Plant Protection (Scientific Journal of Agriculture)
45(2), Summer, 2022

doi 10.22055/ppr.2022.17436

Effects of sub-lethal concentrations of Biomite® on life-history traits of *Tetranychus urticae* (Acari: Tetranychidae)

M. Havasi[1], K. Kheradmand[2*], H. Mosallanejad[3], Y. Fathipour[4]

1. M.Sc. Graduate student, Department of Entomology and Plant Pathology, College of Aburaihan, University of Tehran, Tehran, Iran
2. ***Corresponding Author:** Associate Professor, Department of Entomology and Plant Pathology, College of Aburaihan, University of Tehran, Tehran, Iran (kkheradmand@ut.ac.ir)
3. Assistant Professor, Iranian Research Institute of Plant Protection, Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran
4. Professor, Department of Entomology, Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran

Received: 22 November 2022 Accepted: 9 March 2022

Abstract

The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), is one of the key pests that can damage a wide range of crops in farms and greenhouses. Using chemical pesticides is one of the main methods for its management. Laboratory bioassays were conducted to evaluate the effects of sub-lethal concentrations (LC_5, LC_{10} and LC_{20}) of Biomite (a formulation based on Citronellol) on biological characters and life table parameters of *T. urticae* under laboratory conditions (25±2°C, 60±5% RH, and L:D16:8 hours). Data were analyzed based on age-stage, two-sex life table analysis. Our results indicated that when adults of *T. urticae* were treated with LC_5, LC_{10} and LC_{20} of Biomite, the oviposition period and total lifetime were significantly reduced compared with the control. The highest and lowest values of the fecundity (61.1 and 41.56 eggs/female) and longevity (13.01and 9.97 days) were obtained in control and LC_{20}, respectively. The individuals treated with LC_{10} (R_0 = 38.1) and LC_{20} (R_0 = 32.92) showed a significantly reduced net reproductive rate, compared to individuals that treated with LC_5 (R_0 = 47.01) and to the control (R_0 = 48.88 individuals/female/generation). The intrinsic rate of increase (r) and finite rate of increase (λ), were not significantly reduced in different treatments compared to the control. The mean generation time (T) decreased significantly at upper concentration (LC_{20}=15.58 days), in comparison to LC_5 (16.66 days). Due to the obtained results of current study and considering the detrimental effects of Biomite on some biological parameters, it could be incorporated in IPM programs of *T. urticae*.

Keywords: Biomite®, Life table, Sub-lethal concentrations, Tetranychus urticae

Associate editor: A. Rasekh (Prof.)

Citation: Havasi, M., Kheradmand, K., Mosallanejad, H., & Fathipour, Y. (2022). Effects of sub-lethal concentrations of Biomite® on life-history traits of Tetranychus urticae (Acari: Tetranychidae). Plant Protection (Scientific Journal of Agriculture), *45*(2), 33-48. https://doi.org/ 10.22055/ppr.2022.17436.

INTRODUCTION

Mites are considered to be major pests of various crops. The two-spotted spider mite (TSSM) *Tetranychus urticae* Koch (Acari: Tetranychidae) is the main constraint of crops and ornamental plants worldwide in greenhouse and outdoor conditions (Kim & Yoo, 2002; Sedaratian et al., 2011; Khanamani et al., 2013; Maleknia et al., 2016; Havasi et al., 2019b, 2021). It is a highly polyphagous pest feeding on more than 1,200 plant species belonging to more than 250 plant families (Grbić et al., 2011). Efficient control of TSSM relies largely on the use of insecticides and acaricides (van Leeuwen et al., 2015). However, TSSM is well known for its ability to quickly expand resistance against different classes of pesticides (van Leeuwen et al., 2010). A new challenge was established for plant protection, as strict adjustments limited the utilization of synthetic pesticides in greenhouses (Riahi et al., 2017).

The wide use of synthetic pesticides leads to affect non-target organisms (Yorulmaz & Ay, 2009), human safety (Van Pottelberge et al., 2009), the emergence of secondary pests (Garriga & Caballero, 2011), and the development of resistance (Goulson, 2013). Also, Dittrich et al. (1974), James and Price (2002), and Szczepaniec et al. (2011) reported that the introduction of multiple pesticides could cause hormoligosis (reproductive stimulation at sub-lethal doses) in spider mites.

Developing new compounds with novel modes of action achieving effective control of spider mites (Marcic & Medo, 2014). Currently, the new pesticides/acaricides are developed in reply to general requests for safer, environmentally-friendly pest management methods and they are needed to meet severe toxicological and ecotoxicological regulative basis (Dekeyser, 2005; Casida, 2012; Marčić, 2012; EPPO, 2014). Biomite® (common name: Citronellol) is considered as an organic miticide with a minimum risk of controlling different pest mites such as two-spotted spider mite, pacific mite, citrus rust mite, and european red mite. According to Biochemical Classification Committee, citronellol is classified as a biochemical pesticide (Reilly et al., 2009). The exploitation of sub-lethal effects, i.e., the physiological and/or behavioral effects on individuals that survive exposure to a lethal or sub-lethal dose/concentration of pesticides, is principal comprehension of the impact of agrochemicals on the development and population parameters of pests (Desneux et al., 2007). It is crucial to assess the sublethal effects of pesticides on pests at population levels, to know the lethal affects, in order to comprehensively consider the whole impact of a pesticide (Hedayati et al., 2019).

The age-stage, two-sex life table theory, which combines the stage differentiation and both sexes of a population (Chi & Liu, 1985; Chi, 1988), has often been used to assess these demographic parameters and to evaluate the various sub-lethal effects of diverse pesticides on insects (e.g., Zhang et al., 2017; Zhen et al., 2018) and mites (e.g. Li et al., 2017; Saber et al., 2018).

However, no evidence is available with respect to the sublethal effects of Biomite® on biological parameters of the TSSM. Therefore, this study aims to determine the sublethal effects of Biomite® on some biological characteristics and demographic parameters of TSSM, to provide the information needed for developing an appropriate mite management strategy.

MATERIALS AND METHODS

Stock colonies of *T. urticae*

The initial population of *T. urticae* was collected from infested greenhouses in the Pakdasht region (southeastern Tehran, Iran). The mite colony was established on laboratory on bean leaves (*Phaseolus vulgaris* L. var Khomein (Fabaceae)) at 25± 2 °C, 60± 5% R.H. and a photoperiod of 16:8 hr (Light:Dark).

Acaricide tested

A natural based miticide with the commercial name Biomite® (Arysta LifeScience), was used in this study. The main active ingredient of Biomite® is citronellol, a monoterpene alcohol, which is a pale yellow oily liquid. The active ingredients in the final product Biomite® which is produced by an integrated system, involve the blending of geraniol, citronellol, nerolidol, farnesol and other ingredients (Reilly et al., 2009).

Bioassay

A modified leaf dip method (Helle & Overmeer 1985; Ibrahim & Yee, 2000) was used to assess the response of *T. urticae* adults to the different Biomite® concentrations. The preliminary test was performed to determine five concentrations that cause at the range of 10–90% mortality in adult mites. The concentrations were 125, 300, 720, 1700 and 4000 ppm. To this end, freshly cut bean leaf discs (4 cm in diameter) were immersed for 15 seconds in Biomite® solution and air-dried [about three hours] indoors. However, the control leaf discs were only dipped in distilled water.About experimental arena, briefly, a 1 cm-diameter pore was made in the center of the plastic Petri dishes having a 9 cm diameter and 1.5 cm height. The first Petri dish was sealed to another applied for supplying water by using glue. Additionally, two pores with 2 mm diameter were created in the upper part of the second Petri dish to fill with water. A wick prepared from filter paper was passed through central hole to the second Petri dish. In fact, the wick provided enough water to keep the leaves fresh in the upper dish. Further, a thin layer of moist cotton was laid on the bottom and covered with filter paper to prevent the leaves from drying. Furthermore, all the leaves were placed on the filter paper in the Petri dishes and restricted to saturated cotton in order to prevent the mites from escaping. Finally, the experimental arena was covered with a ventilated lid. The bean leaf discs were placed in Petri dishes up-side-down. Additionally, 20 same-aged adult mites (24-hour-old 10 males and 10 females) were placed on the treated leaf discs for each concentration by using a fine soft pointed brush. The bioassay was replicated four times for five concentrations of the acaricide as well as the control. Then, the mite mortality was assessed after 24 hours of exposure. Mites were considered as dead if after touching with a small fine brush under stereomicroscope (OPTIKA, SZM-1), they could not crawl and were non-functional. The experiments were conducted at thelaboratory conditions of 25±2°C, 60±5% RH and photoperiod of 16:8 hr (Light: Dark). The LC_5, LC_{10} and LC_{20} concentrations were estimated to assess the sublethal effects of Biomite® on *T. urticae*.

Effect of sublethal concentrations on biological characteristics

After treating the bean leaf discs with LC_5, LC_{10} and LC_{20} concentrations of Biomite ®, 24-hours-old females were placed on the discs. The leaves were air-dried for about three hours. Distilled water was served as control. The bean leaf discs (40 mm in diameter). In this step of experiments were used 80 pairs of unmated male and female mites. Then, 24-hours-old females were placed on the leaf discs. After 24 hours, the surviving females in each treatment were separately introduced onto the untreated bean leaf discs. In 24 hours, only one egg laid by the treated and untreated females remained in each Petri dish, and the other eggs and females were removed from the experiment arena. In the next step, 100 eggs were used to evaluate the sublethal concentrations on biological characteristics and life table parameters of *T. urticae*. All experiments were conducted in a growth chamber at 25±2℃, 60±5% RH, and a photoperiod of 16:8 hrs (L:D) , while the development and survival time were checked daily. Furthermore, the selected males from the stock colony were used when not enough males were available for pairing with females. The males from the colony were just used for mating and removed for life table parameters calculation. Finally, the survival of adult mites and fecundity of females were recorded daily until the death of the last female. Then, the population parameters were calculated. Old and highly infested plants were replaced (every 48 hours) by new ones as required.

Data analysis

The LC_5, LC_{10}, LC_{20}, and LC_{50} values and their 95% fiducially limits were calculated using the procedure Probit analysis (Finney, 1971) using IBM-SPSS statistics (SPSS version19.0). Furthermore, mortality data for adults were corrected by Abbott's formula (Abbott, 1925). The original data for all individuals were analyzed according to the theoretical model (Chi, 1988). All parameters including the age-stage-specific survival rate (s_{xj}), age-specific survival rate (l_x), age-specific fecundity (m_x), as well as all population growth parameters [the intrinsic rate of increase (r), the finite rate of increase (λ), the gross reproductive rate (*GRR*), and the net reproductive rate (R_0) (Fathipour & Maleknia, 2016) were calculated according to the method of Chi and Liu (1985), and Chi (1988) using TWOSEX-MS Chart (Chi, 2019b). The mean and standard errors of the population growth parameters were estimated by the bootstrap technique (Efron & Tibshirani, 1993). Furthermore, the paired bootstrap test (100,000) test using TWO-SEX-MS Chart program was employed for the statistical differences among the means of parameters related to development, fecundity, reproductive periods as well as population growth parameters at different treatments (Efron & Tibshirani, 1993; Huang & Chi, 2013; Akkopru et al., 2015).

RESULTS

Concentration-response bioassay

The results of probit analysis are presented in Table 1. As table 1 show estimated LC_{50} for the TSSM was 957 ppm. No mortality was recorded in the control (Table 1).

Development time, adult longevity and total life span

Sub-lethal effects of experimental concentrations of Biomite on development time, longevity and total life span for both sexes are given in Table 2. None of egg, larvae, protonymph, as well as deutonymph of male individuals were not affected by different concentrations of Biomite; also except deutonymph, other stages of females was not significantly influenced by different concentrations of Biomite®. When the individuals treated with LC_{20} concentration of Biomite, males and females longevity, as well as total life span were significantly different from control and other sub-lethal concentrations. The longest and the lowest female adult longevity (longest: 13.01 d for control; lowest: 9.97 d for LC_{20}), as well as total life span (longest: 23.71 d for control; lowest: 20.59 d for LC_{20}) were observed in control and LC_{20} treatment, respectively (Table 2).

Reproductive periods

The pre-oviposition period was not affected by all experimental treatments (Table 3). The TPOP ranged between 11.65 to 11.89. The minimum number of oviposition day was 7.81 for LC_{20} treatment. The effect of Biomite on *T. urticae* fecundity depended on different concentrations (Table 3). Fecundity of female mites, as an average on the four treatment, was lowest at LC_{20} (41.56 eggs/female) concentration; whereas at control treatment it was markedly higher (61.11 eggs/female).

Population growth parameters

Table 4 represents population growth parameters of *T. urticae* after treatment with the different concentrations of Biomite. The cohort exposure to control (0.234 day^{-1}) treatment and LC_{20} (0.224 day^{-1}) concentration had the highest and lowest intrinsic rate of increase (r), respectively. However, no significant difference was observed between different treatments. Similarly, the highest and lowest values of the finite rate of increase (λ) occurred on distilled water and LC_{20} concentration, respectively. The net reproductive rate (R_0) (32.92 individuals/female/generation), the mean generation time (T) (15.58 day), and the gross reproduction rate (*GRR*) (35.59 individuals/female/generation) were significantly lower for LC_{20} value compared to other treatments.

Table 1.Probit analysis for the concentration–mortality response of Biomite on adult females and males of *Tetranychus urticae*

	LC_5	LC_{10}	LC_{20}	LC_{50}	Df	x^2	*P*	No.*
	118.8	188.4	329.1	956.9	4	1.73	0.63	480
Upper	169.8	253.6	416.3	1162.3				
Lower	72.4	125.7	242.9	791.1				

*20 individuals per replicate, four replicates per concentration, six concentrations per assay

Table 2. Mean (±SE) of female and male development time (days) of *Tetranychus urticae* for control and different concentrations of Biomite

Parameter	CK	LC_5	LC_{10}	LC_{20}
Male				
Egg duration (day)	4.19±0.10[a]	4.14±0.10[a]	4.27±0.12 [a]	4.31±0.12[a]
Larva duration (day)	2.11±0.09[a]	2.07±0.07[a]	2.07±0.07[a]	2.06±0.06[a]
Protonymph (day)	2.12±0.09[a]	2.07±0.07[a]	2.13±0.09 [a]	2.12±0.09[a]
Deutonymph (day)	2.09±0.06[a]	2.14±0.10[a]	2.13±0.09[a]	2.06±0.06[a]
Male longevity (day)	10.56±0.18[a]	10.50±0.17[a]	9.87±0.19[a]	8.94±0.23[b]
Total life span (day)	21.00±0.25[a]	20.93±0.30[a]	20.47±0.27[a]	19.50±0.24[b]
Female				
Egg duration (day)	4.16±0.04[a]	4.20±0.08[a]	4.20±0.04[a]	4.25±0.05[a]
Larva duration (day)	2.14±0.04[a]	2.17±0.05[a]	2.08±0.03[a]	2.04±0.02[a]
Protonymph (day)	2.26±0.06[a]	2.27±0.08[a]	2.27±0.04[a]	2.35±0.05[a]
Deutonymph (day)	2.12±0.04[a]	2.14±0.09[a]	2.05±0.02[a]	1.98±0.02[b]
Female longevity (day)	13.01±0.02[a]	12.91±0.13[a]	11.33±0.09[b]	9.97±0.02[c]
Total life span (day)	23.71±0.08[a]	23.70±0.25[a]	22.2±0.09[b]	20.59±0.08[c]

The SE were estimated by using 100,000 bootstraps. The means followed by the same letter in each row are not significantly using paired bootstraps test at the 5% significance level. CK is the control

Table 3. Mean (±SE) reproductive period and total fecundity of offspring from females of *Tetranychus urticae* treated with sublethal concentrations of Biomite and distilled water (CK)

Parameter	CK	LC_5	LC_{10}	LC_{20}
oviposition period (day)	10.92±0.03[a]	10.81±0.05[a]	9.55±0.06[b]	7.81±0.04 [c]
[a]APOP (day)	1.09±0.03[a]	1.10±0.03[a]	1.05±0.02[a]	1.16±0.04 [a]
[b]TPOP (day)	11.76±0.09[a]	11.89±0.11[a]	11.65±0.08[a]	11.78±0.08[a]
Total fecundity (eggs/female)	61.11±0.22[a]	61.09±0.31[a]	48.59±0.26[b]	41.56±0.32[c]

The SE were estimated by using 100,000 bootstraps. The means followed by the same letter in each row are not significantly using paired bootstraps test at the 5% significance level. a Age pre-oviposition period, bTotal pre-oviposition period

Table 4. Life table parameters (mean ±SE) of *Tetranychus urticae* at different concentrations of Biomite and control treatment

Parameters	CK	LC_5	LC_{10}	LC_{20}
r (day^{-1})	0.234±0.003[a]	0.231±0.003[a]	0.228±0.003[a]	0.224±0.003[a]
λ (day^{-1})	1.263±0.004[a]	1.259± 0.004[a]	1.256±0.004[a]	1.251±0.004[a]
R_0(individuals/female/generation)	48.88 ± 2.44[a]	47.01 ± 2.54[a]	38.12±2.00[b]	32.92±0.91[c]
GRR(individuals/female/generation)	54.01±2.14[a]	55.75 ± 1.97[a]	42.69 ±1.9[b]	35.59±1.55[c]
T (day)	16.61±0.08[a]	16.66± 0.10[a]	15.93±0.08[b]	15.58±0.07[c]

The SE were estimated by using 100,000 bootstraps. The means followed by the same letter are not significantly using paired bootstraps test at the 5% significance level. CK is the water control

Survival and Fecundity curves

Figure 1 demonstrated the daily survivorship of both untreated and treated individuals of *T. urticae* with sub-lethal concentrations of Biomite. Exposure to Biomite through sub-lethal concentrations resulted in a reduced of survival. The total lifetime for the untreated mites was 26 days, while it was 26, 25 and 22 days for LC_5, LC_{10} and LC_{20} concentrations, respectively. In addition, the maximum values of m_x were 5.34 eggs/female/day for untreated mites which were on the 21^{st} day of the lifespan (Fig. 2). However, The peak values of m_x for LC_5, LC_{10} and LC_{20} treatments were 5.19, 4.67 and 4.77 eggs/female/day respectively, which occurred on days 20, 15 and 15 (Fig. 2).

The age stage-specific survival rate (S_{xj}) curve indicated chance that a spider mite egg will survive to age *x* and stage *j* (Figure3). This curve showed separately different life stages of *T. urticae* (Figure 3). The highest survival rate was obtained 80% and 16% for female and male in control treatment.

DISCUSSION

This study provides the population parameters and demographic data related to offspring in *T. urticae* treated with sublethal concentrations of Biomite®. The recommended field application rates of Biomite® are 1, 1.5, and 2 L/hectare for controlli *T. urticae* (Nikpay et al., 2016; Ziaee et al., 2017). In the current study, although the applied concentrations were lower than what recommended, but the sublethal concentrations affected the growth of the two-spotted spider mites. Because demographic analyses is able of processing a precise estimate of the growth rate of an insect pest population, a thorough comprehension of these parameters is essential in expanding ecologically sound pest management strategies and programs (Atlihan et al., 2017). The studies conducted on sublethal effects revealed

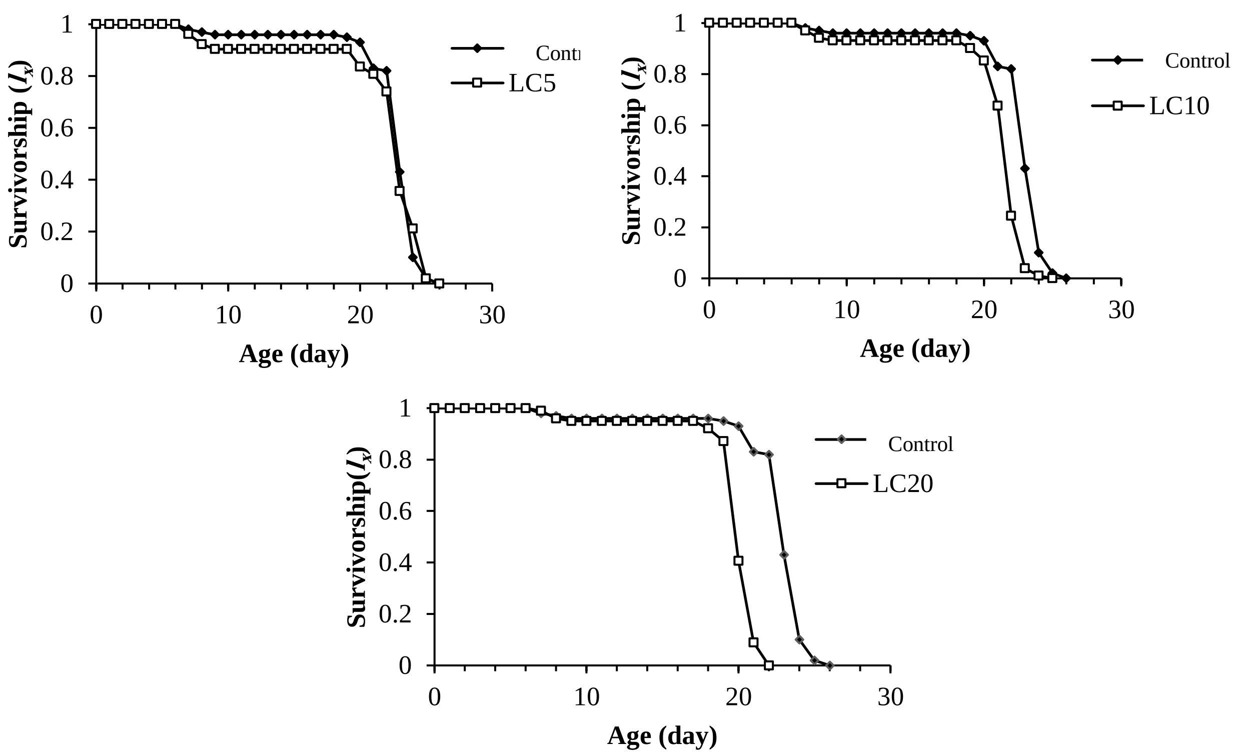

Figure 1. Age-specific survival curve (lx) of *Tetranychus urticae* at different concentrations of Biomite and control treatment

that the negative and non-lethal impacts of insecticides on pests can provide practical information for forming effective pest control strategies (Irigaray et al., 2007; Stavrinides & Mills, 2009; Wang et al., 2009).

Nevertheless, various studies have been conducted on the effects of different pesticides on biological characteristics of two-spotted spider mite and its predatory mites (Cloyd et al., 2006; Duchovskien et al., 2009; Marcic et al., 2010; Sanatgar et al., 2011; Havasi et al., 2019a; Havasi et al., 2020a,b). However, no evidence is available with respect to the sub-lethal (LC_5, LC_{10} and LC_{20}) effects of Biomite on two-spotted spider mite. The results of this study indicated that Biomite has no significant negative effect on development times of different life stages of pre-puberty for all the tested concentrations among males. Regarding females, no significant differences were observed among the various stages of pre-puberty for all the tested concentrations, except in deutonymph stages. Similar to the present results, Alinejad et al. (2015) clearly noted that with an increase in the concentration level of fenazaquin on biological characteristics of *T. urticae*, no significant differences were observed among various concentrations (LC_{10}, LC_{20} and LC_{30}) with the control group. Fenazaquin, IUPAC name 4-tert-butylphenethyl quinazolin-4-yl-ether, commercial formulation Pride® 20 % SC, and inhibits the mitochondrial electron transport chain (Dekeyser, 2005).

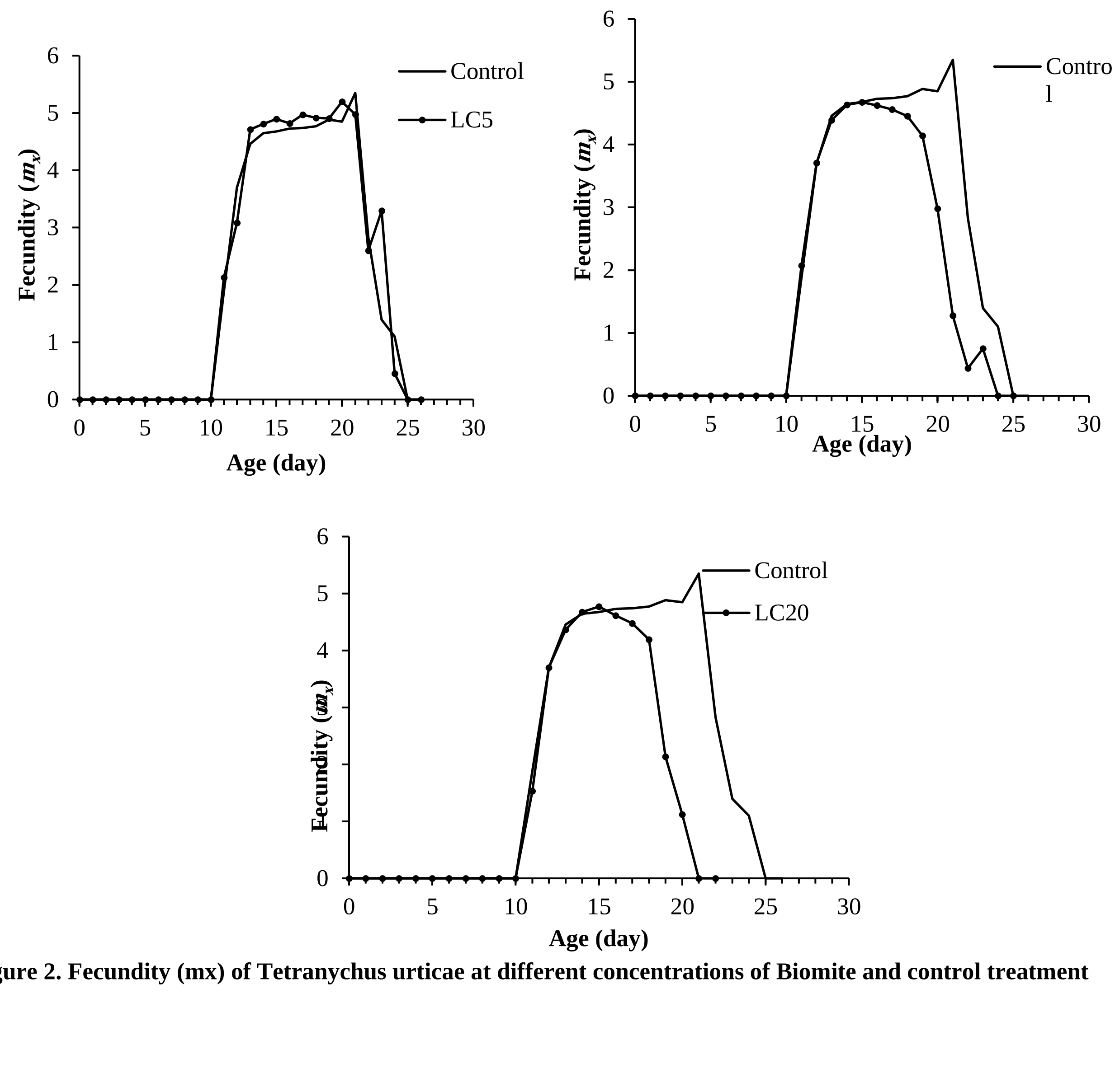

Figure 2. Fecundity (mx) of Tetranychus urticae at different concentrations of Biomite and control treatment

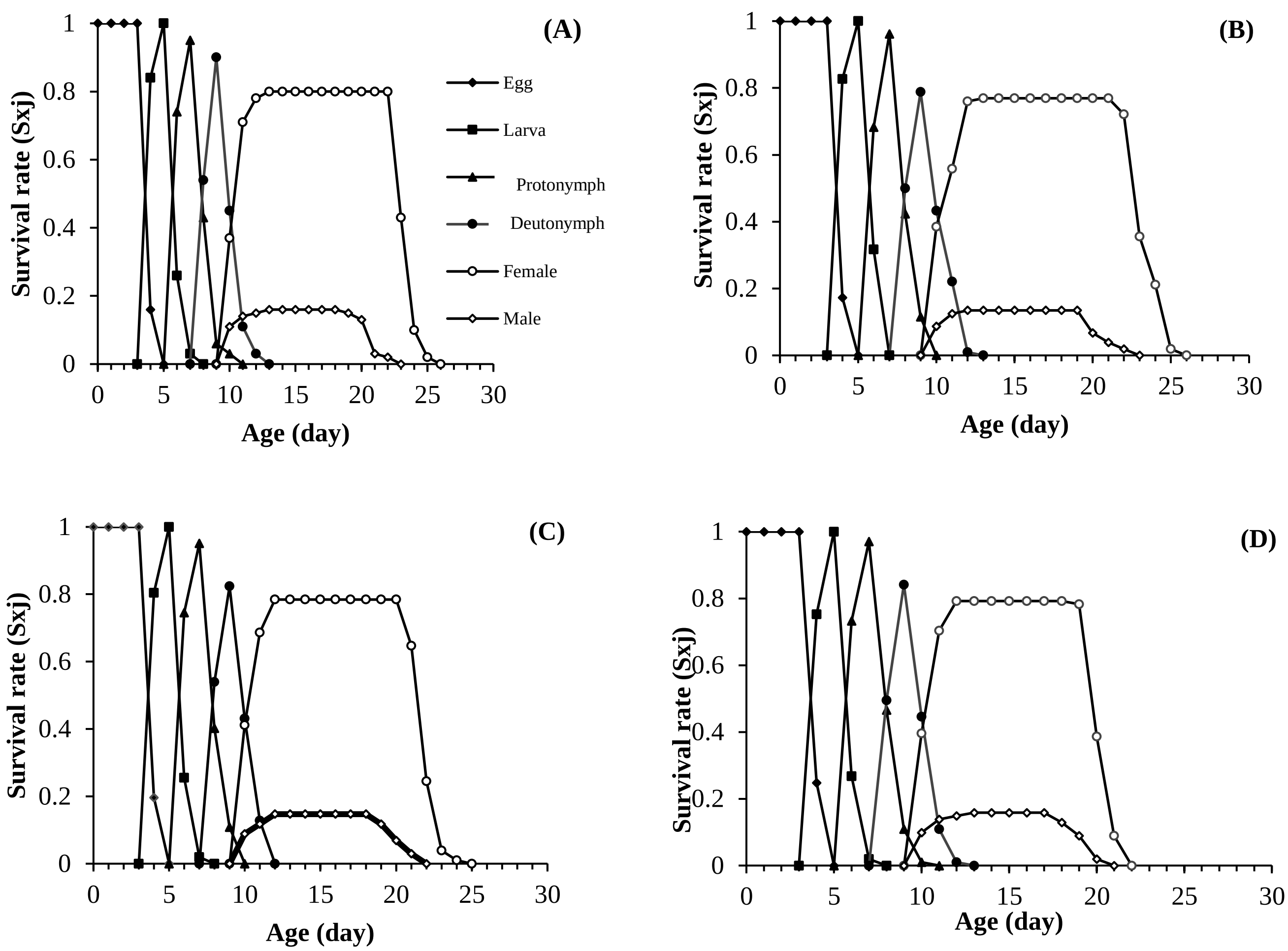

Figure 3. Age-stage specific survival rate (sxj) of *Tetranychus urticae* for control (A) and different concentrations of Biomite: LC5 (B), LC10 (C) and LC20 (D)

Li et al. (2017) showed that exposure to higher concentrations (LC_{10} and LC_{20}) caused a significant difference in females when treated by sub-lethal concentrations of bifenazate during pre-adult survival rate of *T. urticae* to compare with the control. Bifenazate belongs to the group of hydrazine derivatives (Van Leeuwen et al., 2010), and is being used worldwide for control of spider mites on several crop systems (Dekeyser, 2005; Van Leeuwen et al., 2015).

Based on the results of the current study, the use of different concentrations of the biomite caused a significant and negative effect on the longevity and the total lifetime in both males and females. These findings are in accordance with the results obtained by Havasi et al. (2018) who found that diflovidazin treatment (LC_{10} and LC_{20}), caused a significant decrease in period of longevity and the total lifespan. Diflovidazin is regarded as a pesticide with contact and trans-laminar activity (Havasi et al. 2019a). The findings do not support the study of Mohammadi et al. (2016) who found total life span of *Tetranychus turkestani* Ugarov and Nikolskii (Prostigmata: Tetranychidae) were significantly increased when the motes were exposed to three cucumber cultivars treated with Biomite, compared with the control groups. The difference may be related to the sub-lethal (LC_{20}) used or species of mite or species study. Our results showed that although pre-oviposition periods were not affected by different concentrations of Biomite, with increasing the concentration, a significant reduction in the oviposition period and total fecundity of *T. urticae* individuals. The results of the present study introduced the sublethal concentrations of Biomite, leading to significantly low fecundity and oviposition duration *T. urticae* (at LC_{10} and LC_{20} concentrations) when compared with those in the control; which demonstrated that the potential of treated mites by Biomite for population improvement at next generation would be slow.

The results of this study are in agreement with those of Marcic (2007, 2012) who found that spirodiclofen and spirotetramat caused a decrease in the number of eggs laid by *T. urticae* females. On the other research, Wang et al. (2016) reported that the use of sub-lethal concentration (LC_{10} and LC_{20}) of spinetoram, leads to significant increase in the fecundity of *T. urticae*. Spinetoram, a reduced-risk insecticide, belongs to a novel class of chemicals called spinosyns (DeAmicis et al., 2011; Park et al., 2012); it primarily activates the insect's nervous system and causes involuntary muscle contractions, paralysis, and ultimately death (Crouse 2007; Orr et al., 2009). Another study revealed that the application of spinosad, has significant acaricidal effects against *T. urticae* oviposition period (Villanueva & Walgenach, 2006). It is worthwhile noting that spinosad has been suggested as a highly valuable bioactive natural product utilized as a pesticide versus a variety of pests (Santos & Pereira, 2020).

The age-stage, two-sex life table study explain the stage differentiation of the immature stage and offers a comprehensive description of the entire life history stage differentiation (Liu et al., 2018; Yu et al., 2018). The data acquired in our study indicate that exposure to sub-lethal concentrations of Biomite at LC_{10} and LC_{20} concentrations, during the female adult stage had a negative impact on the TSSM population (i.e. significant effect at R_0, *GRR* and *T* values). In the present study, the *r* and λ-values of *T. urticae* exposed to Biomite were not different among treatments. But the difference between control and Biomite acaricide, was not significant.

Li et al. (2006) and Martínez-Villar et al. (2005) reported that the values of *r* in offspring of abamectin and azadirachtin-treated adult females of *Amphitetranychus viennensis* and *T. urticae* respectively, significantly decreased. Abamectin stimulates the gamma-aminobutyric acid (GABA) system, ‘a chemical transmitter’ produced at nerve endings, which inhibits both nerve-to-nerve and nerve-to-muscle communication (Dekeyser, 2005). Also, azadirachtin, a mixture of several structurally related tetranortriterpenoids isolated from the seeds of the neem tree (Azadirachta indica), has attracted the greatest attention (Immaraju, 1998). In other hand, Barati and Hejazi (2015) showed that *T. urticae* exposure to the acetamiprid, had a higher *r* and λ-values to compare with untreated TSSM. Acetamiprid belonged to chemical sub-group of neonicotinoids that is competitive modulators for the nicotinic acetylcholine receptor (nAChR) available at (IRAC, available at www.irac-online.org/documents/moa-classification 2018). Another study, Mohammadi et al. (2016) showed that the use of Biomite, caused a significant increase for *r* parameter and age-stage survival rates at *T. turkestani* treated to compare by control. This difference may be related to the type of mite study or host plant. A life-table study with LC_{10} and LC_{20} concentrations of Biomite found that this treatment caused a significant reduction in R_0 parameters. Sáenz-de-Cabezón et al. (2006) reported that the R_0 parameter for *T. urticae* which exposure to triflumuron, was lower than un-treated control.

Gross reproduction rate (*GRR*) of two-spotted spider mite exposed Biomite, were significantly different among treatments. *GRR* values of *T. urticae* treated (LC_{10} and LC_{20}) were significant decreased to compare by control which are in line with results obtained by Wang et al. (2014) and Marcic (2007) who found that bifentrin (LC_{10} and LC_{20}) and spirodiclofen (6,12, 24, 48 and 96 µg/l) treatment, caused significant decrease *GRR* of *T. urticae*, compared to the untreated control.

Regarding the curves of survival and age-specific fecundity, an increase in the concentration of this acaricide, has a downward trend in l_x and m_x values, at high concentrations, compared to the control group. Based on the obtained results, it can be seen that according to the curve of the age-stage specific survival rate (s_{xj}), there is an overlap between the various stages of *T. urticae* individuals. Our findings are in accordance to Havasi et al. (2018) that showed the TSSM treated by diflovidazin, had an overlap among different stages. According to our study, exposure of sub-lethal concentrations of Biomite intense affects various life table adjectives of *T. urticae*, i.e. survival, fecundity, *GRR*, mean generation time (T), and net reproductive rate (R_0), whereas effect of Biomite is not significant on increase rate of increase (r) and finite rate of increase (λ) at sub-lethal concentration. Research on sub-lethal effects of an acaricide aims to find the negative non-lethal impacts of the acaricide on several life table parameters that possibly affect population dynamics (Stark & Banks, 2003). To better understand the effects of Biomite on *T. urticae*, more further behavioral and physiological studies are also needed in the future on their field suitability for spider mite management.

ACKNOWLEDGEMENTS

We greatly appreciate University of Tehran's support on this project.

REFERENCES

Abbott, W. S. (1925). A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology*, *18*(2), 265-267.

Akköprü, E.P., Atlıhan, R., Okut H., & Chi, H. (2015). Demographic assessment of plant cultivar resistance to insect pests: a case study of the dusky-veined walnut aphid (Hemiptera: Callaphididae) on five walnut cultivars. *Journal of Economic Entomology, 108* (2), 378-87. https://doi.org/10.1093/jee/tov011

Alinejad, M., Kheradmand, K., & Fathipour, Y. (2015). Sublethal effects of fenazaquin on biological performance of the two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae): application of age-stage, two-sex life tables. *Acarina*, *23* (2),172-80. https://elib.utmn.ru/jspui/handle/ru-tsu/12845

Alinejad, M., Kheradmand, K., & Fathipour, Y. (2014). Sublethal effects of fenazaquin on life table parameters of the predatory mite *Amblyseius swirskii* (Acari: Phytoseiidae). *Experimental and Applied Acarology, 64* (3), 361-73. https://doi.org/10.1007/s10493-014-9830-y

Alinejad, M., Kheradmand, K., & Fathipour, Y. (2016). Assessment of sublethal effects of spirodiclofen on biological performance of the predatory mite, *Amblyseius swirskii*. *Systematic and Applied Acarology, 21* (3), 375-84. https://doi.org/10.11158/saa.21.3.12.

Atlihan, R., Kasap, İ., Özgökçe, M. S., Polat-Akköprü, E., & Chi, H. (2017). Population growth of Dysaphis pyri (Hemiptera: Aphididae) on different pear cultivars with discussion on curve fitting in life table studies. *Journal of Economic Entomology*, *110*(4), 1890-1898. https://doi.org/10.1093/jee/tox174

Barati, R., & Hejazi, M.J. (2015). Reproductive parameters of *Tetranychus urticae* (Acari: Tetranychidae) affected by neonicotinoid insecticides. *Experimental and Applied Acarology, 66*(4), 481-9. https://doi.org/10.1007/s10493-015-9910-7.

Casida, J. E. (2012). The greening of pesticide–environment interactions: some personal observations. *Environmental health perspectives*, *120*(4), 487-493. https://doi.org/10.1289/ehp.1104405

Chi, H., & Liu, H. (1985). Two new methods for the study of insect population ecology. *Bulletin Institute of Zoology and Academia Sinica, 24*(2), 225-240.

Chi, H. (1988). Life-table analysis incorporating both sexes and variable development rates among individuals. *Environmental Entomology, 17*(1), 26-34. https://doi.org/10.1093/ee/17.1.26

Chi, H. (2019). Twosex-Mschart: a computer program for the age-stage, two-sex life table analysis. National Chung Hsing University, Taichung, Taiwan. Available from http://140.120.197.173/ecology/prod02.htm.

Cloyd, R.A., Galle, C.L., & Keith, S.R. (2006). Compatibility of three miticides with the predatory mites *Neoseiulus californicus* McGregor and *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae). *HortScience*, *41*(3), 707-10. https://doi.org/10.21273/HORTSCI.41.3.707

Crouse, G.D. (2007). DE-175 (Spinetoram), a new semi-synthetic spinosyn in development. Modern *crop protection compounds, 3,* 1013-1031. https://ci.nii.ac.jp/naid/10030707829/en/.

DeAmicis, C., Edwards, N.A., Giles, M.B., Harris, G.H., Hewitson, P., Janaway, L., & Ignatova, S. (2011). Comparison of preparative reversed phase liquid chromatography and countercurrent chromatography for the kilogram scale purification of crude spinetoram insecticide. *Journal of Chromatography A*, *1218*(36), 6122-7. https://doi.org/10.1016/j.chroma.2011.06.073.

Dekeyser, M. A. (2005). Acaricide mode of action. *Pest Management Science: Formerly Pesticide Science*, *61*(2), 103-110. https://doi.org/10.1002/ps.994

Desneux, N., Decourtye, A., & Delpuech, J.M. (2007). The sublethal effects of pesticides on beneficial arthropods. *Annual Review of Entomology, 52,* 81-106. https://doi.org/10.1146/annurev.ento.52.110405.091440

Dittrich, V., Streibert, P., & Bathe, P.A. (1974). An old case reopened: mite stimulation by insecticide residues. *Environment Entomology*, *3*(3), 534-40.

Duchovskienė, L, & Survilienė E. (2009). Effect of Abamectin on two-spotted spider mite and leaf miner flies in greenhouse cucumbers. Sodininkystė ir daržininkystė. 28: 47-56.

Efron, B. & Tibshirani, R.J. (1993). Permutation tests. In An introduction to the bootstrap (202-219). Springer US.

EPPO (European and Mediterranean Plant Protection Organization) (2014). New EU plant protection products legislation. https://www.eppo.int/PPPRODUCTS/information/new_eu_regulations.htm

Fathipour, Y., & Maleknia B. (2016). Mite predators. In Ecofriendly pest management for food security (329-366). Academic Press. https://doi.org/10.1016/B978-0-12-803265-7.00011-7.

Finney, D. J. (1971). Probit analysis 3rd ed Cambridge Univ. *Press. London, UK. pp*.

Garriga, M., & Caballero, J. (2011). Insights into the structure of urea-like compounds as inhibitors of the juvenile hormone epoxide hydrolase (JHEH) of the tobacco hornworm *Manduca sexta*: Analysis of the binding modes and structure–activity relationships of the inhibitors by docking and CoMFA calculations. *Chemosphere, 82*(11), 1604-1613. https://doi.org/10.1016/j.chemosphere.2010.11.048

Goulson, D. (2013). An overview of the environmental risks posed by neonicotinoid insecticides. *Journal of Applied Ecology, 50*(4), 977-987. https://doi.org/10.1111/1365-2664.12111

Grbić, M., Van Leeuwen, T., Clark, R.M., Rombauts, S., Rouzé, P., Grbić, V., Osborne, E.J., Dermauw, W., Ngoc, P.C.T., Ortego, F., & Hernández-Crespo, P. (2011). The genome of *Tetranychus urticae* reveals herbivorous pest adaptations. *Nature, 479*(7374), 487-492. https://doi.org/10.1038/nature10640

Havasi, M., Kheradmand, K., Mosallanejad, H., & Fathipour Y. (2018). Sublethal effects of diflovidazin on life table parameters of two-spotted spider mite *Tetranychus urticae* (Acari: Tetranychidae). *International Journal of Acarology, 44*(2-3),115-20. https://doi.org/10.1080/01647954.2017.1417328

Havasi, M., Kheradmand, K., Mosallanejad, H., & Fathipour Y. (2019a). Sublethal effects of diflovidazin on demographic parameters of the predatory mite, *Neoseiulus californicus* (Acari: Phytoseiidae). *International Journal of Acarology, 45,* 238-244. https://doi.org/10.1080/01647954.2019.1607550

Havasi, M., Kheradmand, K., Mosallanejad, H., & Fathipour Y. (2020a). Influence of low-lethal concentrations of thiamethoxam on biological characteristics of *Neoseiulus californicus* (Acari: Phytoseiidae). *Journal of Crop Protection, 9*(1), 41-55. http://jcp.modares.ac.ir/article-3-32441-en.html

Havasi, M., Kheradmand, K., Mosallanejad, H., & Fathipour Y. (2020b). Life history traits and demographic parameters of *Neoseiulus californicus* McGregor (Acari: Phytoseiidae) treated with the Biomite®. *Systematic and Applied Acarology, 25*(1), 125-138. https://doi.org/10.11158/saa.25.1.10

Havasi, M., Kheradmand, K., Parsa M., & Riahi, E. (2019b). Acaricidal activity of *Punica granatum* L. peels extract against *Tetranychus urticae* Koch (Acari: Tetranychidae). *Archive of Phytopathology and Plant Protection,* 1-14. https://doi.org/10.1080/03235408.2019.1700590

Havasi, M., Sangak Sani Bozhgani, N., Golmohmmadi, G., & Kheradmand, K. (2021). Impact of hexythiazox on life table parameters of the *Amblyseius swirskii* (Acari: Phytoseiidae) and its prey *Tetranychus urticae*. *Journal of Crop Protection, 10,* 295-308. http://jcp.modares.ac.ir/article-3-44924-en.html

Hedayati, M., Sadeghi, A., Maroufpoor, M., Ghobari, H., & Güncan A. (2019). Transgenerational sublethal effects of abamectin and pyridaben on demographic traits of *Phytonemus pallidus* (Banks)(Acari: Tarsonemidae). *Ecotoxicology, 28*(4), 467-477. https://doi.org/10.1007/s10646-019-02040-2

Helle, W., & Overmeer, W.P.J. (1985). Toxicological test methods. In: W. Helle and Sabelis MW.(eds), Spider Mites. Their Biology, Natural Enemies and Control. Vol. 1A. Elsevier, Amsterdam, Oxford, New York, Tokio, 391–395.

Huang, Y.B., & Chi, H. (2013). Life tables of *Bactrocera cucurbitae* (Diptera: Tephritidae): with an invalidation of the jackknife technique. *Journal of Applied Entomology, 137*(5),327-339. https://doi.org/10.1111/jen.12002

IBM SPSS. (2010). IBM SPSS Statistics for Windows, Version 19.

Ibrahim, Y.B., & Yee, T.S. (2000). Influence of sublethal exposure to abamectin on the biological performance of *Neoseiulus longispinosus* (Acari: Phytoseiidae). *Journal of Economic Entomology, 93*(4),1085-9.

Immaraju, J. A. (1998). The commercial use of azadirachtin and its integration into viable pest control programmes. Pesticide Science, 54(3), 285-289.

James, D.G., & Price, T.S. (2002). Fecundity in two spotted spider mite (Acari: Tetranychidae) is increased by direct and systemic exposure to imidacloprid. Jour*nal of Economic Entomology, 95*(4), 729-732.

Khanamani, M., Fathipour, Y., & Hajiqanbar, H. (2013). Population growth response of *Tetranychus urticae* to eggplant quality: application of female age-specific and age-stage, two-sex life tables. *International Journal of Acarology, 39*(8), 638-648. https://doi.org/10.1080/01647954.2013.861867

Kim, S.S., & Yoo, S.S. (2002). Comparative toxicity of some acaricides to the predatory mite, *Phytoseiulus persimilis* and the two spotted spider mite, *Tetranychus urticae*. *BioControl, 47*(5),563-573. https://doi.org/10.1023/A:1016585607728.

Li, D., Tian, J., & Shen, Z. (2006). Assessment of sublethal effects of clofentezine on life-table parameters in hawthorn spider mite (*Tetranychus viennensis*). *Experimental and Applied Acarology, 38*(4), 255-73. https://doi.org/10.1007/s10493-006-0016-0

Li, YY., Fan, X., Zhang, G.H., Liu, Y.Q., Chen, H.Q., Liu, H., & Wang, J.J. (2017). Sublethal effects of bifenazate on life history and population parameters of *Tetranychus urticae* (Acari: Tetranychidae). *Systematic and Applied Acarology, 22*(1),148-58. https://doi.org/10.11158/saa.22.1.15

Liu, YH., Jia D., Yuan, X.F., Wang, Y.X., Chi, H., Ridsdill-Smith, T.J., & Ma, R.Y. (2018). Response to short-term cold storage for eggs of *Agasicles hygrophila* (Coleoptera: Chrysomelidae), a biological control agent of alligator weed *Alternanthera philoxeroides* (Caryophyllales: Amaranthaceae). *Journal of Economic Entomology, 111*(4), 1569-76.

Luo, Y., Ni, J., Zheng, K., Yang, Z., Xie, D., Da, A., Chai, J., Jiang, X., & Li, S. (2018).Cloning and different expression of ATP synthase genes between propargite resistant and susceptible strains of *Tetranychus cinnabarinus* (Acarina: Tetranychidae). *Journal Asia-Pacific Entomology, 21*(1), 402-7. https://doi.org/10.1016/j.aspen.2018.01.023

Maleknia, B., Fathipour, Y., & Soufbaf, M. (2016). How greenhouse cucumber cultivars affect population growth and two-sex life table parameters of *Tetranychus urticae* (Acari: Tetranychidae). *International Journal of Acarology, 42*(2), 70-80. https://doi.org/10.1080/01647954.2015.1118157

Marčić, D. (2007). Sublethal effects of spirodiclofen on life history and life-table parameters of two-spotted spider mite (*Tetranychus urticae*). *Experimental and Applied Acarology, 42*(2),121-129. https://doi.org/10.1007/s10493-007-9082-1.

Marcic, D. (2012). Acaricides in modern management of plant-feeding mites. *Journal of Pest Science*, *85*(4), 395-408. https://doi.org/10.1007/s10340-012-0442-1

Marčić, D., & Međo I. (2014). Acaricidal activity and sublethal effects of an oxymatrine-based biopesticide on two-spotted spider mite (Acari: Tetranychidae). *Experimental and Applied Acarology, 64*(3), 375-391. https://doi.org/10.1007/s10493-014-9831-x

Marčić, D., Ogurlic, I., Mutavdzic, S., & Peric, P. (2010). The effects of spiromesifen on life history traits and population growth of two-spotted spider mite (Acari: Tetranychidae). *Experimental and Applied Acarology, 50*(3), 255-267. https://doi.org/10.1007/s10493-009-9316-5

Martínez-Villar, E., Sáenz-De-Cabezón, FJ., Moreno-Grijalba, F., Marco, V., & Pérez-Moreno, I. (2005). Effects of azadirachtin on the two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae). *Experimental and Applied Acarology*, *35*(3),215. https://doi.org/10.1007/s10493-004-5082-6

Mohammadi, S., Ziaee, M., & Seraj, A.A. (2016). Sublethal effects of Biomite® on the population growth and life table parameters of *Tetranychus turkestani* Ugarov and Nikolskii on three cucumber cultivars. *Systematic and Applied Acarology, 21*(2), 218-226. https://doi.org/10.11158/saa.21.2.6

Mollaloo, M.G., Kheradmand, K., Sadeghi, R., & Talebi, A.A. (2017). Demographic analysis of sublethal effects of spiromesifen on *Neoseiulus californicus* (Acari: Phytoseiidae). *Acarologia, 57*(3), 571-580. 10.24349/acarologia/20174173

Nikpay, A., Soleyman-Nejadian, E., Goldasteh, S., & Farazmand, H. (2016). Efficacy of Biomite (R) and GC-Mite (R) on *Oligonychus Sacchari* and its predator *Stethorus gilvifrons* on sugarcane: Preliminary results. *International Sugar Journal, 18*, 454-8.

Orr, N., Shaffner, A.J., Richey, K., & Crouse, G.D. (2009). Novel mode of action of spinosad: Receptor binding studies demonstrating lack of interaction with known insecticidal target sites. *Pesticide Biochemistry and Physiology, 95*(1),1-5. https://doi.org/10.1016/j.pestbp.2009.04.009

Park, K.H., Choi, J.H., Abd El-Aty, A.M., Cho, S.K., Park, J.H., Kim, B.M., Yang, A., Na, TW., Rahman, M.M., Im, G.J., & Shim, JH. (2012). Determination of spinetoram and its metabolites in amaranth and parsley using QuEChERS-based extraction and liquid chromatography–tandem mass spectrometry. *Food chemistry*, *134*(4), 2552-9. https://doi.org/10.1016/j.foodchem.2012.04.066

Reilly, S.K., Hollis, L., Jones, R.S., & Wilkins, R. (2009). US Environmental Protection Agency Office of Pesticide Programs Biopesticides registration action document, suggested format for acute toxicity studies, Citronellol (PC Code 167004) (Vol. 1, pp. 22). US Environmental Protection Agency.

Riahi, E., Fathipour, Y., Talebi, A.A., & Mehrabadi, M. (2017). Linking life table and consumption rate of *Amblyseius swirskii* (Acari: Phytoseiidae) in presence and absence of different pollens. *Annual of the Entomology Society of America, 110*(2), 244-253.

Saber, M., Ahmadi, Z., & Mahdavinia, G. (2018). Sublethal effects of spirodiclofen, abamectin and pyridaben on life-history traits and life-table parameters of two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae). *Experimental and Applied Acarology, 75*(1),55-67. https://doi.org/10.1007/s10493-018-0226-2

Saenz-de-Cabezon Irigaray, FJ., Zalom, F.G., & Thompson, P.B. (2007). Residual toxicity of acaricides to Galendromus occidentalis and *Phytoseiulus persimilis* reproductive potential. Biolo. Control: theory and application in pest management.

Sáenz-de-Cabezón, FJ., Martínez-Villar, E., Moreno, F., Marco, V., & Pérez-Moreno, I. (2006). Influence of sublethal exposure to triflumuron on the biological performance of *Tetranychus urticae* Koch (Acari: Tetranychidae). *Spanish Journal of Agriculture Review, 4*(2),167-72.

Sanatgar, E., Shoushtari, R.V., Zamani, A.A., & Nejadian, E.S. (2011). Effect of frequent application of hexythiazox on predatory mite *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae). *Academic Journal of Entomology, 4*(3), 94-101.

Sedaratian, A., Fathipour, Y., & Moharramipour, S. (2011). Comparative life table analysis of *Tetranychus urticae* (Acari: Tetranychidae) on 14 soybean genotypes. *Insect Science, 18*(5),541-53. https://doi.org/10.1111/j.1744-7917.2010.01379.x

Stark, J.D., & Banks, JE. (2003). Population-level effects of pesticides and other toxicants on arthropods. *Annual review of entomology, 48*, 505-19. https://doi.org/10.1146/annurev.ento.48.091801.112621

Stavrinides, M.C., & Mills, N.J. (2009). Demographic effects of pesticides on biological control of Pacific spider mite (*Tetranychus pacificus*) by the western predatory mite (*Galendromus occidentalis*). *Biological Control, 48*(3), 267-73. https://doi.org/10.1016/j.biocontrol.2008.10.017

Szczepaniec, A., Creary, S.F., Laskowski, K.L., Nyrop, J.P., & Raupp, M.J. (2011). Neonicotinoid insecticide imidacloprid causes outbreaks of spider mites on elm trees in urban landscapes. *PloS one, 6*(5), e20018. https://doi.org/10.1371/journal.pone.0020018

Van Leeuwen, T., Tirry, L., Yamamoto, A., Nauen, R., & Dermauw, W. (2015). The economic importance of acaricides in the control of phytophagous mites and an update on recent acaricide mode of action research. *Pesticide biochemistry and physiology, 121,* 12-21. https://doi.org/10.1016/j.pestbp.2014.12.009

Van Leeuwen, T., Vontas, J., Tsagkarakou, A., Dermauw, W., & Tirry, L. (2010). Acaricide resistance mechanisms in the two-spotted spider mite *Tetranychus urticae* and other important Acari: a review. *Insect biochemistry and molecular Biology, 40*(8), 563-572. https://doi.org/10.1016/j.ibmb.2010.05.008

Van Pottelberge, S., Van Leeuwen, T., Nauen, R., & Tirry, L. (2009). Resistance mechanisms to mitochondrial electron transport inhibitors in a field-collected strain of *Tetranychus urticae* Koch (Acari:

Tetranychidae). *Bulletin of Entomological Research, 99*(1), 23. https://doi.org/10.1017/S0007485308006081

Villanueva, R.T., & Walgenbach, J.F. (2006). Acaricidal properties of spinosad against *Tetranychus urticae* and *Panonychus ulmi* (Acari: Tetranychidae). *Journal of Economic Entomology, 99*(3), 843-9.

Wang L., Zhang, Y., Xie, W., Wu, Q., & Wang, S. (2016). Sublethal effects of spinetoram on the two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae). *Pesticide Biochemistry and Physiology, 132*,102-7. https://doi.org/10.1016/j.pestbp.2016.02.002

Wang S., Tang, X., Wang, L., Zhang, Y., Wu, Q., & Xie, W. (2014). Effects of sublethal concentrations of bifenthrin on the two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae). *Systematic and Applied Acarology, 19*(4), 481-90. https://doi.org/10.11158/saa.19.4.11.

Wang, D., Gong, P., Li, M., Qiu, X., & Wang, K. (2009). Sublethal effects of spinosad on survival, growth and reproduction of Helicoverpa armigera (Lepidoptera: Noctuidae). *Pest Management Science: Formerly Pesticide Science, 65*(2), 223-227. https://doi.org/10.1002/ps.1672

Yorulmaz, S., & Ay, R. (2009). Multiple resistance, detoxifying enzyme activity, and inheritance of abamectin resistance in *Tetranychus urticae* Koch (Acarina: Tetranychidae). *Turkish Journal of Agriculture and Forestry, 33*(4), 393-402. doi:10.3906/tar-0809-15

Yu, J.Z, Chen, B.H., Güncan, A., Atlıhan, R., Gökçe, A., Smith, C.L., Gümüş, E., & Chi, H. (2018). Demography and mass-rearing *Harmonia dimidiata* (Coleoptera: Coccinellidae) using *Aphis gossypii* (Hemiptera: Aphididae) and eggs of *Bactrocera dorsalis* (Diptera: Tephritidae). *Journal of Economic Entomology, 111*(2), 595-602.

Ziaee, M., Nikpay, A., Koohzad-Mohammadi, P., & Behnam-Oskuyee, S. (2017). The toxicity of Biomite®, GC-mite®, Oberon® and Envidor® acaricides against sugarcane yellow mite, Oligonychus sacchari (Acari: Tetranychidae). *Persian Journal of Acarology*, *6*(2). http://dx.doi.org/10.22073/pja.v6i2.28024

Zhang, P., Zhao, YH., Wang, Q.H., Mu, W., & Liu, F. (2017). Lethal and sublethal effects of the chitin synthesis inhibitor chlorfluazuron on *Bradysia odoriphaga* Yang and Zhang (Diptera: Sciaridae). Pesticide *Biochemistry and Physiology, 136*, 80-88. https://doi.org/10.1016/j.pestbp.2016.07.007

Zhen, C., Miao, L., & Gao, X. (2018). Sublethal effects of sulfoxaflor on biological characteristics and vitellogenin gene (AlVg) expression in the mirid bug, *Apolygus lucorum* (Meyer-Dür). *Pesticide Biochemistry and Physiology*, *144*, 57-63. https://doi.org/10.1016/j.pestbp.2017.11.008

گیاه‌پزشکی (مجله علمی کشاورزی)
جلد ۴۵، شماره۲، تابستان ۱۴۰۱

doi 10.22055/ppr.2022.17436

اثر غلظت‌های زیر کشنده بایومایت® بر فراسنجه‌های چرخه زندگی کنه تارتن دو لکه‌ای *Tetranychus urticae* (Acari:Tetranychidae)

محمدرضا هواسی[۱]، کتایون خردمند*[۲]، هادی مصلی‌نژاد[۳] و یعقوب فتحی‌پور[۴]

۱- دانش‌آموخته کارشناسی ارشد، گروه حشره‌شناسی و بیماری‌های گیاهی، پردیس ابوریحان، دانشگاه تهران، تهران، ایران

۲- ***نویسنده مسوول**: دانشیار، گروه حشره شناسی و بیماری‌های گیاهی، پردیس ابوریحان، دانشگاه تهران، تهران، ایران (kkheradmand@ut.ac.ir)

۳- استادیار، موسسه تحقیقات گیاه‌پزشکی کشور، بخش تحقیقات آفت‌کش‌ها، تهران، ایران

۴- استاد، گروه حشره‌شناسی، دانشکده کشاورزی، دانشگاه تربیت مدرس، تهران، ایران

تاریخ دریافت: ۱۴۰۰/۰۹/۰۱ تاریخ پذیرش: ۱۴۰۰/۱۲/۱۸

چکیده

کنه تارتن دولکه‌ای، *Tetranychus urticae* Koch (Acari: Tetranychidae)، یکی از آفات کلیدی است که می تواند به طیف وسیعی از محصولات در مزارع و گلخانه‌ها آسیب وارد سازد. استفاده از سموم شیمیایی از جمله روش‌های اصلی مدیریت این آفت به شمار می‌آید. آزمون‌های زیست‌سنجی آزمایشگاهی، برای ارزیابی اثرات غلظت‌های زیر کشنده (LC_5، LC_{10} و LC_{20}) بایومایت® (یک فرمولاسیون مبتنی بر سیترونلول) روی ویژگی‌های زیستی و پارامترهای جمعیتی *T. urticae* در شرایط آزمایشگاهی (دمای ۲±۲۵ درجه سلسیوس، رطوبت نسبی ۵±۶۰ درصد، و ۱۶:۸ L:D) انجام شدند. داده‌های به دست آمده، بر اساس روش تجزیه جدول زندگی دوجنسی سن- مرحله زیستی مورد تجزیه و تحلیل قرار گرفتند. طبق نتایج، در اثر تیمار کنه‌های کامل با LC_5، LC_{10} و LC_{20} بایومایت، دوره تخم‌گذاری و طول عمر کل در مقایسه با شاهد به طور قابل توجهی کاهش یافت. بیشترین و کمترین مقدار زادآوری (۶۱/۱ و ۴۱/۵۶ تخم /ماده) و طول عمر (۱۳/۰۱ و ۹/۹۷ روز) به ترتیب در تیمار شاهد و LC_{20} به دست آمد. در افراد تیمار شده با غلظت‌های LC_{10} (R_0 = ۳۸/۱) وLC_{20} (R_0 = ۳۲/۹۲) نرخ خالص تولیدمثل در مقایسه با افراد تیمار شده با غلظت‌های LC_5 (R_0 =۴۷/۰۱) و شاهد (R_0 =۴۸/۸۸ افراد/ماده/نسل) به طور معنی‌داری کمتر بود. نرخ ذاتی (r) و نرخ متناهی افزایش جمعیت (λ) در تیمارهای مختلف نسبت به شاهد کاهش معنی‌داری را نشان نداد. متوسط مدت زمان یک نسل (T) در غلظت LC_{20} (۱۵/۵۸ روز)، در مقایسه باLC_5 (۱۶/۶۶ روز) به طور قابل توجهی کاهش یافت. با توجه به نتایج به‌دست‌آمده از پژوهش حاضر و نیز اثرات قابل توجه بایومایت روی برخی پارامترهای زیستی این کنه تارتن دولکه‌ای این کنه‌کش را می‌توان در برنامه‌های مدیریت تلفیقی این آفت مهم پیشنهاد کرد.

کلیدواژه‌ها:* *بایومایت®، جدول زندگی، غلظت‌های زیرکشنده، Tetranychus urticae

دبیر تخصصی: دکتر آرش راسخ

Citation: Havasi, M., Kheradmand, K., Mosallanejad, H., & Fathipour, Y. (2022). Effects of sub-lethal concentrations of Biomite® on life-history traits of Tetranychus urticae (Acari: Tetranychidae). Plant Protection (Scientific Journal of Agriculture), *45*(2), 33-48. https://doi.org/ 10.22055/ppr.2022.17436.