Efficacy of Acaricides on *Eutetranychus orientalis* (Acari: Tetranychidae) and Its Compatibility with Predatory Mite *Euseius scutalis* (Acarei: Phytoseiidae) under Field Conditions

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Abstract

Efficacy evaluation of seven acaricides, i.e. Acarine (Abamectin 5% EC), Gat Fast (2% Abamectin + 10% Thiamthoxam (12% SC)), Ortis Super (Fenpyroximate 5% EC), Concord (Chlorfenapyr 24% EC), Perfect (2% Abamectin + 10% Chlorfenapyr (12% EW)), Micronet S (Sulfur 80% WP) and Acarots (Fenpyroximate 5% SC) at recommended dose (RD), against the brown spider mite, *Eutetranychus orientalis* (Tetranychidae) and its predatory mite, *Euseius scutalis* (Phytoseiidae), was applied on citrus crop in Assiut Governorate under field conditions. Three assorted exposure eras: three days, one week and two weeks, were achieved in May 2018. It was found that a total reduction rate of these 7 acaricides against *E. orientalis* was 88.26%, 90.40%, 87.99%, 88.91%, 88.78%, 88.41% and 87.82% and against *E. scutalis* was 23.69%, 19.61%, 14.33%, 12.7%, 15.52%, 16.51% and 15.33%, respectively. Abamactin 5% was significantly higher than other acaricides ($p<0.05$) followed by Fenpyroximate 5% EC and Fenpyroximate 5% SC. On the other hand, the rest of acaricides appeared to be insignificant ($p>0.05$). Acaricides can be used against *E. orientalis* without affecting *E. scutalis* where the results showed compatibility between acaricide and predatory mites in the field. For mode of action, Fenpyroximate is safer for human and animal than others because it acts as mitochondrial electron transport inhibitor with contact action. Application of serial concentrations from these compounds is recommended to reduce its toxicity in the environment.

Keywords: efficacy, *E. orientalis*, predatory mites, acaricide, reduction rates
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1. Introduction

The brown spider-mite, *Eutetranychus orientalis* (Tetranychidae) originated in the Middle East and its presence is extended in citric crops of Africa, Southern, Eastern Asia and Australia [1, 2]. The principle host of *E. orientalis* is *Citrus* spp., despite causing it damage to more than 50 plant species [3]. Also, a broad-spectrum of ornamental, medicinal and agricultural plants suffers from *E. orientalis* as a serious pest [4]. It mainly colonizes the upper leaf surfaces and those areas around the midribs. Discoloration of leaves and pale-yellow streaks along the midribs and veins are the main symptoms that appeared [5].

It is difficult to control this mite which may develop in the coming years and to limit biological and behavioral attitudes and its economic effect because of the misuse of a wide variety of agrochemicals that adversely affect on natural enemies [6], its stimulating on fertility and fecundity [7] and these mites are very small and difficult to detect on or inside the plants that are transported throughout the world.

Phytoseiid mites are important natural enemies of several phytophagous mites and other pests on various crops [8, 9]. *Euseius scutalis* was reported to be a common phytoseiid mite in Middle East countries (Lebanon, Iran, Egypt, Jordan) and North Africa on a variety of host plants including *Citrus* spp. [8]. Previous studies have shown that *E. scutalis* is not only a predator of spider mites, but also feeds on eggs and immature stages of whiteflies [10-12].

Control of *E. orientalis* is based on the chemical control and many research studies were focused on this method. For example, Tanigoshi *et al.* [13] evaluated the toxicity of fenbutatin-oxide, cyhexatin, bromopropylate and amitraz on lemon orchards, *Citrus limon* Burmann. Moreover, Márquez *et al.* [3] tested the efficacy of dicofol, propargite, hexitiazox, etoxazol and fenpiroximate against *E. orientalis* on Valencia-late orange crops and Fine lemon. Several phytosanitary treatments per year are usually needed for its control. In Egypt, acaricides are the primary means used to control *E. orientalis*. Abamectin, one of acaricides which applied in Egypt, belongs to the family known as macrocyclic lactones. It is derived from a life form growing in soil. Scientists first became aware of microorganisms in the mid-1970s [14]. It is often used as insecticide, an acaricide and a nematicide and is sold under many commercial names such as Vertimec, Reaper, CAM-MEK 1.8% and Termictine 5% EC. It does not remain in the environment and does not increase in proportion [15]. Thiamethoxam is used for applying on *Tetranychus urticae* (Koch) and its predator *Phytoseiulus persimilis* [16]. Moreover, thiamethoxam, a second generation of neonicotinoid, has excellent systemic characteristics and control of a broad range of commercially important pests, such as aphids, jassids, whiteflies, thrips, rice hoppers, Colorado potato beetle, flea beetles and wireworms, as well as some lepidopteran species. In addition, it can prevent some of virus transmissions [17]. Fenpyroximate is the ISO common name for tert-butyl (E)-alpha-(1,3-dimethyl-5-phenoxypyrazol-4-ylmethyleneamino-oxy)-p-toluate (IUPAC). This pesticide was applied on *T. urticae* [18]. Chlorfenapyr can disrupt ATP production and loss of energy leading to cell dysfunction and subsequent death of the organism [19]. It was applied against various pests such as termites [20], stored product-insects [21] in addition to *T.urticae* [22]. This molecule has low mammalian toxicity and is classified as slightly hazardous insecticide as per WHO criterion [23].

Phytosanitary authorities have adopted emergency safety measures to avoid the spread of the pest but further studies concerning its biology, behavior and control are needed to generate adequate knowledge to develop optimal control policies. This work aimed to evaluate the efficacy of seven chemicals of plant origin to control *E. orientalis* and predatory mite *Euseius scutalis* as natural enemy under field conditions in Assuit Governorate, Egypt.

2. Materials and methods

2.1. Commercial acaricides

Based on Table 1, Acarine (Abamectin 5% EC), Gat Fast (2% Abamectin + 10% Thiamethoxam (12% SC)), Ortis Super (Fenpyroximate 5% EC), Concord (Chlorfenaypyr 24% EC), Perfect (2% Abamectin + 10% Chlorfynapyr (12% EW), Micronet S (80% WP Sulfur) and Acarots (Fenproximate 5% SC) were obtained from agriculture company for pesticides. The recommended doses: (25 ml/100 l water for Acarine, 160 ml/100 l water for Gat Fast, 200 ml/100 l water for Ortis Super, 60 ml/100 l water for Concord, 120 ml/100 l water for Perfect, 500 g/100 l water for Micronet S and 50 ml/100 l water for Acarots), for direct spray were only applied in this work. Physiological effect to each acaricide was indicated.

Table1. Components evaluated in the assay to control *E. orietalis* and *E. scutalis.*

Commercial name	Active component and formula type	Effect	Recommended dose.
Acarine	Abamectin 5% EC	Contact and ingestion [3]	25 ml/100 l water
Gat fast	2% Abamectin + 10% Thiamthoxam (12% SC)	Contact and ingestion [3]	160 ml/100 l water
Ortis super	Fenpyroximate (5% EC)	Mitochondrial electron transport inhibitor with contact action [3,18]	200 ml/100 l water
Concord	Chlorfenpyr (24% EC)	ATP production inhibitor by contact [19]	60 ml/100 l water
Perfect	2% Abamectin + 10% Chlorfenaypr (12 EW %)	Contact	120 ml/100 l water
Micronet S	Sulfur (WP 80%)	Contact	500 gm/100 l water
Acarots	Fenproximate (5% SC)	Mitochondrial electron transport inhibitor with contact action [3, 18]	50 ml/100 l water

2.2. Field assessment

The study was applied during month of May 2018, under field condition. The field experiments were carried out at the experimental research station, Assiut, (Egypt) on *Citrus sinensis* trees infested with *E. orientalis* on their leaves with the observation *E. scutalis* existence feeding on its prey. Twenty-five trees were under study, distributed on two feeden (one tree per each acaricide and four replicates for each component in addition to control (well water). Ten infested leaves from each tree were marked and packaged as groups for each chemical prior spraying. To avoid interaction among treatments, groups of marked leaves were separated from each other.

To calculate the number of mites that inhabited the leaves prior to spraying, researchers counted the total number of adults on each leaf with the use of a magnifying glass. Afterwards, seven acaricides with recommended dose (RD) were sprayed on the respective trees with the use of sprayer (10 L capacity). In order to determine the count for three days, one week and two weeks after the spraying, the total number of adults on ten marked leaves was calculated by using a magnifying glass and by touching each mite to observe its movement.

2.3. Statistical analysis

Reduction rate was determined by Henderson and Tilton equation [24]:

$$\text{The corrected \% reduction} = \left(1 - \frac{\text{n in control before treatment x n in T after treatment}}{\text{n in control after treatment x n in T before treatment}}\right) \times 100$$

Where n = number of mites, T= treated mite, Co=control mite.

Microsoft Excel (2010) was applied to determine mean of number of populations. Statistically, all variables were examined with the use of one-way analysis of variance (ANOVA).

3. Results and Discussion

Presented data showed efficacy of seven acaricides at RD against *E. orientalis* and its predatory mites, *E. scutalis*, under field conditions. These compounds are described by non-contaminated pesticides [15], which derived from plants to reduce problems caused by other chemical pesticide groups.

Tables 2 and 3 and Figures 1 and 2 indicated the mean number of individuals of *E. orientalis* and *E. scutalis* per ten leaves pre-spraying and after spraying during assorted exposure periods. For Acarine (Abamectin 5% EC), mean number of populations of *E. orientalis* and *E. scutalis* pre-spraying, were 189.25 and 23.5, respectively. Three days, one week and two weeks after applying, mean number of *E. orintalis* and *E. scutalis* individuals were 24.75 and 22.25; 25.5 and 22.25; 33.75 and 22.25, respectively, with mean of reduction rate of 89% and 11.36%, 89.2% and 26.9% and 86.5% and 32.81%, respectively.

By applying Gat Fast (2% Abamectin + 10% Thiamethoxam), mean number of populations of *E. orientalis* and *E. scutalis*, pre-spray, were 183.3 and 20.25, respectively. After spraying for three days, one week and two weeks, mean number of *E. orientalis* individuals were 18.8, 20.5 and 28, and mean reduction rates were 91.73%, 91.24% and 88.23%, respectively whereas mean number of *E. scutalis* were 18, 20.75 and 22.5 with mean reduction rate of 16.78%, 20.9% and 21.15%, respectively. The effects of Thiamethoxam on *T. urticae* were higher when residual and contaminated food exposures were considered according to Pozebon *et al*. [16]. These researchers reported that the total effect was higher than 90% when contaminated food exposure was involved. On *P. persimilis*, the total effect was higher in residual and contaminated prey exposures compared with topical exposure, and all combinations of routes of exposure attained a total effect higher than 90%. Low use rates, flexible application methods, excellent efficacy, long-lasting residual activity and favorable safety profile make this new insecticide well-suited for modern integrated pest management programs in many cropping systems [17].

Based on Ortis Super (Fenpyroximate 5% EC), mean numbers of individuals of *E. orientalis* and *E. scutalis* at pre-spraying were 166.5 and 18, respectively. After three days, one week and two week spraying, mean numbers of *E. orientalis* population were 23.25, 23.25 and 30 with mean reduction rate of 88.61%, 88.96%, 86.39%, respectively, and for *E. scutlais* were 17, 20 and 21 with mean reduction rate of 11.58%, 14.2% and 17.2%, respectively.

For Concord (Chlorfenapyr 24% EC), mean numbers of *E. orientalis* populations after pre-spraying were 200.75 and then after three days, one week and two weeks spraying, the mean numbers of individuals were 22, 26 and 37.75 with reduction rates of 91%, 89.85% and 85.89%, respectively. Additionally, mean numbers of individual *E. scutalis* were 14, 12.5, 16.25 and 17.5 at pre-spraying, three days, one week and two weeks after exposure with mean reduction rates of 16.41%, 10.4% and 11.29%, respectively.

For Perfect (2% Abamectin+10% Chloefenapyr (12 EW %)), Micronet S (Sulfur 80% WP) and Acarots (Fenpyroximate 5% SC); mean numbers of *E. orientalis* populations at pre-spraying were 168.5, 185.25 and 194.25 and of *E. scutalis* were 18.5, 21 and 19, respectively. Mean numbers of individuals after three days were 16.75, 19.75 and 24.25 with mean reduction rates of 91.76%, 91.21% and 89.83% for *E. orientalis*, and 19.75, 19.25 and 16.75 for *E. scutalis* with reduction rates of 11.44%, 14.18% and 17.47%, respectively. For one-week exposure, mean numbers of individuals (*E. orientalis*) were 21.25, 23.5 and 26 with mean reduction rates of 90.13%, 90.00% and 89.35%, respectively, whereas mean numbers of *E. scutalis* were 19.75, 22.5 and 21.75 with reduction rates of 17.59%, 17.29% and11.63%, respectively. Two-week exposure indicated that mean numbers of *E. orientalis* were 34.75, 39.25 and 40.5 with reduction rates of 84.44%, 84.01% and 84.29%, respectively, and 21.5, 24.25 and 22.25 for *E. scutalis* with reduction rates of 17.52%, 18.05% and 16.89%, respectively.

Kenneth *et al.* [22] reported that *Tetranychus urticae* mortality from Chlorfenapyr residues was significantly greater than the control (1, 3, 7, and 14 d after application). Even after two weeks, Chlorfenapyr residues caused 55% mortality to adult *T. urticae* compared to 6% mortality in the control. Also, *Tetranychus urticae* mortality from Bifenthrin and Abamectin residues was not significantly greater than the control at 1 d after application. However, *T. urticae* mortality for both Bifenthrin and Abamectin residues was significantly greater than the control (3, 7 and 14 d after application) due to its bio-origin. In addition, more researches are needed on the mode of action and compatibility of tested acaricides with biological agent products (e.g. predatory mites and entomopathogenic fungi) and other available acaricides.

Table 2. Mean number of *E. orientalis* population before treatment and after treatment for three days, one-week and two-week exposure.

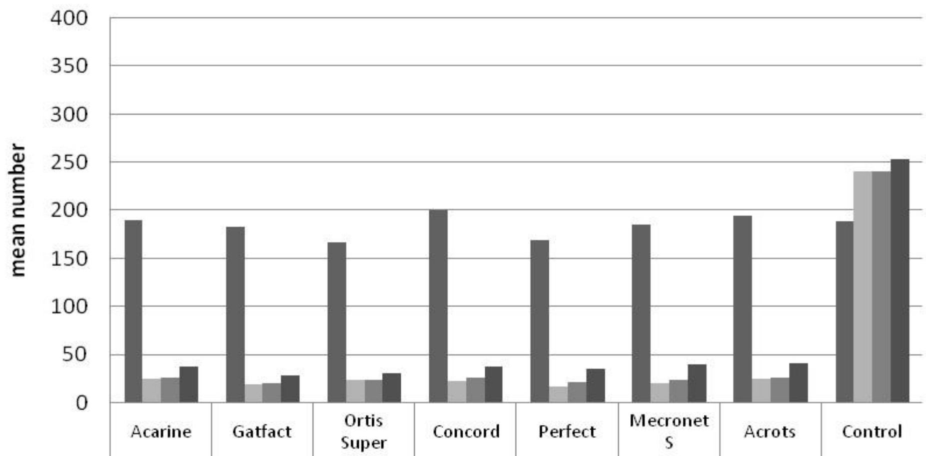
Acaricide	Exposure period			
	Day 0	Three days	One week	Two weeks
	Mean number ±SD	Mean number ± SD	Mean number ± SD	Mean number ± SD
Acarine	189.25 ± 25.81	24.75 ± 4.75^{b}	25.5 ± 6.56^{b}	33.75 ± 9.63^{b}
Gat fast	183.25 ± 29.03	18.75 ± 5.12^{a}	20.5 ± 4.20^{a}	23 ± 2.16^{a}
Ortis	166.25 ± 21.52	23.25 ± 4.65^{b}	23.25 ±4 .65^{b}	30 ± 5.71^{b}
Concord	200.75 ± 20.47	22.00 ± 4.83^{b}	26 ± 5.23^{b}	37.75 ± 5.74^{b,c}
Perfect	168.25 ± 33.01	16.75 ± 5.9^{a}	21.25 ± 4.79^{a}	34.75 ± 5.38^{b}
Micronet S	185.25 ± 31.19	19.75 ± 4.65^{b}	23.5 ± 5.51^{b}	39.25 ± 4.5^{c}
Acarots	194.25 ± 15.59	24.25 ± 4.65^{b}	26 ± 4.97	40.5 ± 4.20^{c}
control	189 ± 17.03	229.8 ± 14.73	240.5 ± 22.69	252.75 ± 16.62

Means followed by different letters in the same column differ significantly ($p<0.05$).

Table 3. The corrected reduction (%) of *E. oreintalis* and its predatory mite, *E. scutalis*, on *C. sinensis* crop treated with assorted acaricides in May 2018.

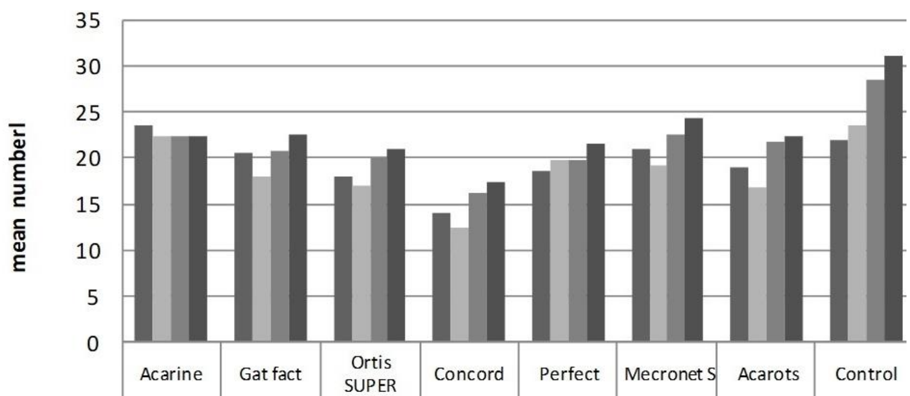
Acaricide	Mean of Red.% after spray					
	Three days		One week		Two weeks	
	E.orientalis	*E.scutalis*	*E.orientalis*	*E.scutalis*	*E.orientalis*	*E.scutalis*
Acarine (Abamectin 5% Ec)	89.00% ± 3.14^{b}	11.36% ± 0.07^{a}	89.22% ± 3.19^{c}	26.91% ± 0.41^{f}	86.57% ± 3.70^{b}	32.81% ± 0.31^{f}
Gat fast (2%Abamectin+ 10% thiamthoxam)	91.73% ± 0.32^{a}	16.78% ± 0.42^{c}	91.24% ± 0.77^{a}	20.9% ± 0.15^{e}	88.23% ± 2.92^{a}	21.15% ± 0.38^{e}
Ortis Super (Fenpyroximate 5% Ec)	88.61% ± 1.10^{b}	11.58% ± 0.52^{a}	88.96% ± 2.01^{b}	14.2% ± 0.07^{c}	86.39% ± 3.02^{b}	17.2% ± 0.97^{c}
Concord (Chlorfenapyr)	91.00% ± 1.61^{b}	16.41% ± 0.85^{b}	89.85% ± 1.50^{b}	10.4% ± 0.97^{a}	85.89% ± 2.27^{c}	11.29% ± 0.62^{a}
Perfect (2% Abamectin + 10% Cholrfenapyr)	91.76% ± 2.43^{a}	11.44% ± 0.39^{a}	90.13% ± 0.61^{b}	17.59% ± 0.69^{d}	84.44% ± 1.76^{c}	17.52% ± 0.69^{c}
Micronet S (Sulfer 80% WP)	91.21% ± 1.63^{a}	14.18% ± 0.33^{b}	90.00% ± 1.76^{b}	17.29% ± 0.50^{d}	84.01% ± 2.02^{c}	18.05% ± 0.82^{d}
Acarots (Fenpyroximate 5% SC)	89.83% ± 0.93^{b}	17.47% ± 0.41^{c}	89.35% ± 2.71^{b}	11.63% ± 0.45^{b}	84.29% ± 2.73^{c}	16.89% ± 0.29^{b}

Means followed by different letters in the same column differ significantly ($p<0.05$).



	Acarine	Gatfact	Ortis Super	Concord	Perfect	Mecronet S	Acrots	Control
prespry	189.25	183.25	166.5	200.75	168.5	185.25	194.25	189
podt three day	24.75	18.75	23.25	22	16.75	19.75	24.25	240.5
post one week	25.5	20.5	23.25	26	21.25	23.5	26	240.5
post two week	37.75	28	30	37.75	34.75	39.25	40.5	252.75

Figure 1. Mean number of *E. orientalis* individuals/10 leaves: pre and post spray on citrus crop in Assiut Governorate



	Acarine	Gat fact	Ortis SUPER	Concord	Perfect	Mecronet S	Acarots	Control
pre spray	23.5	20.5	18	14	18.5	21	19	22
post 3 days spray	22.25	18	17	12.5	19.75	19.25	16.75	23.5
post 7 days	22.25	20.75	20	16.25	19.75	22.5	21.75	28.5
post 14 day spray	22.25	22.5	21	17.5	21.5	24.25	22.25	31

Figure2. Mean number of *Euseius scutalis* individual/10 leaves on citrus crop in Assiut Governorate

The best acaricides that reduced *E. orientalis* population were Perfect (2% Abamectin + 10% Chlorfenapyr, 12% EW) with the mean number of 16.75±5.9, Gat Fast (2% Abamectin +

10% Thiamethoxam, 12% SC) with the mean number of 18.75±5.12 after three-day exposure and continued in superiority after one week and two weeks.

The data in Table 3 show the corrected reduction (%) of *E. oreintalis* and its predatory mite, *E. scutalis*. After three-day exposure, the acaricides that showed high efficiency for controlling *E. oreintalis* were Perfect (2%Abamectin + 10% Chlorphynapyr) with 91.76% for *E. orientalis* and 11.44% for *E. scutalis*. For one-week and two-week exposure, the corrected reduction (%) of *E. orientalis* and *E. scutalis* were Gat Fast (2% Abamectin + 10% Thiamthoxam) with 91.24% for *E. orientalis* and 20.9% for *E. scutalis*, for one week and 88.23% and 21.15%, for two weeks, respectively.

Few studies recorded the effect of acaricides against *E. orientalis*. Márquez *et al*. [3] recorded that Dicofol, Propargite, Hexitiazox, Etoxazol and Fenpyroximate can cause a decrease in the mortality of *E. orientalis* by 100, 98.85, 85.05, 83.92 and 100%, and by 97.82, 85.92, 81.87, 100 and 100% on Valencia-late orange crops and Fine lemon after one week of exposure, respectively. Motoba *et al.* [18] recorded that *T. urticae* sprayed with 0.5 μg/ml Fenpyroximate showed distortions in mitochondria, in peripheral nerve cells such as swelling, irregular cristae arrangement, and lower matrix electron density caused by the compound when observed by transmission electron microscopy. Similar distortions in mitochondria were also obvious in the ovaries and epidermal cells, but not in muscular cells or central nervous mass cells. So, this composition is the most applied in Egypt. On the other hand, EFSA 2013 [25] concluded that Fenpyroximate had low ecotoxic to soil dwelling organisms and LC_{50} inhalation [0.21 - 0.33 mg/l air/4-h (nose-only)] of rat showed that the substance is very toxic.

Alhewairini [15] estimated that adult mortality percentages of *E. orientalis* were 17.40, 20.62, 23.77, 36.70, 41.60, 59.60 and 79.80% after one week of exposure to 500, 1000, 2000, 3000, 4000, 5000 and 6000 ppm of Huwa-San TR50, respectively, under field conditions. The populations of *E. orientalis* reduced to 76.68 and 79.56% and to 78.52 and 80.12% after one-week exposure to the recommended dose (RD) of Abamectin and Bifenthrin under field and laboratory conditions, respectively.

Consequently, all components, in particular Abamectin and fenpyroximate, can be used as pesticide with effectiveness against *E. orientalis*, without affecting on *E. scutalis* population in the field. From this investigation, it indicates that *E. scutalis* did not significantly affect the used compounds from plant-in origin. Natural enemies have received considerable attention in restriction of potential pest populations [26]. Biological control of arthropod pests has been traditionally used for a long time in different crops, therefore, it should be used with other compatible integrated pest management methods [27]. Conservation biological control (CBC) defines as the protection of natural enemies against adverse effects of pesticides and incompatible cultural practices and improving their efficiency by providing food sources [28, 29]. The use of CBC as a component of integrated mite management in agriculture is a strategy that is increasingly important and popular. Concurrent with the increasing use of CBC in agriculture has been a realization that ‘generalist’ natural enemies (i.e. those who have a broad prey preference) can often play a major role in mite suppression [30]. Thus, CBC as a strategy that enhances guilds or communities of both specialist and generalist natural enemies is now viewed as a mite management strategy, very likely to improve crop protection. Another factor that has encouraged and enhanced the use of CBC in many crop systems is the availability and the use of pesticides that are narrow-spectrum and safe to many beneficial insects and mites [31-33]. CBC research in many crop systems is focused on improving reliability by strengthening the natural enemy community both in terms of population density and species diversity [34].

4. Conclusions

Evaluation of seven acaricides of bio-origin against *E. orientalis* achieved high reduction rates in the field without harming its predatory mites, *E. scutalis*. All applications were under recommended dose for each component. Our results appeared that Gat Fast (2% Abamectin + 10% Thiamthoxam) showed high effective against *E. orientalis* with slight negative impact towards *E. scutalis* within three week exposure by the application of 160cm^3 /100 l water. Mode of action of Abamectin and Thiamthoxam should further be studied.

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