, 2016).

The plant extract azadirachtin (Amen 1.0%) was moderately toxic, supporting data from Thubru *et al.* (2016) on another egg parasitoid, *Trichogramma brassicae* (Bezdenko).

The insect growth regulator (IGR) pyriproxyfen (Muligan 10%) and the plant extract matrine (Kingbo 0.6%) are slightly harmful (IOBC class 3) to the parasitoid *T. cacoeciae* while the IGR bistrifluron is harmless (corrected mortality did not exceed 7.3%; IOBC class 1).

Sublethal effects

Parasitism ratio of *E. cautella* eggs by female parasitoids of *T. cacoeciae*, which had survived 24h exposure to dry insecticide residues, was significant lower compared to the control, while it differed among the tested insecticides (Table 3). Similarly, longevity of adult females of *T. cacoeciae* that survived initial 24h exposure to the insecticide resi-

dues was significantly lower than that of the control but there were variations in the effect among the insecticides (Table 3).

Based on parasitism ratios of *T. cacoeciae* on *E. cautella*, the IGRs pyriproxyfen and bistrifluron are classified as slightly harmful (IOBC class 2) and harmless (IOBC class 1) to *T. cacoeciae*, respectively. The plant extracts azadirachtin and matrine are classified as slightly harmful (IOBC class 2) and harmless (IOBC class 1) to the parasitoid, respectively. In terms of effect on longevity, the most harmful insecticides to the parasitoid were pyriproxyfen and azadirachtin (Table 3).

Regarding IGRs, Consoli *et al.* (1998) and Hassan *et al.* (1998) found that lufenuron was slightly harmful to *T. cacoeciae*. However, Abaar *et al.* (2010) reported that fenoxycarb, diflubenzuron, and lufenuron were not harmful to pupae or toxic to *T. cacoeciae* eggs and the low toxicity levels of IGR in *T. cacoeciae* larvae have been reflected in the high rates of adult emergence compared to the control.

Azadirachtin, although a botanical insecticide, was found to be moderately harmful to *T. cacoeciae* regarding mortality and slightly harmful regarding parasitism ratio. Our results are in conflict with those reported by Thubru *et al.* (2016), who found that surface contact toxicity of azadirachtin was

Table 3. Parasitism ratio of *Trichogramma cacoeciae* on eggs of *Ephestia cautella* and longevity of adult females of the parasitoid, which survived 24 h exposure to dry residues of insecticides on glass plates treated at the recommended application rates.

Treatment		% hatching after nine days \pm SE	Reduction in parasitism rate (E%)	IOBC Classification	Longevity (days)
Insecticide	Class				
Bistrifluron (Hanaro 10%)	IGR	83.80 \pm 4.40 b	9.21	1	3.60 \pm 0.20 b
Pyriproxyfen (Muligan 10%)		47.13 \pm 4.21 d	48.98	2	1.67 \pm 0.12 c
Matrine (Kingbo 0.6%)	Plant Extract	66.73 \pm 2.61 c	27.64	1	3.27 \pm 0.12 b
Azadirachtin (Amen 1.0%)		40.93 \pm 3.52 e	57.95	2	1.33 \pm 0.12 c
Control		92.33 \pm 4.04 a			4.67 \pm 0.58 a
LSD (P > 0.05) = 25.345					LSD (P > 0.05) = 1.622
F value = 0.046					LSD (P > 0.05) = 1.622

All values are means of 5 replicates \pm SE. Means in the same column followed by the same letter are not significantly different (Fisher's test, P > 0.05). IOBC insecticide classification, where Class 1: harmless (E < 30%); Class 2: slightly harmful (30% < E < 79%); Class 3: moderately harmful (80% < E < 99%); and Class 4: harmful (E > 99%).

slightly harmful to adults of *T. brassicae* mortality, while it was harmful to parasitism ratio and longevity of the parasitoid. These differences may be due to differences in sensitivity to insecticides among *Trichogramma* species as well as the host species upon which the parasitoid species are reared (Brunner *et al.*, 2001).

To summarize, the two IGRs (bistrifluron, pyriproxyfen) and the plant extract matrine were the least harmful insecticides to adults of *T. cacoeciae* in terms of lethal effect (mortality after 24h exposure) as well as sublethal effects (parasitism ratio on *E. cauttella* and parasitoid longevity). Bistrifluron and pyriproxyfen have been classified in the IOBC database as harmless to *T. cacoeciae* (IOBC, 2005). Our results support this classification for bistrifluron but not for pyriproxyfen,

which was classified as slightly harmful. This difference in classification may be due to variability in sensitivity to pesticides among *Trichogramma* spp., caused by host rearing conditions e.g. size of host egg that affects the growth and development of parasitoids (Suh *et al.*, 2000; Goulart *et al.*, 2008; Hegazi and Khafagi, 2001).

Insecticide Persistence

Mortality of the parasitoid after exposure to aged residues of the tested insecticides on tomato leaves differed among the insecticides and different age of residues (Table 4). Cypermethrin and phenthoate resulted in 100% mortality of adult females exposed to one day old residues and were classified as harmful (IOBC class 4) to *T. cacoeciae*. One day old residues of deltamethrin

Table 4. Mean % survival of adult females of the egg parasitoid *Trichogramma cacoeciae*, when exposed to aged insecticide residues (persistence of insecticide effect).

Insecticide	Class	Mean adult survival (%)					IOBC Classification
		Days after treatment					
		1	2	3	7	14	
Cypermethrin (Hi power)	Pyrethroid	0.00 d	5.00 d	14.00 d	31.00 e	39.00 de	4
Deltamethrin (Flotron 2.5%)		4.00 cd	6.00 d	16.00 d	29.00 ef	42.00 d	3
Malathion (Sulmathion 57%)	Organophosphate	2.00 cd	9.00 d	18.00 d	26.00 ef	34.00 ef	3
Phenthoate (Peston 50%)		0.00 d	7.00 d	15.00 d	24.00 fg	24.00 g	4
Methomyl (Metho900)	Carbamate	7.00 cd	8.00 d	13.00 d	25.00 efg	31.00 fg	3
Carbosulfan (Marshal 25%)		7.00 cd	12.00 a	15.00 d	25.00 efg	36.00 def	3
Bistrifluron (Hanaro 10%)	IGR	1.00 b	83.00 b	84.00 b	86.00 b	94.00 a	1
Pyriproxyfen (Muligan 10%)		77.00 b	77.00 b	49.00 b	80.00 c	85.00 b	1
Matrine (Kingbo 0.6%)	Plant Extract	41.00 d	45.00 c	47.00 c	49.00 d	52.00 c	2
Azadirachtin (Amen 1.0%)		9.00 c	10.00 d	13.00 d	19.00 g	26.00 g	3
Control		20a					
LSD (P > 0.05)		25.503	20.533	24.093	27.348	17.855	
F value		0.007	0.249	0.041	0.044	0.041	

All values are means of 5 replicates. Means in the same column followed by the same letter are not significantly different (Fisher's test, $P > 0.05$). IOBC insecticide classification where Class 1: harmless ($E < 30\%$); Class 2: slightly harmful ($30\% < E < 79\%$); Class 3: moderately harmful ($80\% < E < 99\%$); and Class 4: harmful ($E > 99\%$).

thrin, malathion, methomyl, azadirachtin, and carbosulfan, causing 96, 98, 93, 91 and 93% adult mortality, respectively, as compared with the control, are classified as moderately harmful (IOBC class 3) to *T. cacoeciae*. Our results corroborate those reported by Youssef *et al.* (2004) for *T. exgium* on olive leaves, and Blibech *et al.* (2015) who found that deltamethrin residues on olive leaves affected parasitism in *T. oleae*, *T. cacoeciae*, and *T. bourarachae*, 31 days post-treatment. Nevertheless, Suh *et al.* (2000) showed that deltamethrin has short-term persistence on cotton leaves, and this difference in persistence may be attributed to variation among *Trichogramma* spp. sensitivity to pesticides (Goulart *et al.*, 2008) and pesticide interactions with plant leaf types or climate conditions (Bueno *et al.*, 2008).

One day old residues of the IGR insecticides, bistrifluron and pyriproxyfen, caused 19% and 23% mortality of *T. cacoeciae*, respectively, and were classified as harmless. One and 14 days post-treatment residues of the botanical insecticide matrine caused 59% and 48% mortality, respectively, and were classified as slightly harmful. According to Brunner *et al.* (2001) the benzoylhydrazin IGRs, tebufenozid and methoxyfenozide, on treated Oregon spur apple tree leaves at leaf-disk bioassays produced no sublethal effect on *Colpoclypeus florus* (Hym.: Eulophidae) and *Trichogramma platneri*, which are potential biological control agents of leafrollers in apple orchards.

Overall, toxicity of insecticide residues on tomato leaves to *T. cacoeciae*, from one to 14 days after treatment varied among the insecticides (Table 4). However, most of them were considered moderately harmful to harmful 24 h post-treatment. Residue toxicity reduced with time and became moderately harmful, 2 and 3 days after treatment and slightly harmful at 7 and 14 days. Zhu *et al.* (2009) also noted that persistence of insecticide residues on leaf surfaces differed among pesticides and that the effects on the natural enemy *T. evanescens* in their study decreased with time. Also, the under-study IGR aged residues were harmless at all

time points after -application and these results are consistent with those reported by Hassan *et al.* (1998).

In conclusion, most of the tested insecticides were moderately harmful to harmful to *T. cacoeciae*, except for the IGR insecticides, which can be considered further for use in a sustainable IPM programme against major Lepidopteran pests of date palm.

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Επίδραση δέκα εντομοκτόνων που εφαρμόζονται στην καλλιέργεια της χουρμαδιάς στη Σαουδική Αραβία, στο παρασιτοειδές *Trichogramma cacoeciae*

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Η επίδραση δέκα εντομοκτόνων, που εφαρμόζονται συνήθως στην καλλιέργεια της χουρμαδιάς στη Σαουδική Αραβία, αξιολογήθηκε στο εργαστήριο σε ενήλικα άτομα του *Trichogramma cacoeciae*, ενός σημαντικού ωοπαρασιτοειδούς του λεπιδόπτερου *Ephestia calidella*. Οι βιοδοκιμές διεξήχθησαν σύμφωνα με το πρωτόκολλο του Διεθνούς Οργανισμού IOBC/WPRS/Ομάδα Εργασίας 'Pesticides and Beneficial Organisms'. Τα αποτελέσματα έδειξαν ότι τα σκευάσματα με δραστικές ουσίες cypermethrin, deltamethrin, malathion, phenthoate, methomyl και carbosulfan ήταν μέτρια επιβλαβή (κλάση IOBC 3) στο παρασιτοειδές. Από τα βοτανικά εντομοκτόνα, το σκεύασμα με δραστική azadirachtin ήταν μέτρια επιβλαβές (κλάση IOBC 3) ενώ αυτό με τη δραστική matrine ήταν ελαφρώς επιβλαβές (κλάση IOBC 2). Ο ρυθμιστής ανάπτυξης των εντόμων pyriproxifen ήταν ελαφρώς επιβλαβής ενώ το σκεύασμα με δραστική bistrifluron ήταν αβλαβές (κλάση IOBC 1). Όσον αφορά στις έμμεσες αρνητικές επιδράσεις των εντομοκτόνων, το ποσοστό παρασιτισμού σε σύγκριση με το μάρτυρα μειώθηκε από τα σκευάσματα με δραστικές pyriproxifen και azadirachtin σε 49,0% και 58,0%, αντίστοιχα, επομένως τα εν λόγω εντομοκτόνα ταξινομούνται ως ελαφρώς επιβλαβή (κλάση IOBC 2) στο *T. cacoeciae*. Τα σκευάσματα με δραστικές bistrifluron και matrine ήταν αβλαβή (κλάση IOBC 1) καθώς τα ποσοστά παρασιτισμού μειώθηκαν κατά 9,2% και 27,6% αντίστοιχα. Η μακροβιότητα των ενήλικων ατόμων του παρασιτοειδούς που εκτέθηκαν σε bistrifluron και matrine (3,6 και 3,3 ημέρες, αντίστοιχα) και σε pyriproxifen και azadirachtin (1,7 και 1,3 ημέρες, αντίστοιχα) ήταν σημαντικά χαμηλότερη από αυτή του μάρτυρα (4,67 ημέρες). Σε δοκιμές σε συνθήκες ημι-υπαίθρου, τα υπολείμματα των περισσότερων εντομοκτόνων σε φύλλα τομάτας, κοινό φυτό-ξενιστή λεπιδοπτέρων που παρασιτούνται από το *T. cacoeciae*, ήταν μέτρια επιβλαβή έως επιβλαβή με βάση τη θνησιμότητα του παρασιτοειδούς, 24 ώρες μετά την εφαρμογή, ενώ ήταν ελαφρώς επιβλαβή, 7 και 14 ημέρες μετά την εφαρμογή.

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