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Impact of Some Pesticides on Pupae of the Parasitoid *Eretmocerus mundus* (Mercet) and *Encarisa formosa* (Gahan) under laboratory Conditions

Randa Abu-Tara*, Fawzy Samara, Magd Gamal*, Fawzy Shalaby*****
Samir Assaf* and Ghassan Rostom*
*General Society of Scientific Agricultural Research, Syria
**Plant Protection Dept., Faculty of Agriculture, Damascus University, Syria
***Plant Protection Dept., Faculty of Agriculture, Benha University, Egypt

ABSTRACT

Efficacies of six different pesticides (each used in two concentrations according to recommendations of the manufacturing companies) on pupae of the two hymenopterous aphelinids, *Eretmocerus mundus* (Mercet) and *Encarsia formosa* (Gahan) (parasitoids of the tobacco whitefly, *Bemisia tabaci*) were estimated under laboratory conditions. Results confirmed that *Er. mundus* was, generally, more susceptible to pesticides (significantly higher pupal mortality rates;5.4 – 87.5%, among treated individuals) than *E. formosa* (5–51.4% mortality). Highest efficacy on the two parasitoid species resulted from treatments by the acaricide diafenthiuron which caused 71.9 and 87.5% pupal mortality of *Er. mundus* pupae by the low and high concentrations, respectively and 45.7 and 51.4%, respectively among pupae of *E. formosa*. The acaricide fenpyroximate came next as it led to 64.7 & 73.5% and 27.5 & 45% mortalities among pupae of *Er.* mundus and *E. formosa*, respectively. On the contrary, the least effective was the insecticide pymetrozine which caused the lowest mortality rates (5.4, 16.2 and 5 & 7.5% among pupae of the two parasitoids, respectively). The remaining three pesticides could be arranged, descendingly, according to the recorded mortality rates as; the insecticide pyridaben, then the two fungicides cymoxanil+famoxadone and Copper hydroxide. According to the obtained results, the insecticide, pymetrozine and the fungicide, copper hydroxide may be, fairly, recommended for insect and fungus control in integration with releasing of *Er. mundus* or/and *E. formosa* for whitefly control, as these two pesticides proved the relatively safest on the two parasitoid species. On the contrary, the two acaricides diafenthiuron and fenpyroximate and, also, the insecticide pyridaben are better to be applied at times when the two parasitoids under investigation are not released.

Key Words: *Bemisia tabaci, Encarsia formosa, Eretmocerus mundus,* Pesticides.

INTRODUCTION

The tobacco whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera-Homoptera: Aleyrodidae) is a worldwide serious insect pest on many crops and vegetable plants. Its direct damage refers to the action of sap-sucking nymphs and adults. The severity of resultant damage is positively related to the rate of infestation, and negatively to the plant growth stage. Most important is the active role of the feeding adults in transmitting viruses causing plant diseases of which the tomato yellow leaf-curl virus (TYLCV) may be, fairly, considered the most important as it, mostly, leads to total loss of plants and yield.

Up to the time being, successive spraying of chemical insecticides is, unfortunately, the main control method of whitefly, leading to environmental pollution, direct toxicity to man and animal and development of insect resistance to pesticides, in addition to the severe reduction in population densities of beneficial insects. For this reason, it seems necessary to look for alternative safe methods of which the cultural, mechanical and biological control methods are applied in integrated control programs in which insecticides may be also used, only, whenever needed. Also, in this concern, the safer insecticides which proof effective on the target pest(s) and of lower effect on beneficial insects are preferred for application. Several authors studied the impact of insecticides on the whitefly parasitoids (El-Sayed and Abo El-Ghar, 1992; Van De Veire and Tirry, 1998; Forrer, 2001; Hoddle *et al*, 2001; Murphy, 2003; Sterk *et al*, 2003; Oetting, 2004; Baur, 2006 and Quinn and Trinklein, 2006). From this point of view, came the idea of this investigation which aimed to assay the efficacy of different groups of pesticides on pupae of the two important whitefly parasitoid species, *Eretmocerus mundus* (Mercet) and *Encarsia formosa* (Gahan), hoping to put in light a recommendation leading to the use of the least effective pesticide(s) for pest(s) control in the same time of releasing whitefly parasitoid(s).

MATERIALS AND METHODS

Pesticides used

The chosen pesticides for this experiment included two insecticides (pymetrozine and pyridaben), two acaricides (diafenthiuron and fenpyroximate) and two fungicides (cymoxanil + famoxadone and copper

hydroxide). All of the six pesticides are recommended for pests' control by the Syrian Ministry of Agriculture and Land Reclamation. Each pesticide was assayed in two concentrations as recommended by the manufacturing company. Table (1) demonstrates the chemical formulation, common and commercial names, formulations and the assayed concentrations.

Weights and volumes of the tested pesticides (according to those presented in the mentioned table) were put in a 500 cm^3 glass flasks, diluted with a small quantity of distilled water, then the quantity of water was increased to the calculated volume to reach the desired concentration. Control treatments were conducted using distilled water.

Rearing of *B. tabaci* and parasitoids

The tobacco whitefly individuals and those of the parasitoid *Er. mundus* were obtained from Doma region in Syria (General Society for Scientific Agricultural Research), while the parasitoid *E. formosa* was obtained from farmers' fields at Yabrood region, Syria. Insects were reared on eggplant cultivated in special rooms in the glasshouse to obtain enough numbers of pure culture needed for achieving the planned experiments.

Pesticidal treatments

Pupae of the two parasitoid species were treated as parasitized whitefly mummies containing fresh pupae (Sterk *et al.*, 2003). Each parasitoid received 12 treatments (two; by the high and low concentrations of each pesticide). Each treatment was repeated in 4 replicates to make a total of 48 replicates.

Ten parasitized mummies on an eggplant leaf were treated, using the dipping technique, in the desired concentration for five seconds, then placed in 10 cm diameter Petri-dishes to be kept for 15 days after which the numbers of emerged adults were counted, while the remaining pupae (which did not transform to adults inside mummies) were considered dead by the toxic action of pesticides and, subsequently, the mortality percentages after treatments were calculated and corrected according to the formula of Abbot (1925).

Statistical analysis

Statistical analysis of data was carried out according to Duncan's test (1955) . Tested pesticides were arranged to show the severity of toxicity according to the classification given by EPPO (Oomen *et al.*, 1994). Those were classified according to the mortality percentages to 4 categories:

Grade 1: Pesticides caused > 25% mortality.
Grade 2: Resulted mortalities from 25% to > 50%.
Grade 3: Mortalities ranged from 50% to > 75%.
Grade 4: Pesticides caused 75 to 100% mortality.

Table (1): Tested pesticides by bioassay on pupae of *Er. mundus* and *E. formosa* .

Trade name	Common name	Formulation used	Concentration low	Concentration high	Chemical abstract
Chess	pymetrozine (pyridine)	WG 25%	0.1 g	0.3 g	E-4,5-dihydro-6-methyl-4 [(3-pyridny-lmethylene)amino]-1,2,4-triazin-= 3(2H)-one .
Sanmite	pyridaben	EC 20%	0.1 cm^3	0.5 cm^3	4-chloro-2-(1,1-dimethylethyl)-5-[[[4-(1,1-dimethylethyl)phenyl] methyl] =thio] – 3 (2H) – pxridazinone .
Pegassus	diafenthiuron	SL 25%	0.48cm 3	o.6cm^3	N/(2,6-bis(1-methylethyl)–4–phenoxy-phenyl)- N– (1,1 –dimethylethyl) =thiorea .
Ortus	fenpyroximate (pyrazole)	SC 5%	0.25cm 3	0.5cm^3	1,1 – dimethylethyl (E) – 4 –[[[[(1,3-O-dimethyl –5 –phenoxy-1- H-pyrazol -4 y l)= methylene] amino] oxy] methyl] benzoate .
Equationp	cymoxanil +famoxadone	WDG 22%	0.2gm	0.3gm	2-cyano-N-[(ethylamino)carbonyl]-2(methoxyamino) acetamide.5-methyl-5-(4-phenoxyphenyl)-3-(phenylamino)-2,4-oxazolidin.
Kocide	copper hydroxide	WP 77%	5.6gm	8.5gm	copper hydroxide ($Cu(OH)^2$

RESULTS AND DISCUSSION

Impact of pesticides on pupae of two whitefly parasitoids

1- *Eretmocerus mundus*

Data presented in Table (2) indicate that the acaricide, diafenthiuron was the severest pesticide on *Er. mundus* pupae, as it resulted the highest mortality rates (87.5 and 71.87%) among pupae treated by the high and low concentrations, respectively. The acaricide, fenpyroximate came next in severity of toxicity, leading to73.52 and 64.7% mortality, respectively. The insecticide, pyridaben caused also considerable pupal mortality rates (68.75 and 31.25%, respectively). The two fungicides were of lower efficacy as the high and low concentrations of cymoxanil + famoxadone caused the same mortality level of 33.33%, opposed to 30.55&25%, respectively after pupal treatment by copper hydroxide. While, the least efficacy occurred from pymetrozine treatment which caused 16.21 and 5.4% mortality, respectively among treated *Er. mundus* pupae (Table, 2).

2- *Encarsia formosa*

As shown in Table (2), efficacies of the tested pesticides on *E. formosa* pupae took almost, the same order of severity of toxicity as that occurred in case of *Er. mundus*. It was clear that diafenthiuron had the highest toxicity, leading to 51.42 and 45.71% mortality, followed by fenpyroximate (45 and 27.5%) after treatment of *E. formosa* pupae by the high and low concentrations, respectively (Table, 2) . On contrary, the insecticide pymetrozine had the lowest impact in causing pupal mortality (7.5 and 5%, respectively). The remaining pesticides might be arranged ,descendingly, according to toxicity level as; the insecticide pyridaben (36.84 and 28.94%) and the two fungicides, cymoxanil + famoxadone (25.64 and 10.25%) and copper hydroxide which caused 12.82 and 10.25% mortality among pupae treated by high and low concentrations, respectively (Table, 2).

Statistical analysis by applying "t" test was used to compare between mean numbers of emerged adults after pupal treatments of the two parasitic species. The resultant "t" value was 4.694 confirming that numbers of emerged adults were significantly higher in case of *E. formosa* than *Er. mundus*. Thus indicating that *Er. mundus* pupae were, significantly, more susceptible to pesticidal treatments than those *of E. formosa*.

Categorization of pesticides according to toxicity level

The tested pesticides were categorized according to mortality percentages among pupae after treatment according to that reported by EPPO (2004) (Table, 3):

A- ***Er. mundus***

The insecticide pymetrozine was the single pesticide which could be placed in the first category which resulted less than 25% mortality among treated pupae. Therefore, this pesticide was considered the safest and could be applied against target insects at the same time of releasing *Er. mundus* for whitefly control. The high and low concentrations of the two fungicides, cymoxanil + faxomadone and copper hydroxide and also the low concentration of the insecticide pyridaben fell in category [2] (25 – 33.33% mortality; Table, 2) and consequently were considered moderately effective against *Er. mundus* pupae. The effective pesticides, i.e. category [3] (more than 50 – less than 75% mortality) included the high concentration of pyridaben, high

Table (2): Corrected mortality percentages among pupae treated by different pesticides.

Pesticides	*Eretmocerus mundus*		*Encarsia formosa*	
	High concentration	Low concentration	High concentration	Low concentration
Insecticides:				
pymetrozine	16.21	5.4	7.5	5
pyridaben	68.75	31.25	36.84	28.94
Acaricides:				
diafenthiuron	87.5	71.87	51.42	45.71
fenpyroximate	73.52	64.7	45.0	27.5
Fungicides:				
cymoxanil+ Famoxadon	33.33	33.33	25.64	10.25
copper hydroxide, inorganic	30.55	25.0	12.82	10.25

Table (3): Categorization of the tested pesticides, depending on percentages of pupal mortality after treatments, according to EPPO (2004).

Pesticides	*Eretmocerus mundus*		*Encarsia formosa*	
	High concentration	Low concentration	High concentration	Low concentration
pymetrozine	1	1	1	1
pyridaben	3	2	2	2
diafenthiuron	4	3	3	2
fenpyroximate	3	3	2	2
cymoxanil+ Famoxadon	2	2	2	1
copper hydroxide	2	2	1	1

1 (least effective): > 25% mortality. 2 (moderately effective): 25 – > 50% mortality.
3 (effective): 50 – > 75% mortality. 4 (highest effective): 75 – 100% mortality.

and low concentrations of fenpyroximate and the lower concentration of diafenthiuron. While the higher concentration of diafenthiuron was the only categorized as of highest efficacy [4] (Table, 3).

B- ***E. formosa***

The higher resistance of pupae of *E. formosa* to pesticides than *Er. mundus* is quite clear in Table (3). Pesticides of the first category; *i.e.* the least effective included the high and low concentrations of the insecticide pymetrozine and the fungicide copper hydroxide and the low concentration of the fungicide cymoxanil+famoxadon. These pesticides at the mentioned concentrations might be considered safe to be used for pests' control in the same time of *E. formosa* release for whitefly control. Effective pesticides on *E. formosa* pupae were the two concentrations of the insecticide pyridaben and the acaricide fenpyroximate, the low concentration of the acaricide diafenthiuron and the high concentration of cymoxanil + famoxadon. While, the high concentration of diafenthiuron was the only that proved as effective [category, 3] on *E. formosa* pupae, and accordingly this acaricide is not recommended to be sprayed at the same time of *E. formosa* release.

Duncan's test (1955) was applied to find out the L.S.D. value between mean numbers of adults that, successfully, emerged after treatments of pupae of the two parasitic species by tested pesticides. Calculations confirmed that the efficacies of the two recommended concentrations of the insecticide pymetrozine and the low concentration of the fungicide copper hydroxide on the two parasitoid species were, insignificantly, different than the control (number of emerged adults from pupae treated with distilled water). While, the two concentrations of copper hydroxide and the lower concentration of the fungicide camoxanil + famoxadon ,also, did not affect ,significantly, emergence from treated *E. formosa* pupae. Whilst, the efficacies of the remaining pesticides and concentrations on emergence from treated pupae were significant.

Among the six assayed pesticides, the insecticide pymetrozine appeared as the safest one (lowest mortality rates on *Er. mundus* and *E. formosa*). In harmony to the present results, Hoddle *et al.* (2001) found that the effect of pymetrozine on *Er. eremicus* was not far from the control results. Baur *et al.* (2006) reported that this insecticide is safe on natural enemies and could be used in the IPM programs for pests' control. While, Quinn and Trinklein (2006) observed mild effect of pymetrozine on beneficial insects as *E. formosa*. In complete accordance to the present results, Abu-Tara *et al.* (2008), working on the same pesticides, found that pymetrozine was the safest pesticide on female adults of *Er. mundus* and *E. formosa*. They stated that the mortality percentages among female adults after pymetrozine treatments were not far from the control results. While, on contrary, Van De Veire and Tirry (1998) reported that pymetrozine was one of the toxic pesticides to *E. formosa* (according to EPPO's classification). Also El-Adl *et al.* (1998) found that pymetrozine reduced the percentage of parasitism by *Er. mundus* on *B. tabaci* in Egyptian cotton fields.

As for the other insecticide, pyridaben, it had deleterious effect on pupae of *Er. mundus* and *E. formosa* . The effect on pupae was, in general, intermediate among the six pesticides, while Abu-Tara *et al.* (2008) found that this pesticide was the severest among the same six pesticides on females of the same parasitoids. Also, Van De Veire and Tirry (1998) reported that pyridaben was toxic to *E. formosa* and couldn't be

involved in IPM programs. Murphy (2003) stated that this chemical insecticide had deleterious effect on predators and parasitoids surrounding whitefly infestations.

Concerning the two acaricides; both proved as highly toxic to pupae of the two studied parasitoids, but diafenthiuron was the severest toxic among the 6 pesticides, followed by fenpyroximate ranked second in toxicity level. These results agree with the findings of Van De Veire and Tirry (1998) who considered diafenthiuron as toxic on *E. formosa*. On contrary to the present results, Javed and Matthews (2002) recommended the use of diafenthiuron in IPM programs, and Quinn and Trinklein (2006) reported that fenpyroximate was safe on beneficial insects and predaceous mites. While, Abu-Tara *et al.* (2008) stated that the two mentioned acaricides had slight effect on *E. formosa* females, but in agreement with the present results, they stated that fenpyroximate was severely toxic on *Er. mundus* females.

As for the two fungicides cymoxanil + famoxadon and copper hydroxide; the EPPO (2004) reported these pesticides as safe on natural enemies, the report which agree with the present results in case of copper ydroxide (at the two concentrations) and cymoxanil + famoxadon (at the low concentration) on *E. formosa,* while these products were moderately toxic on *Er. mundus*. Abu-Tara *et al.* (2008) found that the mentioned fungicides were moderately toxic to female adults of *E. fromosa* and toxic to *Er. mundus* females.

As a final conclusion; the insecticide pymetrozine can be considered a safe pesticide on *Er. mundus* and *E. formosa* and may be recommended to be applied for insects' control at the same time of releasing either or both parasitoid species. Copper hydroxide (at the two concentrations) and cymoxanil + famoxadon (at its recommended lower concentration) appeared safe and may be considered in the IPM programs which demands *E. formosa* releases. While, the two fungicides had deleterious effect on *Er. mundus* and accordingly are not recommended to be sprayed during times of parasitoid release. Also, pyridaben, diafenthiuron and fenpyroximate had considerable toxicity on the two whitefly parasitoids and might be recommended for insects and mites' control, only, during periods of absence of *Er. mundus* and/or *E. formosa* release in the field.

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الملخص العربى

تأثير بعض مبيدات الآفات على عذارى الطفيلين الحشريين

Encarsia formosa (Gahan) و *Eretmocerus mundus* (Mercet)

المتطفلين على ذبابة التبغ البيضاء *Bemisia tabaci* (Gennadius) تحت الظروف المعملية

رنده أبوطاره* & فوزى سماره & محمد جمال* & فوزى شلبى*** & سمير عساف* & غسان رستم***

*الهيئة العامة للبحوث العلمية الزراعية، دمشق، سوريا

** قسم وقاية النبات، كلية الزراعة، جامعة دمشق، سوريا

*** قسم وقاية النبات، كلية الزراعة، جامعة بنها ، مصر

أجريت دراسة مخبريه لتحديد مدى تأثير كل من ست مبيدات منها اثنين حشريين (Pyridaben و Pymetrozine) ، اثنين أكاروسيين (Fenpyroximate و Diafenthiuron) ، واثنين فطريين (Copper hydroxide و Cymoxanil + Famoxadone) حيث استخدم كل منهم بتركيزيين (الأعلى والأدنى الموصى بهما من قبل الشركة الصانعة) على عذارى كل من الطفيليين الحشريين *Eretmocerus mundus* و *Encarsia formosa* التابعين لرتبة غشائية الأجنحة Hymenoptera وعائلة Aphelinidae والمتخصصين فى التطفل على ذبابة التبغ البيضاء *Bemisia tabaci* . أثبتت النتائج أن عذارى الطفيل *Er. mundus* كانت أكثر تأثرا بصفة عامة (نسب موت أعلى ٥,٤ و ٨٧.٥%) عن عذارى الطفيل *E. formosa* (٥ – ٥١.٤% موت) . أما عن أشد المبيدات تأثيرا على عذارى النوعين فقد كان المبيد الأكاروسى Diafenthiuron (٧١.٩ و ٨٧.٥% موت بين عذارى الطفيل *Er . mundus* و ٤٥.٧ و ٥١.٤% بين عذارى الطفيل *E. formosa* ، عند المعاملة بالتركيزيين الأدنى و الأعلى، على التوالي) ، تلاه المبيد الأكاروسى Fenpyroximate (٦٤.٧ و ٧٣.٥ % موت بين عذارى الطفيل الأول مقابل ٢٧.٥ و ٤٥%، على التوالي للطفيل الثاني). أما أقل المبيدات تأثيرا فكان المبيد الحشري Pymetrozine الذى سبب أقل نسب موت (٥,٤ و ١٦,٢% مقابل ٥ و ٧,٥% بين عذارى الطفيلين ، على الترتيب). أما الثلاث مبيدات الباقية فقد حل المبيد الحشري Pyridaben ثالثاً من حيث شدة التأثير تلاه المبيدان الفطريان Cymoxanil + Famoxadone و Copper hydroxide، على الترتيب. من النتائج أمكن التوصية بأن المبيد الحشرى Pymetrozine وكذلك المبيد الفطرى Copper hydroxide هما الأكثر أمانا للاستخدام عند وجود إصابة حشرية أو فطرية مع إطلاق أى من الطفيليين لمكافحة الذبابة البيضاء، أما المبيدان الأكاروسيان Diafenthiuron و Fenpyroximate وكذلك المبيد الحشري Pyridaben فقد تم النصح بعدم استخدام أى منهم لمكافحة الأكاروسات أو الحشرات فى وقت إطلاق أى من الطفيلين محل الدراسة.