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Release Rates of Typhlodromus athiasae Porath and Swirski (Acari: Phytoseiidae) to Control the Two-Spotted Spider Mite Tetranychus urticae Koch (Acari: Tetranychidae) on Apple Seedlings under Greenhouse Conditions, معدلات إطلاق المفترس Typhlodromus athiasae Porath and Swirski (Acari: Phytoseiidae) للسيطرة على الأكاروس الأحمر ذو البقعتين Tetranychus urticae Koch (Acari: Tetranychidae) على غراس تفاح ضمن شروط البيوت البلاستيكية

Ibrahem Sakr
Department of plant protection, Faculty of Agriculture, Tichreen University, Latakia, Syria

Majeda Mofleh
General Commission for Scientific Agricultural Researchers (G.C.S.A.R), Syria

Abd-ulnabi Basheer
Department of plant protection, Faculty of Agriculture, Damascus University, Syria

Hamza Dahiah
The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD).

معدلات إطلاق المفترس
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Dr. Ibrahem Sakr (1) **Dr. Majeda Mofleh** (2) **Dr. Abd-ulnabi Basheer** (3-4) **Eng. Hamza Dahiah** (4)

(1) Department of plant protection, Faculty of Agriculture, Tichreen University, Latakia, Syria
(2) General Commission for Scientific Agricultural Researchers (G.C.S.A.R), Syria.
(3) Department of plant protection, Faculty of Agriculture, Damascus University, Syria.
(4) The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD).

basherofecky11@gmail.com

الملخّص

نُفذ العمل في مركز بحوث ودراسات المكافحة الحيوية في كلية الزراعة في جامعة دمشق (سورية)، خلال الفترة الواقعة بين بداية شهر يوليو لعام 2013 و منتصف عام 2014. هدفت هذه الدراسة لاختبار فعالية المفترس *Typhlodromus athiasae* Porath and Swirski (Acari: Phytoseiidae) كعامل من عوامل المكافحة الحيوية في السيطرة على الأكاروس الأحمر ذو البقعتين *Tetranychus urticae* Koch. على غراس تفاح وبمعدلات إطلاق مفترس: فريسة (1:10، 1:20، 1:40 وشاهد دون مفترس). لوحظ إنقاص واضح في مجتمعات *T. urticae* عند نسبة إطلاق (1:10) من الأسبوع الأول بعد إطلاق المفترس *T. athiasae* مع أعلى كثافة للمفترس حدثت في الأسبوع السادس من الإطلاق، و بقيت مجتمعات الفريسة على مستويات منخفضة بعد ذلك، وسجل أعلى متوسط لأعداد الفريسة في الأسبوع الخامس على نسب إطلاق 1:10 و 1:40، و في الأسبوع الرابع على نسب إطلاق 1:20.

بينت الدراسة فعالية المفترس في السيطرة على مجتمعات الفريسة عند إطلاقه على نسبة 1:10 في حين كان المفترس غير قادر على السيطرة على مجتمعات الفريسة عند إنقاص النسبة إلى 1:40.

الكلمات المفتاحية : مكافحة حيوية، المفترس *Typhlodromus athiasae* ، الأكاروس العنكبوتي ذو البقعتين، نسب إطلاق مفترس: فريسة، غراس تفاح.

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Abstract

A study was conducted at the Biological control studies and Research Centre -BCSRS (Damascus University / Syria) during 2013 - 2014. The effectiveness of the predatory mite *Typhlodromus athiasae* Porath and Swirski (Acari: Phytoseiidae) as a suppressive agent of the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), was evaluated on apple seedlings at release rates 1:10, 1:20 1:40 predator:prey and no predaceous mites serving as control under greenhouse conditions. The ratio of 1:10 predator:prey reduced *T. urticae* populations significantly after one week of release with the highest density of *T. athiasae* occurring in 6th week, and kept them at low levels thereafter. The highest mean numbers of *T. urticae* were found in the 5th week at ratios 1:10, 1:40 predator:prey and in the 4th week at 1:20 predator:prey. This study demonstrates the potential of *T. athiasae* to effectively control *T. urticae* on apple seedlings under greenhouse conditions at predator:prey ratio of 1:10. However, *T. athiasae* was unable to control the *T. urticae* populations when the predator:prey ratio reduced to 1:40.

Key words: Biological control, *Typhlodromus athiasae* , Two-spotted spider mite, Release ratios predator: prey, Apple seedling.

Introduction

The two-spotted spider mite *Tetranychus urticae* Koch is one of the serious mite pests infesting apple trees. All stages of this mite, except eggs, are plant eating pests. It reduces the quantity and the quality of the production (Dhooria, 1994; Paternotte, 1998). The importance of this mite pest is not only due to the direct damage of plants including defoliation, leaf burning and even in excessive outbreaks plant death but also to indirect damage of plants due to the decrease of photosynthesis and transpiration (Brandenburg and Kennedy, 1987). The *T. urticae* was widespread, where found in apple orchards such as in two areas of New York State and Syria (Swieda Governorate; Homs Governorate), (Weires et al., 1979; Al-abdullah, 2001 and Dahiah *et al*., 2011). Predation is an important component of ecological aspects because through predators the flow of energy continues throughout a community. It also regulates the populations on which they feed and maintain the fitness of these prey populations (Price, 1997). Recently predators including Phytoseiid mites were considered as effective agents for the biological control of spider mites (Mori and Saito, 1979). Generally, phytoseids are larger than *T. urticae*, pear shaped, and have longer legs. They range in color from pale to reddish depending on species. Phytoseiid eggs are larger than *T. urticae* eggs and elliptical in shape (Henn *et al*., 1995). *Typhlodromus athiasae* Porath and Swirski (Acari : Phytoseiidae) is regarded as predator on many forest plants and fruit trees vine and apples and citrus in various countries (Moraes *et al*., 2004; Al-kshki *et al*., 2011; Dahiah *et al*., 2011 and Barbar, 2013).

Traditionally, growers have depended upon acaricides to protect seedlings and newly grafted plants from spider mite infestations in the nursery. But Tuovinen and Rokx (1991) found that the average density of several types of predatory mite were 12 mite/200 leaves in apple orchards sprayed with pesticides and acaricides, while were 200 mites/200 leaves in unsprayed apple orchards. Also Al-Abdullah (2001) showed that the density of the predator *Typhlodromus pyri* did not exceed 0.8 mite / 200 leaves in some apple orchards sprayed with insecticides, acaricides and fungicide in the Swieda Governorate, while this density increased to eight times when this orchards left without using the pesticides.

As a result, growers require new strategies to control infestations of spider mites on young apple trees. However, an appropriate predator: prey release ratio must be established for this strategy to be effective.

Phytoseiid mite release could be a noteworthy option for the following reasons: preferential feeding on tetranychid mites, short life cycles, high survivorship, better ability to thrive at low prey levels than most insect, and they are easily mass-reared.

Ryoo (1996) found that the efficiency with which predators find and consume pests (prey) is influenced by a number of environmental factors, including prey distribution. When prey are distributed unevenly, individual predators may search longer, and with a correspondingly lower rate of prey patch encounter, than when prey are more uniformly distributed.

The use of predaceous mites to control spider mite pests has been extensively studied in greenhouse crops in Europe. Predator: prey release ratios between 1:60 and 1:20 have been suggested to provide adequate control among greenhouse-grown vegetables and in seasonal cropping systems when phytoseiid predators are used as biological control for the elimination of local tetranychid populations (Janssen and Sabelis 1992). Successful control of tetranychids on greenhouse ornamentals has been achieved at ratios of between 1:20 and 1:4 (Hamlen and Lindquist, 1981). Also, Abad-Moyano *et al*., (2010) reported that Phytoseiulus persimilis was highly effective in reducing both *T. urticae* infestations and damage level on young clementine plants at both two different release rates (40 and 80 phytoseiids per plant) and all three periods considered. In addition, they reported that *N. californicus* performed worse under the same condition, Alatawi *et al*, (2011) noted that the release of the predator *P. persimilis* 1: 4 ratio to control populations *T. urticae*, that after 9 days of release there was a decrease in the populations of prey and after 18 days of release observed spider mite excluded completely.

Croft et al., (2004) noted that when release of the predator Neoseiulus fallacis on apple seedlings, the number of *T. urticae* was 0.90 ± 0.12 mite per leaf, while there was 26 ± 4 mite per leaf without release of a predator.

The *T. athiasae* is considered one of the effective predators for the control of the spider mite in apple fields in Homs (Dahiah *et al*., 2011) and therefore the aim of this study was to determinate the effectiveness of predator *T. athiasae* for control the populations of *T. urticae* by the estimation of predator:prey release ratios.

Material and Methods

This study was conducted in Biological control study and Research Centre -BCSRS- Damascus University (Syria) during 2013 /2014.

Seedlings of Golden cultivar (*Malus domestica* Borkh.) were used for all experiments. For each experiment, 20 potted seedlings were allowed to grow until they had attained (15- 20) leaves. Leaves in excess of 20 were pruned from the tree at the start of the experiment, and additional leaves were cut off each week to evaluate mite populations. The population of *T. urticae* were obtained from a colony maintained on lima beans at temperature 25±2 Cº, relative humidity 65±5% and 16L:8D, *T. athiasae* was collected from apple orchards distributed in two regions: Al-Moraneh and Al-Qusayr (Homs, Syria) in June 2013. Each apple seedling was infested with 25 adult young female two spotted spider mites (5–6 days old). *T. urticae* populations were allowed to increase for three weeks, and all stages of mites were counted on each leaf of each seedling. Seedlings were then assigned to treatment groups (n = 5) based on two spotted spider mite densities in order to ensure that each treatment group contained seedlings with a similar range of initial densities of prey. Next, adult female predaceous mites were placed on the leaves of seedlings at different predator:prey ratios for each experimental group (1:10, 1:20 and 1:40), with an additional group of the cultivar receiving no predaceous mites serving as controls at temperature 25±2 Cº, relative humidity 65±5% and 16L:8D In the greenhouse of the Center for Biological Control Research and Studies in Damascus University – Syria.

One leaf per seedling was examined by a stereomicroscope after one week of the initial release of *T. athiasae*, and the numbers of predator mites and spider mites (eggs and motile stages) per leaf were counted on weekly basis for eight weeks.

Statistical Analysis:

Results were analyzed statistically using the program SPSS 20 by one-way analysis of variance (ANOVA) to estimate significant differences at (0.05) in *T. urticae* density at predator:prey release ratios.

Results and Discussion

The mite population of *T. urticae* at different predator:prey release ratios among eight weeks are shown in (Table 1). The population of *T. urticae* remained higher on control treatment where no predator was released. The mite number reached the peaks 437.8±120.2 per leaf (4th week, Fig.1).

With the release of *T. athiasae*, The *T. urticae* population was the highest 106.2± 12.93 per leaf at release ratio 1:10 predator: prey, but it reached the highest 307.4±56.34 per leaf at release ratio 1:40 predator:prey after five weeks of mite infestation. Whereas it reduced to only 1.8 ± 0.83 and 4.8 ± 1.30 per leaf in 8th week at release ratios 1:10 and 1:40 predator: prey respectively (Table 1).

T. urticae populations increased gradually until 4th week and the population reached its highest level between 3rd week and 5th week. This case is more obvious in control group. After that tetranychid population decreased gradually (Table1). Mean numbers of *T. urticae* in the 1:10 predator:prey treatment was significantly lower in 4th week as compared with the control.(Table 1).

Table 1. Mean (±SE) numbers of *T. urticae* (all stages) at different predator:prey release ratios and the control (without predators) on apple seedlings.

Week	Treatment (Release ratio, predator:prey)				
	Numbers of *T. urticae* Mean (±SE)				
	10:1	20:1	40:1	Control	$LSD_{0.05}$
1	23.6±2.88^{bcB}	29.2±7.12^{cB}	41.6±2.88^{cA}	47.6±4.03^{eA}	9.55
2	56.6±9.31^{bC}	90.6±8.23^{bcB}	82.2±21.12^{bcB}	132.2±22.07^{ceA}	27.19
3	36.2±6.49^{bcB}	125.8±28.30^{abB}	201.8±36.82^{abA}	281.2±47.93^{bcA}	90.73
4	103.4±16.36^{aC}	259.8±37.96^{aB}	199.2±45.36^{bBC}	437.8±120.2^{aA}	121.9
5	106.2±12.93^{aB}	248.8±54.42^{aB}	307.4±56.34^{aA}	379.4±57.53^{abA}	100.35
6	57.4±11.86^{bB}	207.2±48.48^{aA}	222.6±32.56^{abA}	215.4±18.04^{cA}	86.96
7	17.4±7.26^{cB}	12.2±3.70^{cB}	19.4±5.81^{cB}	53.8±10.10^{eA}	14.99
8	1.8±0.83^{cC}	2±1.22^{cBC}	4.8±1.30^{cB}	8.8±1.92^{eA}	2.83
$LSD_{0.05}$	36.02	98.99	104.77	150.45	

-The treatment means in a row followed by the same capital letter for the same week are not statistically different.
-The week means within column followed by the same small letter for the same treatment are not statistically different.

On the untreated plants, mite population increased exponentially and caused damage to the plants. But on the predator treated plants, increase of mite population was checked and remained lower. The plants also remained fresh in comparison to untreated plants. Release ratio of 1:10 predator: prey checked the mite population earlier and kept it lower than the ratio 1:40 predator: prey

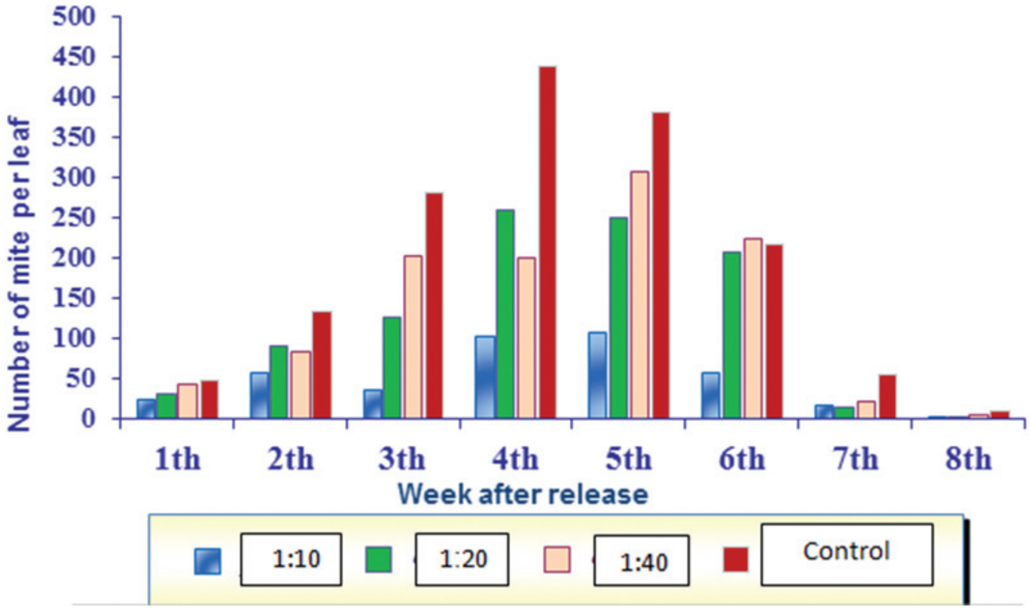

Figure 1. Effect of *T. athiasae* on number of *T. urticae* on apple seedling.

The mean numbers of predator, *T. athiasae* at different release ratios on apple seedlings are presented in (Table 2). Predator number increased gradually in all cases with little exception. The mean population density of *T. athiasae* was significantly higher at predator:prey ratio of 1:10 than at predator: prey ratios of 1:20 and 1:40 (Table 2).

Table 2. Mean (±SE) numbers of *T. athiasae* at different predator: prey release ratios on apple seedlings.

Week	Treatment (Release ratio, predator:prey)			
	Mean (±SE) numbers of *T. athiasae*			
	10:1	20:1	40:1	$LSD_{0.05}$
1	1.8 ± 0.83^{cA}	0.4 ± 0.54^{eB}	0.2 ± 0.44^{cB}	0.7
2	3.4 ± 1.14^{bcA}	1.2 ± 0.44^{ceB}	0.6 ± 0.54^{bB}	1.2
3	4.2 ± 1.09^{bcA}	0.8 ± 0.44^{ceB}	0.4 ± 0.54^{cB}	1.7
4	3.8 ± 0.83^{bcA}	1.4 ± 0.54^{ceB}	0.6 ± 0.54^{bB}	1.4
5	5.2 ± 1.30^{bcA}	1.8 ± 0.83^{bcB}	3.8 ± 0.83^{aA}	1.4
6	13.8 ± 1.48^{aA}	2.6 ± 0.89^{aB}	4 ± 0.70^{aB}	5
7	5.8 ± 0.83^{bA}	3.6 ± 0.89^{aB}	1.4 ± 0.54^{bC}	1.8
8	6.4 ± 1.14^{bA}	2.6 ± 0.89^{abB}	1.6 ± 0.89^{bB}	2.1
$LSD_{0.05}$	3.4	1	1.42	

-The treatment means in a row followed by the same capital letter for the same week are not statistically different.

The mean numbers of *T. athiasae* at different predator:prey release ratios are presented in (Table 3). *T. athiasae* population was the highest 5.55± 3.63 per leaf at release ratio 1:10 predator:prey, Whereas it reduced to only1.8 ± 1.06 and 1.57 ± 1.51 per leaf at release ratios 1:20 and 1:40 predator:prey respectively (Table 3).

Table 3. Mean (±SE) numbers of *T. athiasae* at different predator:prey release ratios.

Treatment (predator:prey release ratio)	Mean (±SE) numbers of *T. athiasae*
1:10	5.55±3.63[a]
1:20	1.8±1.06[b]
1:40	1.57±1.51[b]
$LSD_{0.05}$	**2.2**

-Mean numbers of T. athiasae followed by the same letter not statistically different.

Discussion

The results of this study indicated that *T. athiasae* is capable of suppressing a population of *T. urticae*. A ratio of 1:10 resulted in significant reductions in *T. urticae* numbers, The predator:prey release ratio of 1:10 *T. athiasae* was able to reduce *T. urticae* populations significantly after one week of release and maintain their low levels, thereafter *T. athiasae* persisted for at least two weeks after the elimination of prey, with the highest density of *T. athiasae* occurring in 6th week.

These results are in line with those of several previous studies. For example, Hamlen and Lindquist (1981) and Opit *et al*., (2004) found that *T. urticae* on greenhouse ornamental could be successfully controlled with *P.persimilis* :*T.urticae* at predator:prey ratios of 1:4 and 1:20. In both studies, *T. urticae* populations were successfully reduced after one week of predator release and remained at low levels thereafter, Loomis *et al*., (2003) determined the economic threshold for *T. urticae* on strawberries, and found that it should be up control when a numbers of *T. urticae* reached to 10 mite/ leaf from strawberries.

Kassap (2011) reported that the predatory mite *T.athiasae* is able to regulate Panonychus citri populations at predator:prey ratios of 1:10, but not at a lower predator:prey ratio of 1:40, Chahine *et al*., (1992) noted that release the Predator *P. Persimilis* and for one-time with rate 1: 12 achieved effective control of the *T. urticae* after 22 days of releasing, and in a similar study in Egypt Fawzy (2006) found that release *P. persimilis* by 1: 5 and 1 : 10 gave the same results as has control of *T. urticae* after four weeks.

Grafton-Cardwell *et al*, (1997) reported that *Phytoseiulus longipes* Evans, *Galendromus occidentalis* (Nesbitt), *Neoseiulus californicus* (McGregor) and *Euseius stipulatus* reduced spider mite infestations on citrus seedlings averaging ten *T. urticae* per leaf by at least 85% one week after predator release. The same study found that with average infestations of 22 *P. citri* per leaf, 74–80 percent control of *P. citri* by *N. californicus*, *E. stipulates* and Galendromus helveolus (Chant) required three weeks.

Alatawi (2006) indicated that when release the predator *P. persimilis* with ratios 1:3, 1:15 and 1:30 to assess their effectiveness in controlling populations *T. urticae*, Only the release ratio of 1:3 significantly reduced both pest numbers and plant damage within a short time, That ratio of 1:10 or lower would provide a level of control that is consistently acceptable to most growers.

Some researchers have concluded that certain phytoseiids may be effective at low prey densities, but not at high densities. For example, Kazak *et al*., (2000) reported that P. persimilis was better able to control *T. cinnabarinus* at an initial 1:10 predator: prey ratio than at 1:20 and 1:30 predator:prey ratios, and S¸ekerog˘lu (1977) reported that *Amblyseius fallacis* (Garman) were significantly more effective in reducing *Panonychus ulmi* (Koch) populations at an initial predator:prey ratios of 1:15 than at 1:30, 1:60 and 1:90 predator:prey ratios. The numerical increase of *A. fallacis* was also higher at initial ratios of 1:15 and 1:30 when compared to ratios of 1:60 and 1:90.

Rhodes (2005) noted that both predators *N. californicus* and *P. persimilis* were able to reduce numbers of *T. urticae* to below those found in the control, but it was observed that the difference between the predators in the fourth week noted that there is an increase in the number of *T. urticae* when control with *P. persimilis*, was also noted that the predator *P. persimilis* needs time longer than the predator *N. californicus* to control *T. urticae*.

The present study demonstrates that the predatory mite, *T. athiasae* is able to regulate *T. urticae* populations at predator:prey ratios of 1:10, but not at a lower ratio 1:40.

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N° Ref: 581