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Susceptibility of the Predatory Mite, *Phytoseiulus macropilis* (Banks) and the Two Spotted Spider Mite, *Tetranychus urticae* Koch (Acari: Phytoseiidae - Tetranychidae) to some Acaricides

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ABSTRACT

Relative toxicity of some acaricides to the predatory mite, *Phytoseiulus macropilis* Banks and the two spotted spider mite, *Tetranychus urticae* Koch (Acari: Phytoseiidae, Tetranychidae) was evaluated under laboratory conditions. According to IOBC toxicity classification, all of the tested acaricides were slightly harmful to the predator's females. Six of the acaricides tested: abamectin, bifenazate, chlorfenbyer, hexythiazox, pyridaben and sulfur, were less toxic to adult females of *P. macropilis* than *T. urticae* at LC_{50} values. Hexythiazox was the most effective compound on egg hatching of *T. urticae*, hence hatchability was 35.5%, while 62.22% of predator eggs hatched. All of the tested acaricides caused low mortality rates to eggs of the predator (R=1.05 with hexythiazox). Abamectin, bifenazate, chlorfenbyer, hexythiazox, pyridaben and sulfur appeared to be promising candidates for use in integrated mite management programs.

Key words: *Phytoseiulus macropilis*, *Tetranychus urticae*, selective acaricides.

INTRODUCTION

The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) is one of the most serious plant-feeding mite that infests a wide range of hosts all over the world (Zhang, 2003). Its outbreaks are often a consequence of repeated and non-selective pesticide applications (Tawfic and El-Gohary, 2013). Although natural enemies of phytophagous mites have been reported from several acarine families (Zaher, 1986), the majority of the well known predatory mites belong to the family Phytoseiidae. Phytoseiid mites as biological control agents are effective in agricultural systems. The predatory mite, *Phytoseiulus macropilis* (Banks) has shown high efficacy against *T. urticae* (Heikal and Ibrahim, 2013).

Chemical control is a commonly used management tactic against *T. urticae* in several crops in Egypt. The intensive use of pesticides has caused a considerable reduction of its efficacy due to the evolution of resistance that indicates a need to develop alternative integrated pest management strategies for suppressing its population (Amin *et al.*, 2009). One of the alternative managements is release of the predator *P. macropilis*. Abamectin, Bifenazate, Chlorfenbyer, Hexythiazox, Pyridaben and Sulfur are acaricides commonly used in Egypt. Researches have been documented on the effects of these acaricides on predaceous and phytophagous mites (El-Sharabasy, 2010, and Tawfic and El-Gohary, 2013). However, studying their selectivity against *P. macropilis* is necessary to maximize the role of the biocontrol agent as the information on response of *P. macropilis* to common pesticides in Egypt is very limited.

The present study aimed to test the toxicity and selectivity of 6 acaricides on *P. macropilis* under laboratory conditions.

MATERIALS AND METHODS

Mites rearing

The predatory mite *P. macropilis* was collected from strawberry fields (*Fragaria ananassa* Weston) in Ismailia Governorate, Egypt and was reared in plastic boxes (26 x 15 x 10 cm), in which a cotton pad was placed in the middle of each box, and provided with water as a barrier to prevent mites from escaping. *T. urticae* was collected from castor oil plant (*Ricinus communis* L.) and reared on sweet potato and lima bean plants. The predator was fed by adding lima bean leaves infested with all stages of *T. urticae*. The old dried leaves were replaced weekly with new ones. Predator and prey were reared under the same laboratory conditions at 25±2°C and 65±5% RH and 16:8 L: D hr.

Acaricides

Six acaricides were tested under the laboratory conditions; Abamectin (Kilimite® 1.8 % EC (72 ppm), Bifenazate (Acramite® 48 % SC (168 ppm), Chlorfenbyer (Challenger® 36 % SC (162 ppm), Hexythiazox (Maccomite® 5 % WP (20 ppm), Pyridaben (Pyromate® 20 % WP (40 ppm) and Sulfur (Samark® 70 % WP (1750 ppm). All acaricides were used at their recommended concentrations for field applications.

Bioassays

Effects of acaricides on adult females of *P. macropilis* and *T. urticae*

Bioassay was performed in rearing units consisted of four sweet potato leaf discs (25 mm in diameter) placed on moistened cotton pad in Petri-dishes (90 mm in diameter). Four concentrations with four replications were used for each compound. Effects of the different acaricides were tested against adult females of *T. urticae* (20 adult females/ replicate). Mites were subsequently transferred to the lower surface of sweet potato leaf discs and sprayed with different concentrations using a glass atomizer. For predatory mite, ten adult females were transferred to the leaf discs and sprayed with the same concentrations (10 adult females/ replicate). Similar number of mites was sprayed by distilled water and used as control. Leaf-spray method was accepted by the International Organization for Biological Control, IOBC/WRPS working group on pesticides and beneficial arthropods as a standard routine test (Hele and Sabelis, 1985). Each leaf disc was supplied by all stages of *T. urticae* as food. Mortality rate was recorded 72 hrs after treatments. Mortality rate was corrected using Abbott's formula (Abbott, 1925) and subjected to probit analysis to estimate LC_{50} with 95% confidence limit according to Finney (1971). In addition, efficacy of different compounds was measured according to Sun (1950). Means were separated using LSD at 5% level.

Effects on egg hatchability of *P. macropilis* and *T. urticae*

Ten adult females of *T. urticae* were allowed to oviposit for 24 h on sweet potato leaf discs in a Petri dish. After that, adults were removed. 80 1-day-old eggs (20/4 replicates) of *T. urticae* were sprayed with the same concentration of each compound. Control was sprayed by distilled water. Five females of *P. macropilis* were transferred to sweet potato leaf discs (four replicates) in Petri-dishes and left for oviposition for 24 h and then mite females were removed, 10 eggs/ replicate were directly sprayed with the same concentration. Hatching ratio was assessed 3 and 5 days post treatments.

Effects on daily oviposision and egg fertility of *P. macropilis*

Sweet potato leaf discs (25 mm in diameter) were placed on a moistened cotton pad in a Petri-dish (90 mm in diameter) and sprayed with recommended rate of each acaricide. Control units were sprayed by distilled water. After spraying each acaricide, sixty predator protonymphs (15 protonymph/4 replicates) were transferred to the leaf discs and subjected to their residues (Oomen, 1988). A surplus of *T. urticae* was added as food source. Each tested compound remained for seven days, with daily count of the alife females and number of eggs laid. Total effect (E %) of each compound was determined according Overmeer (1988): E % = 100% - (100% - M_c) × E_r where, M_c = corrected mortality % according to Abbott's formula, E_r = effect on reproduction (average egg production of the female in treatment (R)/ egg production in control group) ($E_r = R_{treatment} / R_{control}$). After determining the total effect, each compound was categorized into classes 1 to 4 according to Hassan (1994); class I = harmless (E < 30%), class II = slightly harmful (E = 30-79%), class III = moderately harmful (E = 80 - 99%) and class IV = harmful (E > 99%).

RESULTS AND DISCUSSION

Effects of acaricides on adult females of *P. macropilis* and *T. urticae*

Effects of the six tested acaricides on *P. macropilis* and *T. urticae* adult females at 72 h post application and according to the IOBC categories are shown in table (1). For *T. urticae* females, treated with different acaricides, mortality percent was significantly different from the control. Pyridaben caused 97.5% mortality, while hexythiazox had the lowest efficacy, as it caused 68.3% mortality. Insignificant differences were found among the other compounds. They could be arranged in descending order as pyridaben , chlorofenbyer , sulfur , bifenazate , abamectin and hexythiazox, respectively (Table 1).

Among the tested acaricides, pyridaben was the most effective compound against predator females as it caused 72.3% mortality. According to IOBC toxicity classification, all of the tested acaricides were ranked category II (slightly-harmful to the predator). The IOBC/WPRS classifying plant protection products on the basis of the adverse effect caused to beneficial arthropods in laboratory tests (Hassan,

Table (1): Percent mortality (Mean±SE) of adult female of *Phytoseiulus macropilis* (n=160) and *Tetranychus urticae* (n=320) IOBC category after 72 h of treatment

Acaricides	% mortality		IOBC
	T. urticae	*P. macropilis*	category
Abamectin	77.5 ± 0.25^{bc}	53.1 ± 1.02^{c}	II
Bifenazate	85.3 ± 0.23^{b}	64.7 ± 0.83^{b}	II
Chlorfenbyer	87.8 ± 0.38^{b}	69.4 ± 0.91^{b}	II
Hexythiazox	68.3 ± 0.25^{c}	46.2 ± 0.24^{d}	II
Pyridaben	100.0^{a}	72.3 ± 0.54^{a}	III
Sulfur	87.1 ± 0.26^{b}	66.2 ± 0.22^{b}	II
Control	0^{c}	0^{c}	I

Means followed by the same letters in the column are not significantly different (P < 0.05).
IOBC*: class I = harmless (E < 30%), class II = slightly harmful (E 30-79%), class III = moderately harmful (E = 80 - 99%) and class IV = harmful (E > 99%).

Table (2): LC$_{50}$ values (ppm) and statics for tested acaricides against *Phytoseiulus macropilis* and *Tetranychus urticae*

Acaricides	*T. urticae*			*P. macropilis*		
	LC$_{50}$ (95% CL)	Slope ± SE	Toxicity index	LC$_{50}$ (95% CL)	Slope ± SE	Toxicity index
Abamectin	12.88 (5.21 – 17.23)	1.24 ± 0.18	29.34	482.51 (213.8 – 721.3)	2.35 ± 0.34	35.07
Bifenazate	10.08 (5.98 – 12.25)	1.56 ± 0.67	37.50	206.75 (95.5 – 495.2)	1.61± 0.41	81.85
Chlorfenbyer	13.36 (1.69 – 14.58)	1.62 ± 0.87	28.29	391.71 (102.2 – 399.5)	1.35 ± 0.38	43.20
Hexythiazox	15.98 (6.69 – 19.78)	1.54 ± 0.64	23.65	1199.38 (535.3 – 2311.5)	1.83 ± 0.12	14.12
Pyridaben	3.78 (1.23 – 9.69)	1.87 ± 0.88	100.00	169.23 (91.2 – 314.8)	1.95 ± 0.33	100.0
Sulfur	11.62 (3.23 – 17.45)	1.68 ± 0.36	32.53	238.64 (101.9 – 327.1)	1.89 ± 0.38	70.91

Table (3): Selectivity ratio (SR) of the tested acaricides against *Phytoseiulus macropilis* and *Tetranychus urticae*

	Abamectin		Bifenazate		Chlorfenbyer		Hexythiazox		Pyridaben		Sulfur	
	LC$_{50}$	Ratio	LC$_{50}$	Ratio	LC$_{50}$	Ratio	LC$_{50}$	Ratio	LC$_{50}$	Ratio	LC$_{50}$	Ratio
T. urticae	12.88	1.00	10.08	1.00	13.36	1.00	15.98	1.00	3.78	1.00	11.62	1.00
P. macropilis	482.51	0.026	206.02	0.048	391.71	0.034	1199.4	0.013	169.23	0.022	238.7	0.045

Table (4): Hatching ratio (Mean ± SE) of *Phytoseiulus macropilis* and *Tetranychus urticae*

Acaricides	Hatching (3 days after treatment)		Hatching (5 days after treatment)	
	T. urticae	*P. macropilis*	*T. urticae*	*P. macropilis*
Abamectin	65.55 ± 0.43^{b}	92.42 ± 3.21^{a}	77.57 ± 0.05^{a}	100^{a}
Bifenazate	47.52 ± 0.11^{bc}	76.32 ± 2.41^{bc}	69.23 ± 0.34^{ab}	96.45 ± 1.51^{a}
Chlorfenbyer	58.50 ± 0.06^{ab}	82.22 ± 1.38^{b}	66.78 ± 0.54^{ab}	100^{a}
Hexythiazox	35.50 ± 0.38^{bc}	62.22 ± 3.02^{bc}	72.36 ± 0.12^{ab}	92.18^{a}
Pyridaben	46.16 ± 0.21^{b}	82.52 ± 1.24^{b}	55.50 ± 0.36^{ab}	85.54 ± 2.21^{b}
Sulfur	49.53 ± 0.38^{c}	72.32 ± 4.12^{c}	64.63 ± 0.38^{ab}	95.61 ± 3.22^{a}
Control	100^{a}	100^{a}	-	-

Means followed by the same letters in the column are not significantly different (P ℜ 0.05).

1994). However, these results are similar to those previously reported by Hardman *et al.,* (2003) on *Typhlodromus pyri* Sheuten. Hexythiazox was harmless to *Phytoseiulus persimilis* (Athias-Henriot) and belonging to category I (Argolo *et al.,* 2014). Also, Kongchuensin and Takafuji (2006) found that sulfur was harmless to adult females of *Neoseiulus longispinosus* (Evans). Alzoubi and Cobanglu (2008) found that hexythiazox had moderately harmful effect on *P. macropilis,* 72 h post treatment. They also mentioned that abamectin had high activity on *T. urticae*, whereas it was harmless to *P. persimilis* and caused 47% mortality 24h after application.

The LC$_{50}$ values of the tested compounds on *P. macropilis* and *T. urticae* are given in table (2). Based on the LC$_{50}$ values, pyridaben was the most effective acaricide against *T. urticae* females, followed by bifenazate (LC$_{50}$ = 3.78 and 10.08 ppm, respectively). The results also revealed the same trend of acaricides action against predator females. The LC$_{50}$ value on *P. macropilis against* pyridaben was 169.23 ppm. Therefore, sensitivity of *P. macropilis* to pyridaben was lower than *T. urticae* by 0.022 times (Table 3). Sensitivity of *P. macropilis* to abamectin, bifenazate, chlorofenbyer, hexythiazox and sulfur were lower than that of *T. urticae* by 0.026, 0.048, 0.034, 0.013 and 0.045 times, respectively. This agrees with Alzoubi and Cobanglu (2008) who found that sensitivity of *P. macropilis* to hexythiazox was lower than *T. urticae* by 6.07 times. Brun *et al.,* (1983) found that the susceptibility of *P. macropilis* to dimethoate was 50 times more than that of *P. persimilis* based on the LC$_{50}$ values. Pyridaben was the most effective acaricide based on 100% toxicity index; 29.34, 37.5, 28.29, 23.65 and 32.53 for abamectin, bifenazate, chlorofenbyer, hexythiazox and sulfur in case of *T. urticae*, respectively (Table 2). The same trend was observed for *P. macropilis*, where it was 35.07, 81.85, 43.20, 14.12 and 70.91, respectively. On the other hand, some synthetic pyrethroids were highly toxic to *P. macropilis* and caused 100% mortality (Amin *et al.,* 2009).

Effects of acaricides on egg hatchability of *P. macropilis* and *T. urticae*

Hatching ratio of *P. macropilis* and *T. urticae* eggs, three days post treatments, showed significant differences (P □ 0.05) between each of the tested acaricides and control (Table 4). The tested acaricides significantly reduced mite hatchability. However, hexythiazox was the most effective one on egg hatching of *T. urticae*, hence only 35.5% eggs hatched, while 62.22% of predator eggs hatched. Alzoubi and Cobanglu (2008) found that hatching ratio of *T. urticae* eggs treated with the acaricide hexythiazox was 11.1%, while it was 95% for *P. persimilis*. On the 5th day post treatment, insignificant differences were found in hatching ratios of *T. urticae* among the tested acaricides, but there were significant differences for *P. macropilis* where its hatching ratio was completed (100%) when it was treated with abamectin and chlorofenbyer.

Effects of acaricides on daily oviposision and egg fertility of *P. macropilis*

Effect on daily oviposision and toxicity coefficient are shown in table (5). All tested acaricides caused low mortality rates to predator female eggs. The R – values (average egg production / female / day) were relatively higher than control, as it ranged from R = 1.05 with hexythiazox to R = 2.78 with abamectin. Noii *et al.*, (2008) reported that the exposure to abamectin residues had a great total effect (E) 100% on *Phytoseius plumifer* (C. & F.), while obtained results recorded only 25.95%. Pyridaben had the highest coefficient of toxicity (E = 57.78), followed by chlorfenbyer (E = 33.72). According to IOBC classification, all tested acaricidse had toxicity class I (harmless), except pyridaben which recorded class II as slightly harmful. These results agree with those obtained by Alzoubi and Cobanglu (2008) for hexythiazox.

The acaricids that demonstrated selectivity in laboratory tests may have similar effects under greenhouse or field conditions (Reis *et al.*, 2006). he present study showed that all the tested compounds were harmful to *T. urticae* and harmless or slightly harmful and selective to adult female *P. macropilis*. Further studies and tests of the applied acaricides should be carried out under semi- or field conditions for selectivity.

Table (5): Daily oviposition, percent mortality of laid eggs and coefficient of toxicity (E %) of *Phytoseiulus macropilis* females treated with different acaricides

Acaricides	^1M_c	^2R	^3E_r	^4E %	IOBC category
Abamectin	18.15	2.78	1.43	25.95	I
Bifenazate	25.38	1.97	1.01	25.63	I
Chlorfenbyer	27.55	2.56	1.32	33.72	I
Hexythiazox	15.36	2.88	1.48	22.73	I
Pyridaben	35.23	3.19	1.64	57.78	II
Sulfur	19.27	1.98	1.02	19.65	I
Control	-	1.94	-	-	-

^{1} Mc = M_c = corrected mortality %, ^{2} R = the average egg production per female, ^{3} E_r = effect on reproduction, ^{4} E % = coefficient of toxicity.

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