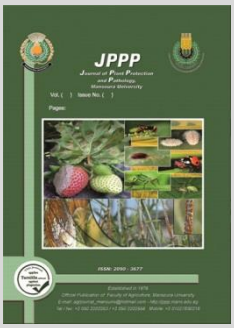
Journal of Plant Protection and Pathology

Journal homepage: www.jppp.mans.edu.eg
Available online at: www. jppp.journals.ekb.eg

Toxicological and Biological Responses of *Tetranychus urticae* Koch to Three Pesticides and their Side Effect on the Predatory Mite, *Euseius scutalis* (A.-H.)

Hala R. Abdel-Rahman*

Department Economic Entomology & Pesticides, Fac. Agric. Cairo Univ., Egypt



ABSTRACT

Cucumber *Cucumis sativus* L. is one of the most popular vegetables in Egypt. Unfortunately, it is a target for several insect, mite pests and pathogens, which mainly controlled by using chemical pesticides. The effect of a single application of the recommended concentration of the acaricide, hexythiazox (10% EC), the insecticide, acetamiprid (20% SP) and the fungicide, ridomil gold plus (71.5% WP) against the main mite pest, *Tetranychus urticae* Koch was evaluated in a greenhouse. Acetamiprid was the most toxic compound to *T. urticae* causing an initial kill of 31.12%, residual efficiency of 69.90% and total effect of 50.51%. These values decreased for hexythiazox to 21.17, 65.26 and 43.21%, while they were 17.55, 26.46 and 22.0% when cucumber treated with ridomil gold plus, respectively. The initial, residual and total effects of the aforementioned compounds on the predatory mite, *Euseius scutalis* (Athias-Henriot), as a non-target mite, were lower and averaged 23.23, 22.30 and 22.76%; 39.04, 41.68 and 40.36%; and 13.64, 11.79 and 12.71%, respectively. Half of the recommended concentration was applied in laboratory to determine the side effect of these compounds on the life-table parameters of the non-target predatory mite, *E. scutalis* to have information about the forthcoming offspring as compared with the mite pest *T. urticae*. Tested pesticides generally prolonged mean generation time *T*, doubling time *DT*, while reduced the net reproductive rate R_o, natural increase r_m and finite increase e^{rm}. The adverse effect of chemical application was noticeably greater on mite pest *T. urticae* than predatory mite *E. scutalis*.

***Keywords*:** Fungicides, *Tertranychus urticae, Euseius scutalis*, toxicity and life-table parameters.

INTRODUCTION

Cucumber (*Cucumis sativus* L) is one of the most important delicious vegetable crops among the family *Cucurbitaceae* and it is consumed as a raw green fruit or in salads and pickles. In Egypt, in 2017 the total cucumber production recorded 488.723 tons (FAO, 2017).

It is well known that cucumber is a subject to the infestation by many pest species especially phytophagous mites in the family Tetranychidae. The two-spotted spider mite, *Tetranychus urticae* Koch is one of the most dangerous mite pest infesting a wide range of plants worldwide (Zaher, 1986; Abdel Rahman and Fouly, 2001 and Zhang, 2003). There are many natural enemies play an important and significant role in reducing spider mite populations on several vegetables and ornamental plants. Phytoseiid mite species come on the top of this group of bioagents and they have worldwide distribution (Mc Murtry and Croft, 1997 and Fouly and Al-Rahiayani, 2011).

During mite control using different kinds of pesticides, natural enemies may be subjected to the toxic compounds (Sato *et al*., 2002). Pesticides can harm these natural enemies indirectly by killing them or contaminating their hosts or preys. Therefore, it is very important to know the side effect of such chemicals on the non-target organisms because it is essential to determine their negative effects as a part of Integrated Pest Management programs (IPM). Unfortunately, natural enemies are usually more susceptible to the toxic effect of the pesticides than their phytophagous preys owing to their less-developed enzyme-based detoxification systems (Sato *et al*., 2002 and Bostanian and Akalach, 2006). Generally, IPM requires pesticides to be effective against target pests and, at the same time, to be relatively harmless to non-target parasitic and predatory arthropods (Abdel Rahman and Fouly, 2001; Lee *et al*., 2002 and Abdel-Rahman and Ahmed 2018). Most fungicides often have very subtle toxic effects on predaceous mites and they must be thoroughly evaluated before they are implemented in IPM programs (Bostanian *et al*., 2009). Compared with conventional insecticides and acaricides, copper fungicides were considered to be more compatible with the natural enemies of pests (Metcalf, 1980; Pozzebon *et al.*, 2002 and Mao *et al.*, 2011). However, various species of predatory mites responded differently to a certain copper formulations (Bernard *et al.*, 2004 and Alzoubi and Cobanoglu, 2008).

Overall goal of the present study was to determine the compatibility of an acaricide (hexythiazox), that is recommended against spider mites, and an insecticide (acetamiprid), which is mainly recommended against aphids and thrips, as well as copper fungicide (ridomil gold plus) that is locally recommended against powdery mildew disease on cucumber. Therefore, greenhouse cucumber, infested with the two-spotted spider mite *T. urticae*, was

* **Corresponding author.**
E-mail address: Halarashad_62@hotmail.com
DOI: 10.21608/jppp.2019.79455

sprayed with the recommended concentrations of hexythiazox, acetamiprid and ridomil gold plus in order to evaluate their toxicity on mite pest after certain time intervals. Moreover, survey of numbers of the predatory mite species *Euseius scutalis* (Athias-Henriot), that killed by the same previous treatment, was carried out to determine chemical side effect on this natural enemy under greenhouse conditions. On the other hand, half of the recommended concentrations of the aforementioned pesticides were applied in laboratory to evaluate their latent effect on different life-table parameters of mite pest and its predatory mite just to have an overview for the forthcoming offspring in the new generations.

MATERIALS AND METHODS

Pesticides used

Hexythiazox:(5-(4-chlorophenyl)-N-cyclohexyl-4-methyl-2-oxo-3-thiazolidene-carboxamide) (Prince 10% EC), rate of application 20 cm/100L. It is an acaricide, registered mainly against tetranychid mite species especially in greenhouses. It has ovicidal, larvicidal and nymphicidal properties (Hoy and Ling Ouyang, 1986).

Acetamiprid is an insecticide with the chemical formula $C_{10}H_{11}ClN_4$. (aceta 20% SP) rate of application 25g/100L. It is an odorless insecticide belonging to the group of chloropyridinyl neonicotinoids. *N* - [(6-chloro-3-pyridyl) methyl] - *N'*- cyano – *N* – methyl - acetamidine. This product is widely used to control the piercing-sucking pests, such as aphids, mirid bugs and whiteflies (Ishaaya *et al*., 2007; US EPA, 2012; Liang *et al*., 2012 and Fogel *et al*., 2013). This compound belongs to a group which categorizes as biorational insecticides being useful in Integrated Pest Management (IPM) programs (Ishaaya *et al*., 2007).

Copper oxychloride 69% + metalaxyl-M 2.5% (ridomil gold plus 71.5% WP), rate of application 200 g/100L. It is a systemic fungicide, registered against powdery mildew on cucumber plant and has residual properties by combining the two active ingredients of metalaxyl and oxichloride, which are characterized by outstanding preventative and curative activity combined with excellent rain fastness that provides additional security.

Greenhouse Experiments

***Tetranychus urticae* Culture**

Mite individuals of *T. urticae* were collected from kidney bean *Phaseolus vulgaris* L. growing in the Acarology greenhouse, Cairo University, Egypt in 2019. Mites were transferred to pots of 20 cm (in diameter) transplanted with *P. vulgaris*.

***Euseius scutalis* Culture**

A colony of the predatory mite *E. scutalis* was collected from castor oil plants *Ricinus communis* L. growing in the same area of study and supplied with spider mite as a prey and incubated at 27^{o}C and 70% RH. New eggs were collected daily for ten days and used in further studies.

Experimental Procedure

A private greenhouse at El-Mansouria district, Giza of 400 m2 cultivated with cucumber seedlings (Cucumis sativus L) was infested with spider mites together with predatory mite, and left for 30 days. The greenhouse was divided into 4 plots, each contained 10 plants in one row and replicated for four times. The recommended concentration of each of hexythiazox (20 cm/100L), acetamiprid (25g/100L) and ridomil gold plus (200 g/100L) was sprayed, by using a manual sprayer of 20 liters capacity, to the first three plots (treatments). The fourth plot was treated with water only. In all cases, ten leaves (as a sample/treatment) were collected before spraying and then similar samples were gathered after 1, 3, 7 and 14 days post-treatments. Leaf samples were kept in poly bags and transferred, after that, to the laboratory. Examination has been carried out by the aid of a stereomicroscope. Individuals of both mite species were counted.

Analysis study

Experiments were randomly designed where data were analyzed using one-way ANOVA and Duncan's Multiple Range Test (CoStat program, 1990). Reduction percentages in populations of both mites were corrected according to Henderson and Tilton's formula (1955).

Life-table parameters experiment

Two-spotted spider mite *T. urticae*

Adult females of spider mites were collected from the abovementioned colony and then transferred to leaves of castor oil plant and left for laying eggs. Leaves were placed on cotton pads in Petri dishes (15 cm in diameter) and soaked in water. The new eggs were collected daily for ten days and divided into four groups, each of which with 80 eggs. Half of the recommended concentration of hexythiazox 10% EC was sprayed by using of a hand sprayer (1 liter capacity) to the first group of mites, while the second group was sprayed with the same concentration of the insecticide acetamiprid 20% SP. The third group was treated with the fungicide ridomil gold plus 71.5% WP, while the fourth one was sprayed with water as a control. Five replicates were used for each group, each of which with 20 eggs/ arena. In daily count, number of eggs that hatched and did not hatch was recorded. All treatments were kept at 27°C and 70% RH and 14:10 (D: L) photoperiod.

Predatory mite *E. scutalis*

Mite individuals of *E. scutalis* were obtained from infested plants with spider mites. Approximately, 30 newly hatched females of *E. scutalis* were supplied every day with *T. urticae* and left to lay eggs. The aforementioned methodology was followed where mites were subjected to half of the recommended concentration of the same pesticides.

Life-table analysis

Experiment procedure

Five leaf discs (2 cm diameter) of fresh leaves of common bean plant were placed on wet cotton pads. The cotton bed was kept wet by adding droplets of water as needed. Twenty newly matted females of both mite species were transferred to each disc as a replicate. All replicates were sprayed by a hand sprayer (2 L) with ½ of the recommended concentration of the same tested pesticides and kept in laboratory at 27±2°C, 70±5% RH and photoperiod of 14:10 (D: L). Other groups of both mite species were left without treatment and sprayed with water and used as checks. Number of killed mites were recorded where mortality % was calculated 24 h post-treatment. Life

table parameters of treated and untreated mites were determined, where No. of newly laid eggs, developmental period, survival percentages, number of new females/total number of females and males (sex ratio of F1) as well as the fecundity (number of eggs/female/day) were determined according to Birch (1948), Laing (1968) and the Basic Computer Program of Abou-Setta *et al.* (1986).

RESULTS AND DISCUSSION

Toxicity of different pesticides on *Tetranychus urticae*

Greenhouse experiments proved that treatment with the recommended concentration of acetamiprid initially reduced the population of *T. urticae* by 31.12% and increased 3, 7 and 14 days after application to 64.22, 73.19 and 72.30%, respectively (Table 1). There were no significant differences between the toxicity of acetamiprid and hexythiazox especially one day after treatment. The reduction percentages showed significant differences between both insecticide and acaricide 3, 7 and 14 days after application as shown in Table (1). The fungicide ridomil gold plus occupied the third rank in efficiency against *T. urticae* where its application to cucumber plants reduced mite population by 17.55, 32.02, 31.34 and 16.02% after 1, 3, 7 and 14 days, respectively (Table 1). Therefore, it can be concluded that the insecticide acetamiprid was the most toxic compound against spider mite and showed a higher initial kill of 31.12%, residual efficiency of 69.90% and total effect of 50.51%. These values decreased for the acaricide hexythiazox to be 21.17, 65.26 and 43.21%, while they were 17.55, 26.46 and 22.0% when cucumber was treated with ridomil gold plus, respectively (Fig. 1). These previous findings are in agreement with Beers *et al.* (2005) who mentioned that different concentrations of acetamiprid were applied against spider mites highly reduced populations as compared to untreated apple plants. They concluded that the seasonal densities of tetranychid mites were positively correlated with the concentration and number of applications. On the other hand, Grafton-Cardwell and Gu (2003) found that acetamiprid and imidacloprid caused a complete mortality on the predatory insect *Rodalia cardinalis* (Mulsant) (Coccinellidae). Similarly, Lucas *et al*. (2004) mentioned that imidacloprid caused a complete mortality to *Coleomegilla maculate* (De Geer) (Coccinellidae). On the other hand, Pozzebon *et al.* (2002) stated that the repeated application of fungicides especially those containing copper and mancozeb significantly reduced populations of spider mites. On the other hand, Van Leeuwen *et al.* (2015) suggested that hexythiazox and the two other acaricides clofentezine and etoxazole are considered as mite growth inhibitors, that interact with chitin synthase I.

Table 1. Average No. and reduction percentage (%) in population of *Tetranychus urticae* Koch infesting cucumber untreated and treated with the recommended concentration of Hexythiazox, Acetamiprid and Ridomil gold plus under greenhouse conditions

Pesticide	Before treatment	Time after treatment (days)							
		1		3		7		14	
		X	Red. %	X	Red. %	X	Red. %	X	Red. %
Hexythiazox	17.2^{ab}	13.6^{a}	21.77	9.0^{b}	52.29	5.8^{a}	68.94	4.8^{a}	74.56
Acetamiprid	15.8^{a}	11.0^{a}	31.12	6.2^{a}	64.22	4.6^{a}	73.19	4.8^{a}	72.30
Ridomil Gold Plus	22.8^{c}	19.0^{b}	17.55	17.0^{c}	32.02	17.0^{b}	31.34	21.0^{b}	16.02
Control	18.6^{b}	18.8^{b}	--	20.4^{d}	--	20.2^{c}	--	20.4^{b}	--
F	--	19.566	--	59.071	--	199.35	--	138.24	--
P	--	0.000	--	0.000	--	0.000	--	0.000	--
L.S.D.		2.680	--	2.590	--	1.669	--	2.341	--

Means No. of mite individuals/leaf followed by different letters in each row are significantly different.

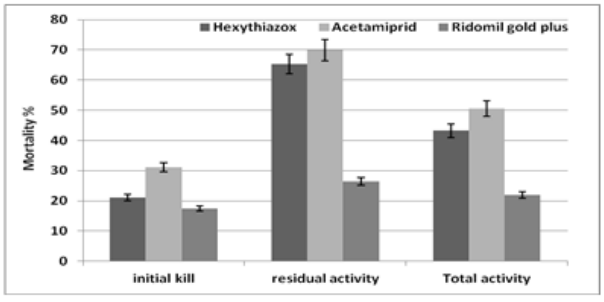


Figure 1. Initial, residual and total activity of Hexythiazox, Acetamiprid and Ridomil gold plus on *Teranychus urticae*

Toxicity of different pesticides on *Euseius scutalis*

Concerning the side toxic effect of the same previous pesticides on the phytoseiid predatory mite *E. scutalis* inhabiting the same ecosystem, data in Table (2) showed that hexythiazox and acetamiprid had a moderate harmful effect on the predator where they reduced its population by 39.04 and 65.98% for acetamiprid and 23.23 and 44.93% for hexythiazox after 1 and 3 days from application, respectively. The mite recovered and built up its own population 7 days after treatment where the negative effect was only 17.39 and 21.98% for the same previous compounds, respectively. The mortality percentage of *E. scutalis* reached zero after two weeks whenever the mite completely recovered from pesticide toxicity. In all cases, ridomil gold plus was the most safest compound to predatory mite where it caused only 13.64, 25.65, 9.13 and 0.6% reduction in mite population after 1, 3, 7 and 14 days from treatment, respectively (Table 2). Moreover, Figure (2) showed that the initial, residual and total effects of hexythiazox, acetamiprid and ridomil gold plus averaged 23.23, 22.30 and 22.76%; 39.04, 41.68 and 40.36%; and 13.64, 11.79 and 12.71%, respectively. These results agree with Alzoubi and Cobanoglu (2008) findings who noticed that hexythiazox toxicity increased by increasing time after application where it caused 60% and 100% spider mite mortality 3 and 7 days after application, respectively. These values were only 40 and 48%, and 37.2 and 68% for the two phytoseiid mites *Amblyseius californicus and Phytoseiulus persimilis* after the two time intervals, respectively. The same authors mentioned that hexythiazox was moderately toxic to the predatory

phytoseiid mites and they, therefore, concluded that this compound can be a promising candidate for a mite management programs especially for *T. urticae*. Although, Childers *et al.* (2001) found that copper hydroxides didn't show harmful impact to some predatory mites. Bernard *et al.* (2004) found that copper hydroxides affected also *Agistemus industani* Gonzalez (Stigmaeidae). Similarly, Mao *et al.* (2011) suggested that the three copper formulations had low or moderate toxicity to *Amblyseius cucumeris* (Oudemans). Similarly, Pozzebon *et al.* (2002) stated that mancozeb and copper oxychloride significantly reduced the population of the phytoseiid predator *Kampimodromus aberrans* (Oudemans) in Italy. They also mentioned that mancozeb harmed populations of *Amblyseius andersoni* (Chant) and suggested that the side effect of fungicides, especially those containing copper oxychloride and mancozeb, on phytoseiid predatory mites should be studied carefully.

From the previous results it can be noticed that acetamiprid was slightly more toxic to spider mite than hexythiazox and both were more effective against this mite pest *T. urticae* than the fungicide ridomil gold plus. In addition, the tested insecticide and acaricide were moderately harmful to the natural enemy *E. scutalis* especially after short time of application. Their negative effect on *E. scutalis* didn't last for a long time where the mite can recover and build up its population after 7 to 14 days post-treatment. Similarly, Alzoubi and Cobanoglu (2007) stated that hexythiazox sprayed at 1/3 field concentration to cucumber was not very toxic to the predatory mite *Neoseiulus californicus* McGregor and *P. persimilis*, which were released to control spider mites in greenhouses in Turkey, but its recommended concentration significantly reduced their populations.

Table 2. Average No. and mortality percentage (%) in population of *Euseius scutalis* (A.-H.) inhabiting cucumber untreated and treated with the recommended concentration of Hexythiazox, Acetamiprid and Ridomil gold plus under greenhouse conditions

Pesticide	Before treatment	Time after treatment (days)							
		1		3		7		14	
		X	Red. %	X	Red. %	X	Red. %	X	Red. %
Hexythiazox	3.6^{a}	3.2^{ab}	23.23	2.4^{b}	44.93	3.4^{a}	21.98	4.2^{a}	0.0
Acetamiprid	3.4^{a}	2.4^{a}	39.04	1.4^{a}	65.98	3.4^{a}	17.39	4.4^{a}	0.0
Ridomil Gold Plus	4.0^{a}	4.0^{bc}	13.64	3.6^{c}	25.65	4.4^{b}	9.13	4.6^{a}	0.6
Control	3.8^{a}	4.4^{c}	--	4.6^{d}	--	4.6^{b}	--	4.4^{a}	--
F	--	8.74	--	32.44	--	6.833	--	0.48	--
P	--	0.001	--	0.000	--	0.003	--	0.69	--
L.S.D.		0.892	--	0.734	--	0.736	--	0.704	--

Means No. of mite individuals/leaf followed by different letters in each row are significantly different

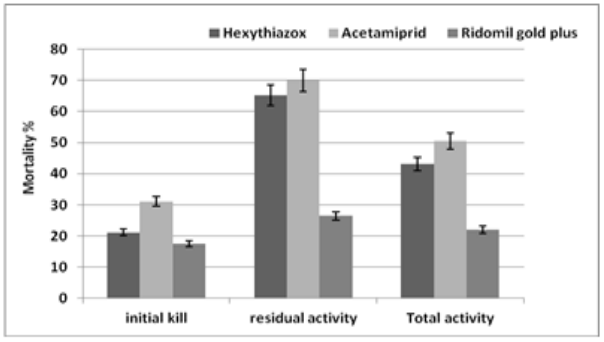


Figure 2. Initial, residual and total activity of Hexythiazox, Acetamiprid and Ridomil gold plus on *Euseius scutalis* under greenhouse conditions

Effect of ½ recommended concentration of different pesticides on life-table parameters of *Tetranychus urticae* and *Euseius scutalis*

The results showed that 98% of spider mites, *T. urticae* in control group passed successfully to adulthood, while only 88, 90 and 92% from mites, which were subjected to ½ of concentration of hexythiazox, acetamiprid and ridomil gold plus reached the adulthood (*Lx*) as shown in Figure (3). Concerning untreated *E. scutalis*, 100% of its population reached adulthood but declined to 92, 90 and 94% after spraying with the same previous compounds, respectively (Fig. 5). Therefore, these results cleared that the tested compounds had a negative effect on mite survival and this impact was clearer on mite pest than its natural enemy. In other word, Figures (3 and 5) proved that survival values (*Lx*) gradually decreased during the period extending from preoviposition to the end of oviposition periods for both *T. urticae* and *E. scutalis*.

Generation time *T* was slightly affected by ½ of concentration of the tested chemicals where *T* prolonged from 22.89 days for untreated individuals of *T. urticae* to 24.04, 24.90 and 24.54 days for those sprayed with hexythiazox, acetamiprid and ridomil gold plus, respectively. These values were 21.11, 21.96, 22.43 and 21.19 days for predatory mites untreated and treated, respectively (Table 3). Similar trend has been noticed with *DT* (the time needed for mites to double their population). Table (3) showed that *DT* lengthened from 1.807 days for untreated spider mite to 2.521, 2.479 and 2.380 days for those treated with hexythiazox, acetamiprid and ridomil gold plus, respectively. The same issue was slightly observed with *E. scutalis* where *DT* was prolonged to 2.380, 2.290 and 2.054 days in treated mites while it was only 1.785 days for untreated ones, respectively as shown in Table (3). Similar results were obtained by Fogel *et al.* (2013) who reviewed that acetamiprid caused lengthening in the development of the predatory coccinellid insect *E. connexa*. Also, Grafton-Cardwell and Gu (2003) noticed that fertility of *Rodalia cardinalis* females reduced after exposure to acetamiprid. Van Leeuwen *et al.* (2015) also found that clofentezine prolonged *Tetranychus viennsis* (Zacher) development and generation time for 2.5 days more than control individuals.

The female proportion (No. females /females + males) was also affected by application, where female offspring represented approximately 64% for untreated spider mite and reduced to 54, 56 and 60% for those treated with hexythiazox, acetamiprid and ridomil gold plus, respectively. Concerning the predatory mite *E. scutalis*, the present results showed that chemical treatment reduced female proportion from 62% in control to 54, 54 and 56% in treated mites as mentioned above, respectively (Table 3). The present results showed that chemical application significantly reduced female proportion of spider mite but their impact was lower on *E. scutalis.* In all cases, ridomil gold plus was the lowest compound in its effect on sex ratio. Similarly, Marcic (2003 and 2007) found a negative impact of flufentezine and hexythiazox and concluded that this effect on non-differentiated reproductive cells in ovipositing mite females treated with acaricides. In other words, the variation of sex ratio in untreated and treated mites proved the hypothesis that a female can shift her sex proportion and produce more males when facing chemical stress. Generally, chemical applications may inhibit or prolong the development of mites and also cause decrease in the ovipositing process for females that survived.

It was also noticed that chemical treatment considerably affected fecundity of both mite species as shown in Table (3) and Figures (4 and 5) where hexythiazox reduced egg production by an average of 61.20 and 54.48% for *T. urticae* and *E. scutalis*, respectively. In other word, the net reproductive rate R_o was 45.24 and 35.37 when *T. urticae* and *E. scutalis* were left without treatment and reduced to 17.55 and 16.10 female/female/generation, respectively. Acetamiprid had a lower effect on fecundity as compared with hexythiazox where R_o values were 20.55 and 19.30 female/female/generation and it means that acetamiprid reduced R_o by 54.57 and 45.91% for *T. urticae* and *E. scutalis*, respectively. In all cases, ridomil gold plus showed the lowest effect on R_o value where it caused a reduction of 50.55 and 37.99% for treated *T. urticae* and *E. scutalis*, respectively (Table 3 and Fig. 6). Similar results were obtained by Stark *et al.* (2004) and Biondi *et al*. (2012) who reviewed that arthropods, that subjected to sublethal doses of pesticides, showed a reduction in most of their biological aspect especially egg laying. Contradictory, Hoy and Ling Ouyang (1986) mentioned that number of deposited eggs of both *Tetranychus pacificus* and *Metaseiulus occidentalis* increased 48 h after treatment with sublethal concentrations of hexythiazox.

Concerning the intrinsic rate of increase (r_m), the present results showed that ½ concentration of hexythiazox, acetamiprid and ridomil gold plus applications variably reduced r_m by approximately 28.31, 27.10 and 24.09% where it was 0.166 ♀♀/♀ (female^{-1}day^{-1}) for untreated spider mites, while it reduced to 0.1119, 0.121and 0.126 ♀♀/♀ after treatment with hexythiazox, acetamiprid and ridomil gold plus as shown in Table (3), respectively. These results are similar to those obtained by Marcic (2003) who found that r_m values *T. urticae* was higher than mite sprayed with clofentezine. This impact variation was not similarly observed between the predatory mite *E. scutalis* where its r_m value was 0.168 ♀♀/♀ for mites in control group and then declined to 0.126, 0.131 and 0.146 by the application with the same aforementioned pesticides, respectively (Table 3). That means hexythiazox, acetamiprid and ridomil gold plus negatively reduced r_m rate of *E. scutalis* by 25, 22 and 13.09%, respectively.

It is known that the finite rate of increase e^{rm} (λ) is how many times the population can multiply in a certain time and represented by ♀♀/♀ /day (day^{-1}). Accordingly, the present study showed that e^{rm} (λ) of *T. urticae*, subjected to ½ concentration of hexythiazox, acetamiprid and ridomil gold plus, was declined by 4.57, 4.40 and 3.57%, respectively. That means e^{rm} declined from 1.181 in control mites to 1.126, 1.129 and 1.134 ♀♀/♀ /day (day^{-1}) in treated mites, respectively (Fig. 7). In other word, hexythiazox slightly reduced the finite rate of increase of spider mite more than acetamiprid insecticide, while the tested fungicide was the lowest effective one. Similar results were obtained by Marcic (2007) who reviewed that spirodiclofen highly reduced both r_m and er^m of spider mites. Chemical pesticides showed similar impact on *E. scutalis*, where hexythiazox was more harmful to the tested predatory mite than acetamiprid and ridomil gold plus. Table (3) cleared that e^{rm} declined from 1.184 in control group to 1.134, 1.140 and 1.156 ♀♀/♀ /day (day^{-1}) when *E. scutalis* was sprayed with the previous mentioned pesticides, respectively. In other words, it can be easily noticed that the finite rate of increase of *E. scutalis* decreased by 4.22, 3.71 and 2.36% as compared with untreated mites, respectively (Fig. 8). Hoy and Ling Ouyang (1986), Kavousi and Talebi (2003) and Cheng *et al.* (2018) observed similar results and demonstrated that clofentezine and hexythiazox fenpyroximate and thiacloprid had a negative impact on different biological aspects of spider mites more than the phytoseiid mites *M. occidentalis*, *P. persimilis* and *Amblyseius swirskii*, respectively. Similar trend of efficiency was noticed where gross reproduction rate (*GRR*) declined for both tested mite species as a result of chemical application. As shown in Table (3) and Figures (7-8), hexythiazox, acetamiprid and ridomil gold plus reduced *GRR* values from 58.24 in control to 42.62, 44.26 and 48.68 for *T. urticae* treated with the aforementioned pesticides, respectively. These values were 32.84 for untreated *E. scuatlis* and declined to 26.24, 28.46 and 30.24 when the mites were subjected to hexythiazox, acetamiprid and ridomil gold plus, respectively. Therefore, the tested pesticides can be arranged with regard to their influence on *GRR* values where hexythiazox occupied the first rank and followed by acetamiprid while ridomil gold plus which came third (Figs. 7-8).

Table 3. Life table parameters of *Euseius scutalis* treated with Hexythiazox, Acetamiprid and Ridomil gold plus in laboratory

Biological parameters	Mite species							
	Tetranychus urticae				*Euseius scutalis*			
	untreated	Treated			untreated	Treated		
		Hexy.	Aceta.	Rido.		Hexy.	Aceta.	Rido.
No. mite individuals	32	28	26	26	30	24	24	22
Survival %	98	88	90	92	100	92	90	94
Female proportion *(No. ♀ / ♀ +♂)*	0.64	0.54	0.56	0.60	0.62	0.54	0.54	0.56
Mean generation time *T*	22.89	24.04	24.90	24.54	21.11	21.96	22.43	21.19
Net reproductive rate R_o	45.24	17.55	20.55	22.37	35.37	16.10	19.13	21.93
Intrinsic rate of increase *rm*	0.166	0.119	0.121	0.126	0.168	0.126	0.131	0.146
Finite rate of increase e^{rm} (λ)	1.181	1.126	1.129	1.134	1.184	1.134	1.14	1.156
Doubling time *DT*	1.807	2.521	2.479	2.380	1.785	2.380	2.290	2.054
Growth reproduction *GRR*	58.24	42.62	44.26	48.68	32.84	26.24	28.46	30.24

Hexy.= Hexythiazox, Aceta.= Acetamiprid, Rido.= Ridomil gold plus

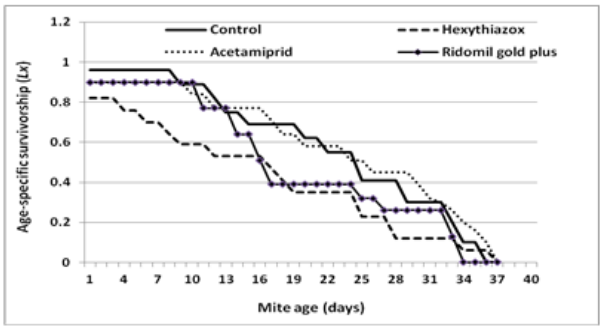


Figure 3. Survivorship (Lx) of untreated and treated *Tetranychus urticae* with Hexythiazox, Acetamiprid and Ridomil gold plus in laboratory

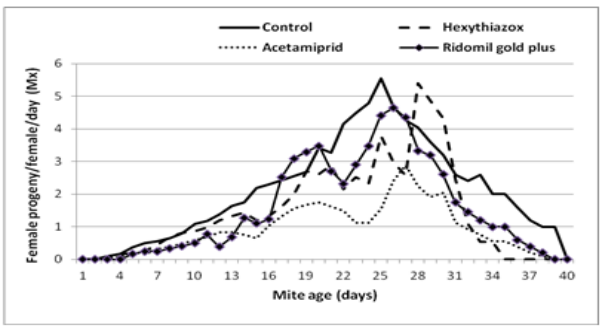


Figure 4. Fecundity (Mx) of untreated and treated *Tetranychus urticae* with Hexythiazox, Acetamiprid and Ridomil gold plus in laboratory

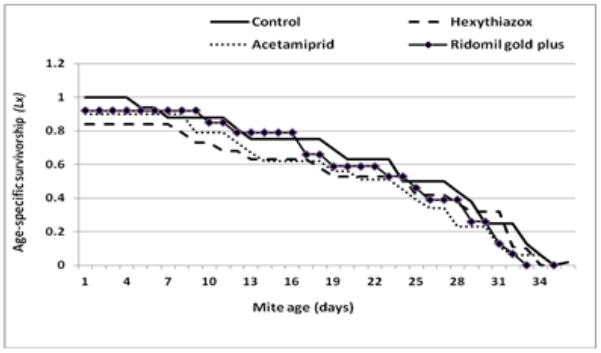


Figure 5. Survivorship (Lx) of untreated and treated *Euseius scutalis* with Hexythiazox, Acetamiprid and Ridomil gold plus in laboratory

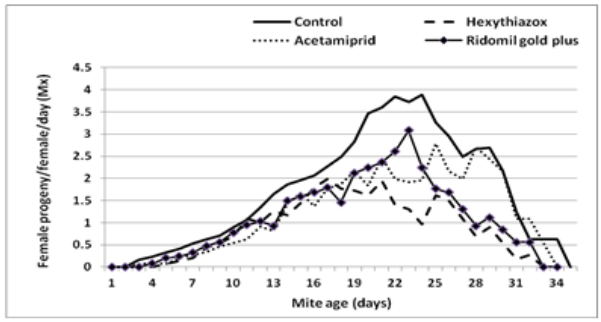


Figure 6. Fecundity (Mx) of untreated and treated *Euseius scutalis* with Hexythiazox, Acetamiprid and Ridomil gold plus and kept at 27°C and 70% RH

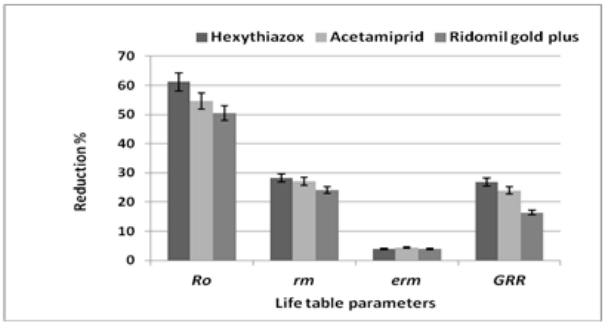


Figure 7. Reduction % in certain biological parameters of treated *Tetranychus urticae* with Hexythiazox, Acetamiprid and Ridomil gold plus in laboratory

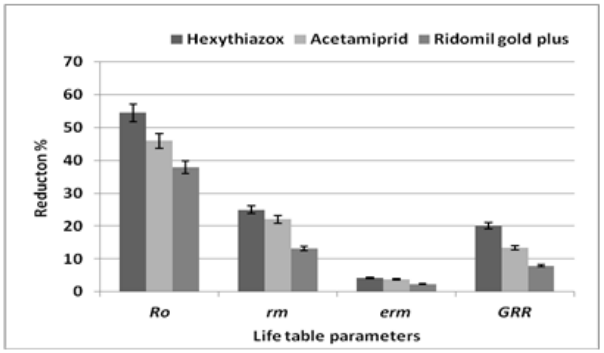


Figure 8. Reduction % in certain biological parameters of treated *E. scutalis* with Hexythiazox, Acetamiprid and Ridomil gold plus in laboratory

CONCLUSION

The present studies showed that there were moderately negative effects on natural enemies where pesticides, which are normally used against insect and mite pests or pathogenic fungi on vegetables and fruits, can rarely enhance natural enemy functions particularly, if they are selective against pests or are used at low concentrations. In other word, low concentrations of pesticides may have behavioral and physiological effects on natural enemies such as attack ratio, handling time, rate of discovery, development time and reproductive potentiality (Verkerk, 2001). Therefore, the present observations clearly showed that *E. scutalis* efficiency seems to be influenced with the direct effect of the tested compounds resulting in negative effects on predatory functions. Accordingly, the present data revealed that we should use selective acaricides that can reduce mite pest population and not harm the natural enemies living in the same ecosystem.

REFERENCES

Abdel Rahman, H.R. and Fouly, A.H. (2001). Residual analysis of some pesticides in sweet pepper and their side effect on non-target mite species in greenhouses. J. Agric. Sci., Mansoura Univ., 26(1): 459-465.

Abdel-Rahman, H. R. and Ahmed, M.M. (2018). Comparative Toxicity of Certain Acaricides Against *Tetranychus urticae* Koch and Their Side Effects on *Phytoseiulus persimilis* A.-H. (Acari: Tetranychidae: Phytoseiidae). J. Plant Prot. and Path., Mansoura Univ., 9(12): 889-896.

Abou-Setta M.M., Sorrell, R.W. and Childers C.C. (1986). Life 48: a BASIC computer program to calculate life table parameters for an insect or mite species. Fla. Entomol. 69(4): 690–697

Alzoubi, S. and Cobanoglu, S. (2007). Effect of sub-lethal dose of different pesticides on the two-spotted spider mite, *Tetranychus urticae* Koch, and its predatory mites under greenhouse conditions. World J. Agric. Sci., 3 (6): 764-770.

Alzoubi, S. and Cobanoglu, S. (2008). Toxicity of some pesticides against *Tetranychus urticae* and its predatory mites under laboratory conditions. Amer. Euras. J. Agric & Eviron., 3 (1): 18-25.

Beers, E.H.; Brunner, J.F.; Dunley, J. E.; Doerr, M. and Granger, K. (2005). Role of neonicotinyl insecticides in Washington apple integrated pest management. Part II. Non-target effects on integrated mite control. Journal of Insect Science, 5 (1): 16- 26. doi.org/10.1093/jis/5.1.16

Bernard, M.; Horne, P. and Hoffmann, A. (2004). Ecological pest management: the effect of viticultural fungicides on beneficial predatory mites.- The Australian & New Zealand Grapegrower & Winemaker, 32nd Annual Technical Issue, 485a: 7-12.

Biondi, A.; Mommaerts, V.; Smagghe, G.; Vinuela, E.; Zappala, L. and Desneux, N. (2012). The non-target impact of spinosyns on beneficial arthropods. Pest Manag Sci 68:1523–1536.

Birch, L. C. (1948).The intrinsic rate of natural increase of an insect population. J.Anim.Ecol., 17: 15 – 26.

Bostanian, J.; Thistlewood, H.M.A.; Hardman, J.M. and Racette, G. (2009). Toxicity of six novel fungicides and sulphur to *Galendromus occidentalis* (Acari: Phytoseiidae). *Exp. Appl. Acarol.*, 47 (1): 63-69.

Bostanian, N.J. and Akalach, M. (2006). The effect of indoxacarb and five other insecticides on *Phytoseiulus persimilis*, *Amblyseius fallacies* (Acari: Phytoseiidae) and nymphs of *Orius insidiosus* (Hemiptera: Anthocoridae). Pest Manag. Sci., 62: 334-9.

Cheng, S.; Lin, R.; Lin, T.; You, Y.; Zeng, Z.; Zhou, Z.; Zhou, Y.; Jiang, H.; Wei, H.; Fu, J. and Yu, C. (2018). Effects of acetamiprid on life cycle development of predatory mite *Amblyseius cucumeris* (Acari: Phytoseiidae) after contact exposure. Chemosphere, 210: 889-895. Doi.org/10.1016/j.

Childers, C.C.; Villanueva, R.; Aguilar, H.; Chwning, R. and Michaud, J. P. (2001). Comparative residual toxicities of pesticides to the predator *Agistemus industani* (Acari: Stigmaeidae) on citrus in Florida. Exp. Appl. Acarol., 25: 461-474.

CoStat Software (2004). CoStat. www.cohort.com. Monterey, California, USA.

DOI 10.1007/s10646-013-1094-5.

EPA (Environmental Protection Agency) (2012). http://www.epa.org.++ Accessed 23 July 2012.

FAO (2017). FAO Stat database available from http://faostat:fao.org. Accessed date.

Fogel, M.N.; Schneider, M.; Desneux, N.; Gonzalez, B.; Ronco, A.E. (2013). Impact of the neonicotinoid acetamiprid on immature stages of the predator *Eriopis connexa* (Coleoptera: Coccinellidae). Ecotoxicology, 22: 1063–1071.

Fouly, A.H. and S.M. Al-Rehiayani (2011). Predatory mites in Qassim region, Saudi Arabia with description of two laelapid mite species (Acari: Gamasida: Laelapidae). J. Entomol., 8 (2): 139-151.

Grafton-Cardwell, E.E. and Gu, P. (2003). Conserving vedalia beetle, *Rodolia cardinalis* (Mulsant) (Coleoptera: Coccinellidae), in citrus: a continuing challenge as new insecticides gain registration. J Econ Entomol 96:1388–1398

Henderson, C.F. and Tilton, F.W. (1955). Tests with acaricides against the brown wheat mite. J. Econ. Entomol., 48:157-161.

Hoy, H.A. and Ling Ouyang, Y. (1986). Selectivity of the Acaricides Clofentezine and Hexythiazox to the Predator *Metaseiulus occidentalis* (Acari: Phytoseiidae). J. Econ. Entomol., 79 (5): 1377–1380. https://doi.org/10.1093/jee/79.5.1377.

https://doi.org/10.1016/j.pestbp.2014.12.009

Ishaaya, I., Barazani, A., Kontsedalov, S. and Horowitz, A.R. (2007). Insecticides with novel modes of action: Mechanism, selectivity and cross-resistance. Entomol Res 37:148–152.

Kavousi, A. and Talebi, K. (2003). Side-effects of three pesticides on the predatory mite, *Phytoseiulus persimils (Acari: Phytoseiidae).* Exp. Appl. Acarol., 31: 51-58.

Laing, J. E. (1968). Life history and life table of *Phytoseiulus persimilis* A.-H. Acarologia, 10: 578-588.

Lee, S.G.; Hilton, S.A.; Broadbent, A.B. and Kim, J.H. (2002). Insecticide resistance in phytoseiid predatory mites, *Phytoseiulus persimilis* and *Amblyseius cucumeris* (Acarina: Phytoseiidae). J. Asia Pacific Entomol., 5 (1): 123-129.

Liang, P.; Tian, Y.A.; Biondi, A.; Desneux, N. and Gao, X.W. (2012). Short-term and trans generational effects of the neonicotinoid nitenpyram on susceptibility to insecticides in two whitefly species. Ecotoxicology, 21:1889–1898.

Lucas, E.; Giroux, S.; Demougeo, S.; Duchesne, R.M. and Coderre, D. (2004). Compatibility of a natural enemy, *Coleomegilla maculata* Lengi (Coleoptera: Coccinellidae) and four insecticides used against the Colorado potato beetle. J. Appl. Entomol., 128: 233–239.

Mao, R.; Zhang, J. and Zhang, R. (2011). Side effects of copper fungicides on *Amblyseius cucumeris* by laboratory bioassays. Bulletin of Insectology, 64 (1): 69-72.

Marcic, D (2003). The effect of clofentezine on life-table parameters in two-spotted spider mite *Tetranychus urticae*. Exp. Appl. Acarol., 30: 249-263.

Marcic, D. (2007). Sublethal effects of spirodiclufen on life history and life-table parameters of two-spotted spider mite (*Tetranychus urticae*). Exp. Appl. Acarol., 42: 121-129.

McMurtry, J.A. and Croft, B.A. (1997). Life-styles of phytoseiid mites and their roles in biological control. Ann. Rev. Entomol., 42: 291-321.

Metcalf, R.L. (1980). Changing role of insecticides in crop protection. Ann. Rev. Entomol., 25: 219-256.

Pozzebon, A.; Duso, C and Pavanetto, E. (2002). Side effects of some fungicides on phytoseiid mites (Acari, Phytoseiidae) in north-Italian vineyards. Anzeiger für Schädlingskunde, 75 (5): 132 – 136. DOI: 10.1046/j.1472-8206.2002.02037.x

Sato, M.E.; Silva, M.D.; Goncalves, L.R.; Souza Filo, M.F. and Raga, A. (2002). Differential toxicity of pesticides to *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae) and *Teranychus urticae* (Acari: Tetranychidae) on strawberry. Neotrop. Entomol., 31: 449-456.

Stark, J.D.; Banks, J.E. and Acheampong, S. (2004). Estimating susceptibility of biological control agents to pesticides: influence of life history strategies and population structure. Biol. Control 29: 392–398.

US EPA, Archive Document (2007). Hexythiazox Summary Document: Registration Review Docket. Docket Number: EPA-HQ-OPP-2006-0114 www.regulations.gov.

Van Leeuwen, T.; Tirry, L.; Yamamoto, A.; Nauen, R. and Dermauw, W. (2015). The economic importance of acaricides in the control of phytophagous mites and an update on recent acaricide mode of action research. Pestic. Biochem. Physiol., 121: 12-21.

Verkerk, R. (2001). Farmer's friends-recognition and conservation of natural enemies of vegetable pests: A field guide for Introduction Extension Staff and Trainers in Zimbabwe. Biology Dept., Imperial College of Science, Technology and Medicine, University f London SW7, 2AZ, pp: 82-110.

Zaher, M.A. (1986). Predaceous and non-phytophagous mites in Egypt (Nile Vally and Delta) PI 480 Program. USA Project No. EG. ARS, 30. Grant. No, FG, Eg., 139, pp 567.

Zhang, Z. Q. (2003). Mites of Greenhouses; Identification, Biology and Control. CABI Publishing. Wallingford. UK.

التأثيرات السمية والبيولوجية لثلاثة مبيدات على الحلم العنكبوتي ذو البقعتين تترانيكس أورتيكا وتأثيرها الجانبي على الحلم المفترس إيوسيس سكيوتاليس

هالة رشاد عبد الرحمن*

قسم الحشرات الإقتصادية والمبيدات ـ كلية الزراعة ـ جامعة القاهرة

يعتبر الخيار من أهم نباتات الخضر في مصر. يعتمد انتاج الخيار على استخدام المكافحة الكيماوية بالمبيدات ضد الحشرات والأكاروسات الضارة وكذلك مسببات الأمراض. في هذه الدراسة تم دراسة الأثر السام للتركيز الموصى به لثلاثة مركبات موصى باستخدامها محليا هي المبيد الأكاروسي هيكسيثيازوكس (10% اي سي) والمبيد الحشري أسيتامبرايد (20% اس بي) والمبيد الفطري ريدوميل جولد بلس (71.5% دبليو بي) ضد الحلم العنكبوتي ذو البقعتين (العنكبوت الأحمر) تترانيكس اورتيكا تحت ظروف البيت المحمي. أوضحت النتائج أن أسيتامبرايد كان الأكثر فعالية في خفض تعداد الآفة الأكاروسية حيث وصلت نسبة القتل الأولية إلى 31.12% والمجمعة 69.90% والكلية 50.51% على الترتيب. إنخفضت هذه المعدلات بالنسبة للمبيد الأكاروسي هيكسيثيازوكس إلى 21.17% و 65.26% و 43.21% بينما كانت أقلها بالنسبة للمبيد الفطري حيث كانت 17.55% و 26.46% و 22.0% - على الترتيب. وكانت نسبة القتل للمركبات محل الإختبار أقل بصورة معنوية على المفترس الأكاروسي إيوسيس سكيوتاليس. ومن ناحية أخرى تم إختبار تأثير نصف التركيز الحقلي على جداول حياة كل من الآفة الأكاروسية والمفترس تحت ظروف المعمل لتوضيح الأثر السام على الأجيال القادمة والمتوقعة من كلا الأكاروسين. أوضحت الدراسة أن رش تلك المركبات على إناث الأكاروس حديثة التزاوج إطالة فترة الجيل التالي وكذلك الفترة الزمنية لمضاعفة النوع للجيل الواحد كما أدت المعاملة إلى خفض ملحوظ في معدل وضع البيض والتزايد النوعي ومعدل انتاج إناث جديدة تضاف للعشيرة كل جيل وكل يوم. كان مركب هيكسيثيازوكس أكثرها تأثيرا على كل من العنكبوت الأحمر والمفترس الأكاروسي.