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Original Article

Toxicity evaluation of oxamyl against tomato russet mite, *Aculops lycopersici* (Massee) (Acari: Eriophyideae) and two spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) under greenhouse conditions

Avaliação da toxicidade de oxamil contra o ácaro do tomateiro, *Aculops lycopersici* (Massee) (Acari: Eriophyideae) e o ácaro-aranha, *Tetranychus urticae* Koch (Acari: Tetranychidae) sob condições de estufa

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Abstract

Agriculture sector of Saudi Arabia is growing swiftly and tomato is an important crop cultivated mostly under green houses. Unfortunately, it is facing severe infestation due to divers mite species. Present study, relates to evaluation of toxicity of oxamyl against two phytophagous mites; *Aculops lycopersici* and *Tetranychus urticae*, isolated from tomato plants suffering from infestation. Simultaneous effect of oxamyl on two predatory mites; *Neosiulus cucumeris* and *Euseius scutalis*, was also evaluated. Three concentrations of oxamyl; half of the recommended dose (HRD), recommended dose (RD) and double recommended dose (DRD), were used against each mite specie to observe mortality within seven days as compared to the control. Significant mortality of 97.91% and 93.92% was observed in *A. lycopersici* and *T. urticae*, respectively at RD. In case of predatory mites; *N. cucumeris* and *E. scutalis*, mortality was 60.61% and 64.48%, respectively, under same conditions. Mortality of mites observed at HRD was insignificant and there was negligible increase in mortality at DRD. Oxamyl being less toxic to predatory mites and significantly mortal to phytophagous mites is recommended as a tool to as a tool to achieve biological control parallel to pesticidal effect.

Keywords: oxamyl, tomato, *Tetranychus urticae*, *Aculops lycopersici*, *Neosiulus cucumeris*, *Euseius scutalis*.

Resumo

O setor agrícola da Arábia Saudita está crescendo rapidamente e o tomate é uma cultura importante cultivada principalmente em estufas. Infelizmente, está enfrentando uma infestação severa devido a diversas espécies de ácaros. O presente estudo refere-se à avaliação da toxicidade do oxamil contra dois ácaros fitófagos; Aculops lycopersici e Tetranychus urticae, isolados de tomateiros infestados. Efeito simultâneo de oxamil em dois ácaros predadores; Neosiulus cucumeris e Euseius scutalis, também foi avaliado. Três concentrações de oxamil; metade da dose recomendada (HRD), dose recomendada (RD) e dose dupla recomendada (DRD), foram usados contra cada espécie de ácaro para observar a mortalidade em sete dias em comparação com o controle. Mortalidade significativa de 97,91% e 93,92% foi observada em A. lycopersici e T. urticae, respectivamente no RD. No caso de ácaros predadores; N. cucumeris e E. scutalis, a mortalidade foi de 60,61% e 64,48%, respectivamente, nas mesmas condições. A mortalidade de ácaros observada no HRD foi insignificante e houve um aumento insignificante na mortalidade no DRD. Oxamil sendo menos tóxico para ácaros predadores e significativamente mortal para ácaros fitófagos é recomendado como ferramenta para alcançar o controle biológico paralelo ao efeito pesticida.

Palavras-chave: oxamil, tomate, *Tetranychus urticae*, *Aculops lycopersici*, *Neosiulus cucumeris*, *Euseius scutalis*.

1. Introduction

Tomato Russet Mite (TRM), *Aculops lycopersici* (Massee) (Acari: Eriophyideae) was first reported in Australia by Massee (1937). Thereafter, it was observed on *Solanum lycopersicum L* plants (Tomato) in several countries such as Korea (Kim et al., 2002), USA (Anderson, 1954), Egypt (Abou-Awad, 1979), Argentina (Rossi, 1962), Brazil (Flechtmann and Aranda, 1970), Venezuela (Cermeli et al., 1982), Japan (Nemoto, 2000) and Saudi Arabia (Gentry, 1965; Martin, 1971; EPPO, 2014). As it can cause significant damage to tomato plants, it was regarded as

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an phytophagous pest affecting tomato crops (*Solanum lycopersicum* L.) and hence, yield. Its outbreak causes serious damage to the epidermal cells of the leaflet resulting into a curling of the leaflet edges, desiccation, harm to tissues and ultimately plant death (Keifer et al., 1982; Royalty and Perring, 1987; Haque and Kawai, 2002). It can also tarnish or damage the surface of the fruits (Kim et al., 2002). In addition, there are more than 24 host plants of *A. lycopersici* spread in three different plant families Solanaceae, Convolvulaceae and Rosaceae (Perring, 1996; Larrain, 2000; Duso et al., 2010).

Eriophyoid mites revealed equal susceptibility to many acaricides like amitraz, dicofol, propargite, ethion, bromopropylate and abamectin as compared with mite species linked to Tetranychidae (Thomas et al., 2009). However, Tetranychidae had few adverse effects from benzoylphenylurea insecticides diflubenzuron and teflubenzuron whereas russet mites were adversely affected (Childers et al., 1996; Scarpellini and Clari, 1999).

The effectiveness of several insecticides and/or acaricides against *A. lycopersici* has been assessed. For instance, Abou-Awad and El-Banhawy (1985) investigated the vulnerability of *A. lycopersici* to methamidophos, dicofol, pyridaphenthion, and fenarimol cypermethrin. Furthermore, Royalty and Perring (1987) compared the toxicity of five acaricides i.e. cyhexatin, avermectin B1, dicofol, thuringiensin, and sulfur to *A. lycopersici.* Kashyap et al. (2014) evaluated the efficacy of azadirachtin, abamectin, hexythiazox, spiromesifen and mineral oil against *A. lycopersici.*

Notwithstanding the strong vulnerability of Eriophyoid mites to most available acaricides, several species of Eriophyoid mites (including *A. lycopersici*) have developed resistance. In Egypt for example, the resistance of *A. lycopersici* to methamidophos was recorded after three seasons of use (Abou-Awad and El-Banhawy, 1985). This would motivate scientific researchers to find alternative strategies for controlling *A. lycopersici*.

The two spotted spider mite (TSMM), *Tetranychus urticae* Koch is regarded as the most important species of the family Tetranychidae, as it is considered as pest of 900 plant species (Jeppson et al., 1997; Meyer, 1996; Naher, 2005). It has been reported that *T. urticae* can cause considerable economic loss to beans, tomatoes, peppers, strawberries and roses (Niu et al., 2014; Kumari et al., 2017; Al-Azzazy and Alhewairini, 2018). Like other phytophagous mites, *T. urticae* feeds on plant leaves and causes injuries to the epidermis that result in yellow and brown blotch, which goes along with dryness and leaf fall (Abou-El-Ela, 2014). Apart from its damage to the plant, *T. urticae* invasion can cause a considerable depletion in the quantity and quality of various profitable crops or in complete yield loss (Niu et al., 2014).

The toxic effects of unique and conventional acaricides such as chlorfenapyr, spiromesifen, hexythiazox, abamectin, fenpyroximate, etoxazole, matrine, beta-cypermethrin, bifenazate, spirodiclofen, diafenthiuron, pyridaben, clofentezine, fenazaquin, dicofol and dimethoate to all *T. urticae* stages were analyzed in several studies (Niu et al., 2014; Shah and Shukla, 2014; Kumari et al., 2017). These include plant abstractions especially Neem (*Azadirachta indica* A. Juss), which is based on the commercial formula, azadirachtin (Bernardi et al., 2013). Moreover, these studies discussed in detail the side effects of these acaricides to predacious mites related to the infestation of *T. urticae*. This is because the use of pesticides is usually necessary to maintain the pest population below the economically sustainable level which cannot be obtained by predation (Maroufpoor et al., 2016).

Acaricides like dicofol, abamectin, hexythiazox and clofentezine, used for controlling acaricides result in a swift resistance after a few years of their use (Beers et al., 1998; Stumpf and Nauen, 2001, 2002; Sato et al., 2005; Whalon et al., 2008; Nicastro et al., 2013; Tirello et al., 2012). To compensate resistance there is need to increase dose of the acaricides, that have long residual toxicity and other environmental hazards (Shah and Shukla, 2014).

Oxamyl is a carbamate pesticide which is used commercially to control insects, mites, ticks and nematodes found in various field crops. It is toxic to human, fish, birds and many other animals including insects and mites, if ingested or adsorbed via skin (Brock, 1988; Bansal, 1983). Chemically, oxamyl is N, N-dimethyl-2-methylcarbamoyloxyimino-2-(methylthio) acetamide (Kidd and James, 1991). In market, it is available as a white crystalline solid or colorless solution.

As a consequence, this study was aimed at evaluating the toxicity of oxamyl against TSSM and TRM and its side effects on the predatory mites, *N. cucumeris* and *E. scutalis* under greenhouses conditions.

2. Materials and Methods

2.1. Solutions and experimental protocol

Commercial formulation of oxamyl (Fymate 24%, oxamyl, 240000ppm) was procured from Astra Company (KSA) for direct spray mixture, the recommended dose was 400 mL/100L (960ppm).

This study was conducted in March 2019. About 20m^2 of two different harvested lands (into two different greenhouses) with tomato saplings (Pritchard cultivar) were selected and divided into 5 plots (each plot was about 2 m^2), and all plots were arrayed in a randomized complete block design. Experiments to evaluate the toxic effect of oxamyl on two acari, *A. lycopersici* and *T. urticae* and two predatory mites *N. cucumeris* and *E. scutalis*, were designed under greenhouse conditions because in Saudi Arabia, tomatoes are mostly cultivated in green houses. A stereomicroscope was used to ascertain the initial density and distribution of *T. urticae* and *A. lycopersici* and the predatory mites, *N. cucumeris* and *E. scutalis* (moving stages) as a pre-spray count, ten tomato leaves of each treatment were randomly gathered and put into a clean labeled plastic bag and taken to the laboratory. Half of the recommended dose (HRD = 480ppm), recommended dose (RD = 960ppm) and double recommended dose (DRD = 1920ppm) of oxamyl including the control (well water) with 5 imitations were directly sprayed by using a knapsack sprayer (20L) on the tomato plants which were densely plagued by tomato russet mite.

A stereomicroscope was used for direct examination that was made one week after the application of three oxamyl concentrations, to ascertain the percentage reduction in the population of tomato russet mites on the tomato plants after spraying.

2.2. Statistical analysis

Henderson and Tilton (1955) equation was used to calculate the percentage depletion in the average populations of *A. lycopersici*, *T. urticae* and the predacious mites, *N. cucumeris* and *E. scutalis* (Equation 1).

$$\text{Corrected (\%)} = \left(1 - \frac{\text{n in Co before treatment} \times \text{n in T after treatment}}{\text{n in Co after treatment} \times \text{n in T before treatment}}\right) * 100 \quad (1)$$

where: n = Number of *A. lycopersici*, *T. urticae* and the predatory mites, *N. cucumeris* and *E. scutalis* population, T = Treated, Co = Control.

The death - count of *A. lycopersici* and *N. cucumeris* was made manually by direct observation under a stereomicroscope. Subsequently, Microsoft Excel Program was used to calculate the average percentage of a number of larvae hatching from eggs. One-way analysis of variance (ANOVA) was used for statistical analysis of all variables of the acquired data (MSTAT-C, 1990).

3. Results

3.1. Effect of different concentrations of oxamyl on selected phytophagous mites

Table 1 shows effect of three concentrations of oxamyl on mortality of two selected mites, collected from infested tomato plants under greenhouse conditions. Mortality observed when *A. lycopersici* is treated with HRD, RD and DRD is 73.70, 97.91 and 100.00%, respectively. In case of *T. urticae* at same three concentrations average mortality is 62.67, 93.92 and 100.00%. At RD mortality in *A. lycopersici* is 3.99% more than *T. urticae*. There is negligible increase in mortality when concentration is increased from RD to DRD (Table 1).

3.2. Effect of different concentrations of oxamyl on selected predatory mites

Table 2 shows effect of three concentrations of oxamyl on mortality of two selected predatory mites, collected from tomato plants infected with *A. lycopersici* and *T. urticae*, under greenhouse conditions. Mortality observed when *N. cucumeris* is treated with HRD, RD and DRD is 25.14, 60.61 and 70.99%, respectively. In case of *E. scutalis* at same three concentrations average mortality is 27.45, 64.48 and 73.28%, respectively. At RD mortality in *N. cucumeris* is

Table 1. Effect of three concentrations of oxamyl on *Aculops lycopersici* and *Tetranychus urticae* in infested tomato plants under greenhouse conditions.

Concentration (ppm)	No. of mites/leaf					
	A. lycopersici			***T. urticae***		
	Pre-spray count	**Average post-spray count***	**Mortality %****	**Pre-spray count**	**Average post-spray count***	**Mortality %****
Control	52.78	52.00	0.00 A	15.06	14.99	0.00 A
HRD	50.28	13.22	73.70 Ba	16.37	6.11	62.67 Bb
RD	48.97	1.02	97.91 Cb	15.81	0.96	93.92 Cb
DRD	54.24	0.00	100.00 Cc	15.70	0.00	100.00 Cc

*Counts made one-week post treatment; **Mortality values calculated with the Henderson-Tilton's equation. The capital letter denotes the significance within the same column and small letter denotes the significance within the same row at P>0.05.

Table 2. Corrected percentage mortality of the predatory mites, *Neosiulus cucumeris* and *Euseius scutalis* associated with tomato plants treated with three concentrations of oxamyl under greenhouse conditions.

Concentration (ppm)	No. of predatory mites/leaf					
	N. cucumeris			***E. scutalis***		
	Pre-spray count	**Average post-spray count***	**Mortality (%)****	**Pre-spray count**	**Average post-spray count***	**Mortality (%)****
Control	5.00	5.09	0.00 A	6.00	6.00	0.00 A
HRD	5.48	4.10	25.14 Ba	7.14	5.18	27.45 Ba
RD	5.92	2.33	60.61 Cb	6.25	2.22	64.48 Cb
DRD	6.86	1.99	70.99 Dc	6.55	1.75	73.28 Dc

*Counts made one-week post treatment; **Mortality values calculated with the Henderson-Tilton's equation. The capital letter denotes the significance within the same column and small letter denotes the significance within the same row at P>0.05.

3.87% lesser than the mortality observed for *E. scutalis*. Results show that mortality in predatory mites is around 30% less as compared to the values obtained in case of phytophagous mites.

3.3. Comparative effect of oxamyl on mortality of phytophagous mites and predatory mites

Figure 1 presents, effect of three concentrations of oxamyl (HRD, RD and DRD) on the mortality of two phytophagous mites; *A. lycopersici* and *T. urticae* and two predatory mites; *N. cucumeris* and *E. scutalis*. It can be observed from the bar graph that mortality in case of predatory mites is lower than the phytophagous mites. Among the two phytophagous mites, mortality is slightly lower in *T. urticae* at HRD and RD with values of 62.67 and 93.92%, respectively.

4. Discussion

In Saudi Arabia agricultural sector is growing rapidly and is facing severe destruction due to infestation caused by diverse mite species. Use of higher concentrations of pesticides has become a common practice in green house cultivation resulting in damage to non-target species and residual effects on the crops. Harmful effects of any pesticide can be avoided by using it carefully and keeping its applied concentration as low as possible. In this study, a commonly used acaricides, oxamyl, has been used to evaluate its toxicity against phytophagous mites and predatory mites infesting tomato plants in green houses of the region of Al-Qassim, Saudi Arabia. Oxamyl was selected because it is relatively safe chemical because it is hydrolyzed rapidly to the corresponding non-toxic compounds and its half-life is only 1 to 2 weeks (Hayes Junior and Laws Junior, 1991). This work is continuation of the author's efforts to introduce effective, friendly and safe pesticides to the growing agriculture of Saudi Arabia (Alhawirini, 2017). Selection of the mites was made on the bases of their abundance on infested tomato plants in green house. Predatory mites were also collected from the same green house and same plants. Experimental trials are fairly successful as oxamyl caused 97.91% and 93.92% mortality in *A. lycopersici* and *T. urticae,* respectively, when used at recommended dosage (Table 1). Toxicity study of a pesticide is incomplete unless its impact on non-target species is evaluated. Therefore, mortality of predatory mites under same conditions and same place was observed. Oxamyl caused mortality of 60.61% and 64.48% in the two selected predatory mites, *N. cucumeris* and *E. scutalis,* respectively (Table 2). Results clearly display that oxamyl is relatively less toxic to predatory mites. This aspect of oxamyl makes it distinctive for its commercial applications because commonly used pesticides like abamectin are equally toxic to target and non-target species (McGregor, 1954).

Oxamyl is, therefore, recommended for use as a pesticide in agriculture sector, specifically in greenhouses to control infestation caused by *A. lycopersici* and *T. urticae*. Further studies are suggested to evaluate its differential action on diverse mite species.

5. Conclusion

It is concluded that oxamyl is an effective acaricide against *A. lycopersici* and *T. urticae*. It is relatively less toxic to predatory mites and shows discriminative action to target and non-target mite species. Oxamyl is a useful acaricide to promote biological control strategies in green houses. Further research is encouraged to investigate its differential toxicity to diverse mite species.

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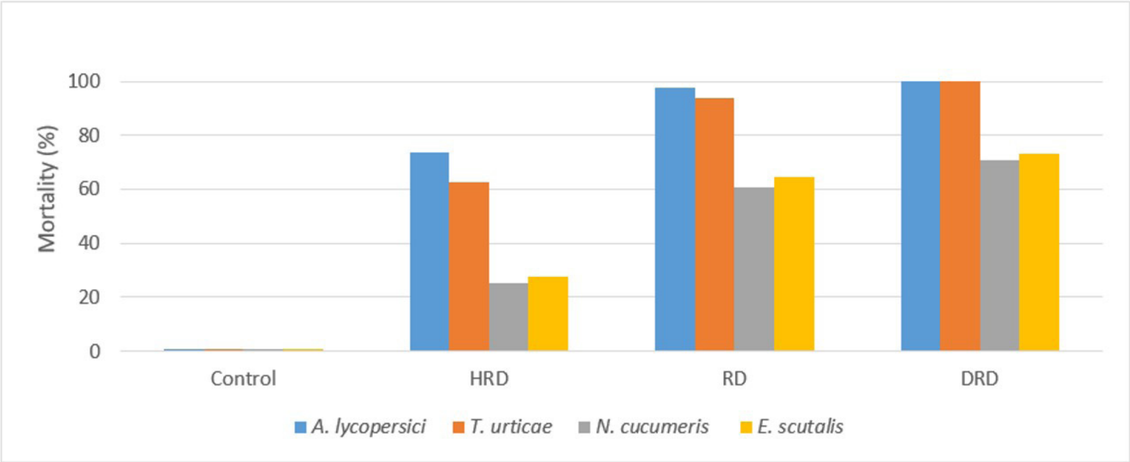

Figure 1. Comparison of the effect of three concentrations of oxamyl (HRD, RD and DRD) on the mortality of *A. lycopersici*, *T. urticae* and the predatory mites, *N. cucumeris* and *E. scutalis*.

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