



Persian J. Acarol., 2021, Vol. 10, No. 2, pp. 191–204.
<https://doi.org/10.22073/pja.v10i2.63667>
Journal homepage: <http://www.biotaxa.org/pja>



Article

Seasonal abundance of *Tetranychus urticae* and *Amblyseius swirskii* (Acari: Tetranychidae and Phytoseiidae) on four strawberry cultivars

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ABSTRACT

The population abundance of *Tetranychus urticae* Koch and its naturally occurring phytoseiid mite, *Amblyseius swirskii* Athias-Henriot on four strawberry cultivars (029, Fortona, Markez and Wanter star) were studied during 2017/2018 and 2018/2019 seasons. In both studied seasons, the population of *T. urticae* was observed from mid-October, and still recorded until the beginning of May. The peaks of infestation appeared in February or March (according to the cultivar) then declined later until the end of the study. The predatory mite (*A. swirskii*) initially appeared in January 2018 and 2019, while its population's peaks were observed in March on the four cultivars. In the two studied seasons, 029 cultivar was infested with the maximum numbers of *T. urticae* followed by Markez and Fortona cultivars, while Wanter star cultivar had the lowest infestation. In the present study, as the foliar concentrations of alkaloids and phenolic compounds increased, the cultivar infestation with *T. urticae* decreased. In all cultivars, a positive correlation between the populations of *A. swirskii* and *T. urticae* was observed. The present work may be considered useful to develop a successful management program of *T. urticae*, a serious pest of strawberry.

KEY WORDS: Population dynamics; predatory phytoseiid mites; Rosaceae; two-spotted spider mite; Tetranychoida.

PAPER INFO.: Received: 30 July 2020, Accepted: 29 October 2020, Published: 15 April 2021

INTRODUCTION

The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), is a serious polyphagous mite pest attacking massive numbers of greenhouse and field crops worldwide (Bostanian *et al.* 2003; Khanamani *et al.* 2014; Azadi-Qoort *et al.* 2019). In several crops worldwide, this mite is a dangerous pest that causes plant damage and significant loss in yield (James and Price 2002). In many cases, plant death can occur as a result of heavy mite infestation (van der Geest 1985).

Strawberry (*Fragaria x ananassa* Duchesne) (Rosaceae) is a fruit crop that had a characteristic flavor and is rich in vitamins (Hancock 1990). In Egypt, strawberry is a very important crop, whether for the fresh local consumption or export (Shehata *et al.* 2011). Concerning the amount of crop production, Egypt is the fourth largest strawberry producer in the world (Essa 2015). Among the pests of strawberry, *T. urticae* is the most serious pest species attacking strawberry in several regions worldwide (Garcia-Mari and Gonzalez-Zamora 1999; Greco *et al.* 1999; Rezaie *et al.* 2013). Previous

How to cite: Fahim, S.F. & El-Saiedy, E.-S.M (2021) Seasonal abundance of *Tetranychus urticae* and *Amblyseius swirskii* (Acari: Tetranychidae and Phytoseiidae) on four strawberry cultivars. *Persian Journal of Acarology*, 10(2): 191–204.

works done on the effect of different levels of *T. urticae* infestation on yield reduction prove its potential for destroying strawberry (Wyman *et al.* 1979; Sances *et al.* 1982; Raworth 1986; Klamkowski *et al.* 2006).

Several natural enemies are associated with spider mites in the agricultural fields (McMurtry *et al.* 1970). In the farming system, these natural enemies are an essential component. In many cases, natural enemies were supposed to reduce spider mite populations (Schoenig and Wilson 1992). Phytoseiid predatory mites are the most important natural enemies of the mite pests (McMurtry and Croft 1997). As regards to phytoseiid mites, *Amblyseius swirskii* Athias-Henriot (Acari: Phytoseiidae) is a polyphagous predatory mite feeding on various types of prey, including thrips, whiteflies (Messelink *et al.* 2006; Calvo *et al.* 2011) and spider mites in many crops (Xu and Enkegaard 2010).

Studying the occurrence of the pest and its natural enemies offers a good tool in decision-making within Integrated Pest Management (IPM) programs (Rahmani *et al.* 2010). Nonetheless, the seasonal abundance of spider mite population is affected by different factors such as predation by natural enemies, climate and host plants (Kitashima and Gotoh 2003; Gotoh *et al.* 2004). In this regard, different plants have various defensive chemicals, such as phenols and alkaloids, for protection against herbivores (Dowd *et al.* 1983; Roininen *et al.* 1993; Hanley *et al.* 2007). These defensive chemicals can cause a decrease in the population growth rate of herbivores (Gotoh and Gomi 2000). However, identifying plant cultivars with less suitability to the mite pest would lead to, at least, delaying pest outbreaks (Fahim *et al.* 2020). Therefore, the objectives of the current study were to: (1) study the seasonal abundance of *T. urticae* and its naturally occurring predator, *A. swirskii* on four strawberry cultivars in Beheira Governorate, Egypt, (2) detect the effect of the leaf contents of alkaloids and total phenolic compounds on the cultivars infestation with *T. urticae*, and (3) evaluate the relationship between *T. urticae* population and *A. swirskii* population, and the climate factors (means of temperature and relative humidity).

MATERIALS AND METHODS

Study field

This study was performed during two successive years (2017/2018 and 2018/2019) in a strawberry field. Four strawberry cultivars (029, Fortona, Markez and Wanter star) were cultivated in an open field located at Markaz Badr, Beheira Governorate, Egypt. The experimental area consists of four equal-size plots with three replications/cultivar plot. The area size for each replicate was 28 m² and each cultivar plot was separated from the other cultivar plots by roads.

For all tested strawberry cultivars, irrigation and other agricultural processes (standard for the area) were applied equally to ensure uniform development of all cultivars. No pesticides were used in the study.

Seasonal abundance of mites on strawberry

The observations on the occurrence and fluctuation of *T. urticae* and *A. swirskii* on each cultivar were recorded at weekly intervals, from 15 October to 13 May in 2017/2018 and from 11 October to 9 May in 2018/2019. On each sampling date, 10 mature leaves were taken from 10 randomly selected plants/replicate (30 leaves per cultivar plot), placed inside labeled plastic bags, kept in an icebox, and transferred to laboratory for investigation (Sato *et al.* 2007). All *T. urticae* and *A. swirskii* stages on upper and lower surfaces of each leaf were counted using a stereomicroscope (Sato *et al.* 2007) and the weekly mean numbers of each mite on each cultivar during each study season were recorded. In addition, the overall mean numbers (during the period in which the mite was present in each season, the weekly values of mite population were averaged over this period to obtain the overall mean number of mite on each cultivar) of each mite were calculated at the end of each season.

Estimation of alkaloids and total phenolic compounds

The leaf contents of alkaloids and total phenolic compounds of each strawberry cultivar were determined as follows:

- The content of alkaloids was determined titrimetrically according to Sabri *et al.* (1973).
- The content of total phenolic compounds was determined by Folin- Ciocateu method as modified by Singleton and Rossi (1965).

Weather parameters

Climatic data (temperature and relative humidity) during the two studied seasons were obtained from the nearest weather station of the sampling areas. The daily values of relative humidity and temperature were averaged over one-week periods to obtain the weekly means of relative humidity and temperature.

Statistical analysis

One-way analysis of variance (ANOVA) was used to compare (1) *T. urticae* populations among sampling dates in each cultivar; (2) *A. swirskii* populations among sampling dates in each cultivar; and (3) the leaf contents of alkaloids and total phenolic compounds among cultivars. The effect of season and cultivar on the populations of *T. urticae* and *A. swirskii* were tested with analysis of variance using General Linear Model (GLM). In the analysis of variance, means comparisons were made using Tukey's multiple range test ($P < 0.05$). A linear regression analysis was performed through a stepwise method to determine the relationship between *T. urticae* population and *A. swirskii* population, and the climatic factors (means of temperature and relative humidity). All statistical analyses were carried out by Statistical Package of Social Science (SPSS), version 20.

RESULTS

Seasonal abundance of mites on strawberry

The population abundance of *T. urticae* and *A. swirskii* on four strawberry cultivars (029, Markez, Fortona and Wanter star) during two successive seasons are shown in Figures 1–3. In both studied seasons, the population of *T. urticae* was initially observed in mid-October, and still recorded until the beginning of May. The peaks of infestation appeared in February or March (according to the cultivar) then declined later until the end of the study. On the four cultivars, the phytoseiid mite, *A. swirskii* was absent from mid-October to January when it appeared. As the population of *T. urticae* increased, *A. swirskii* population also gradually increased and reached its highest level in the last half of March and re-decreased later until the end of study in both seasons.

During the 2017/2018 season, the populations of *T. urticae* were low at the beginning of the sampling duration (15th October) and progressively increased to reach their peaks in late February in 029 and Fortona cultivars or in March in Markez and Wanter star cultivars. The mean numbers of *T. urticae* were significantly higher on 25th February 2018 ($P = 0.00$) for 029 (1195.70 ± 1.27 mites/leaf) and Fortona cultivars (418.23 ± 1.26 mites/leaf) than the other sampling dates. Shortly after the occurrence of the spider mite peak, the highest mean numbers of *A. swirskii* on 029 (2.87 ± 0.12 mites/leaf) and Fortona cultivars (1.53 ± 0.15 mites/leaf) were observed on 25th March 2018 ($P = 0.00$). As comparing to the other sample dates, the significant maximum populations of *T. urticae* on Markez (840.60 ± 1.59 mites/leaf) and Wanter star cultivars (310.20 ± 0.55 mites/leaf) were observed on 11th ($P = 0.00$) and 25th March 2018 ($P = 0.00$), respectively. Almost simultaneously with the peaks of *T. urticae* population, the results showed that the peaks of predatory mite populations on Markez (2.87 ± 0.18 mites/leaf) and Wanter star cultivars (1.27 ± 0.09 mites/leaf) occurred on 25th ($P = 0.00$) and 18th March 2018 ($P = 0.00$), respectively (Fig. 1).

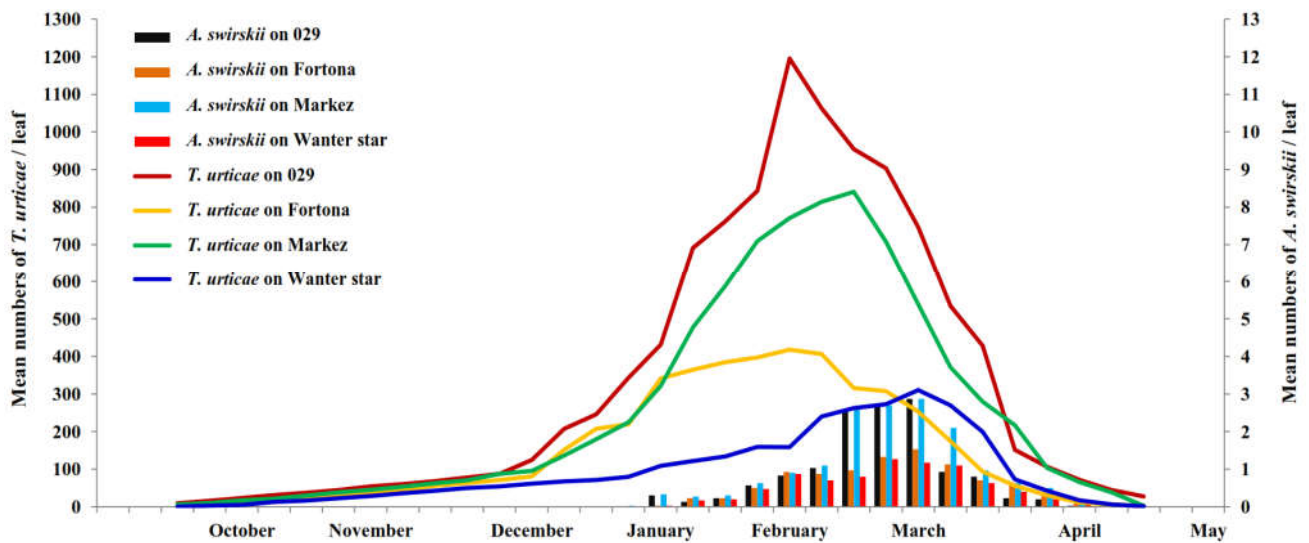


Figure 1. Mean numbers of *Tetranychus urticae* and *Amblyseius swirskii* populations on four strawberry cultivars during 2017/2018 season.

Comparable to what was noticed in the first season, the results of the second season (2018/2019) showed that *T. urticae* were initially noted on 11th October 2018 with an average of 10.93 ± 0.75 , 6.93 ± 0.77 , 4.33 ± 0.54 and 0.13 ± 0.03 mites/leaf for 029, Markez, Fortona and Wanter star cultivars, respectively. On 029 and Fortona cultivars, the significantly highest *T. urticae* populations (mean \pm SE mites/leaf) were detected on 21st February 2019 ($P = 0.00$), while the peaks of *A. swirskii* populations were observed on 21st ($P = 0.00$) and 28th March 2019 ($P = 0.00$), respectively. On Markez and Wanter star cultivars, the population peaks of *T. urticae* were observed on 7th March 2019 ($P = 0.00$). Similarly, the predator population also increased to its maximum mean numbers in March, specifically on 21st ($P = 0.00$) and 28th March 2019 ($P = 0.00$) for Markez and Wanter star cultivars, respectively (Fig. 2).

The results of GLM analysis revealed that *T. urticae* populations differed significantly among cultivar ($F = 11.76$; $P = 0.00$), whereas season didn't significantly contribute to the whole variation in the populations ($F = 0.05$; $P = 0.82$) and no interaction between season and cultivar was detected ($F = 0.01$; $P = 0.99$) (Table 1). In the two studied seasons, the highest overall mean numbers of *T. urticae* were found on the plants of both 029 and Markez cultivars as compared to the other cultivars; without significant differences between 029 and Markez or between Fortona and Wanter star cultivars. Plants of 029 cultivar were infested with the highest overall mean numbers of *T. urticae*, followed by Markez, Fortona and Wanter star cultivars (Fig. 3).

Also, the GLM analysis displayed significant differences in *A. swirskii* populations among cultivars ($F = 3.84$; $P = 0.01$). The effect of season on *A. swirskii* populations was insignificant ($F = 0.01$; $P = 0.94$) and no interaction between season and cultivar was observed ($F = 0.42$; $P = 0.74$) (Table 1). In both seasons, plants of Markez and 029 cultivars carried higher overall mean numbers of *A. swirskii* than plants of the other cultivars; with no significant differences between Markez and 029 or between Fortona and Wanter star cultivars. During the two seasons, the maximum overall average of *A. swirskii* was recorded on Markez, followed by 029, Fortona and Wanter star cultivars (Fig. 3).

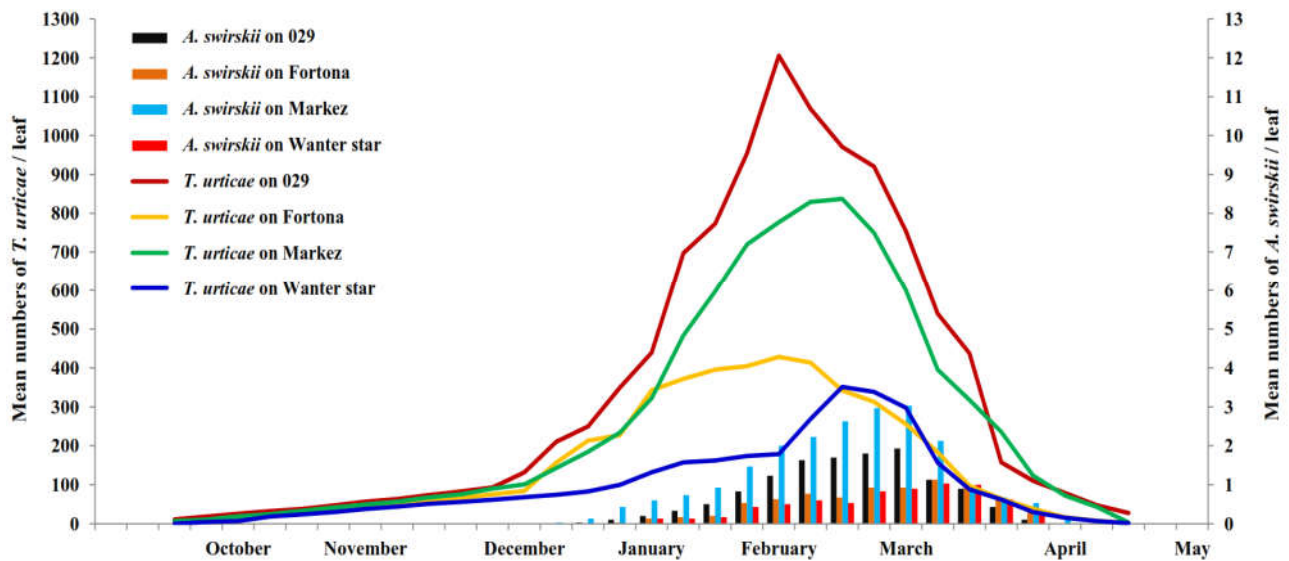


Figure 2. Mean numbers of *Tetranychus urticae* and *Amblyseius swirskii* populations on four strawberry cultivars during 2018/2019 season.

Table 1. Analysis of variance for the effect of season and cultivar on the mite populations.

Source	Ms	df	F	P
<i>Tetranychus urticae</i>				
Season	3393.71	1	0.05	0.82
Cultivar	736437.67	3	11.76	0.00
Season × cultivar	117.20	3	0.01	0.99
Error	62612.05	240		
<i>Amblyseius swirskii</i>				
Season	0.01	1	0.01	0.94
Cultivar	2.08	3	3.84	0.01
Season × cultivar	0.23	3	0.42	0.74
Error	0.54	109		

Effect of alkaloids and total phenolic compounds on T. urticae infestation

It is displayed from Table (2) that the leaf contents of alkaloids and total phenolic compounds were significantly higher on Wanter star and Fortona cultivars as compared to 029 ($F = 7.58$; $P = 0.00$ and $F = 3.83$; $P = 0.04$, respectively). However, there was no significant difference in the leaf content of total phenolic compounds between 029 and Markez cultivars.

The relationship between T. urticae and A. swirskii populations, and the climatic factors on the strawberry cultivars

The linear regression analysis via the stepwise procedure of the relationship between *T. urticae* population and *A. swirskii* population, and the climatic factors (means of temperature and relative humidity) on four strawberry cultivars is presented in Table (3). In both seasons, the R^2 values in the stepwise regression analysis ranged between 0.57 and 0.90 which means that 57 to 90 % of the variations in *T. urticae* population is explained by the linear regression analysis (Table 3). In 2017/2018 and 2018/2019 seasons, the regression analysis using the stepwise method revealed that the variable numbers of *T. urticae* can be better explained in the field by the mean numbers of *A. swirskii*, since the correlation between these two variables was positive for 029 ($P < 0.01$), Markez

($P < 0.01$) and Wanter star cultivars ($P < 0.01$). During both seasons, the population of *T. urticae* displayed a non-significant negative relationship with respect to mean temperature in 029 ($P > 0.05$) and Markez cultivars ($P > 0.05$).

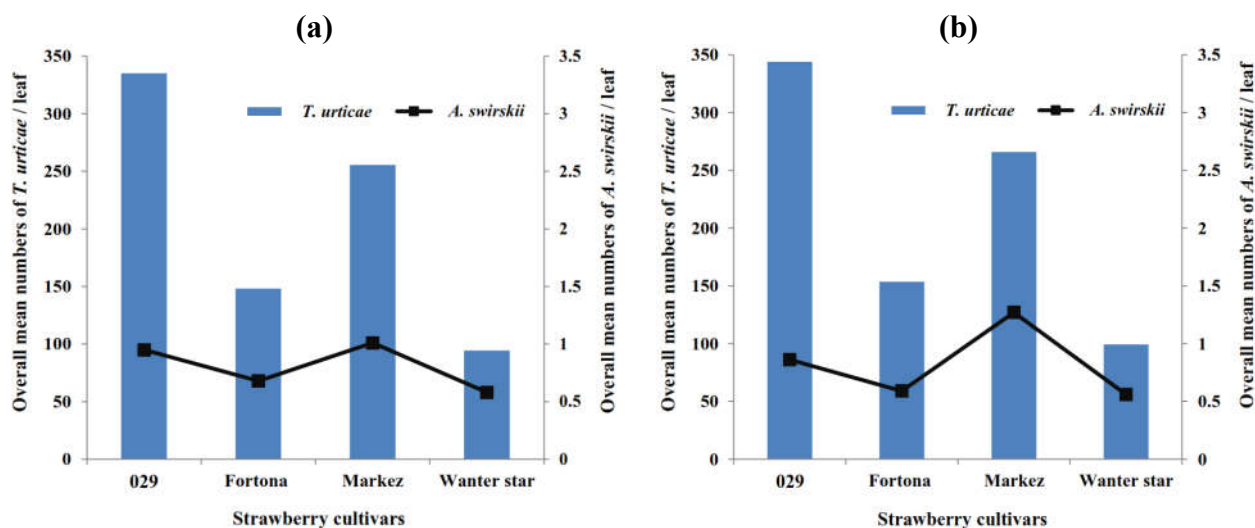


Figure 3. Overall mean numbers of *Tetranychus urticae* and *Amblyseius swirskii* on four strawberry cultivars during (a) 2017/2018 and (b) 2018/2019 seasons.

Table 2. Leaf contents of alkaloids and total phenolic compounds of four strawberry cultivars.

Phytochemicals	Strawberry cultivars				F	P
	029	Fortona	Markez	Wanter star		
Alkaloids (%)	0.20 ± 0.00 b	0.27 ± 0.01 a	0.25 ± 0.01 a	0.27 ± 0.01 a	7.58	0.00
Total phenolic compounds (mg/g)	10.66 ± 0.47 b	12.63 ± 0.52 a	11.50 ± 0.21 ab	12.67 ± 0.67 a	3.83	0.04

The means in every row with different letters are significantly different at $P < 0.05$.

During both studied seasons in Fortona cultivar, the analysis by stepwise regression revealed that the variable numbers of *T. urticae* population in the field can be explained by the average numbers of *A. swirskii* and temperature; these two variables had positive (2017/2018: $P < 0.01$ and 2018/2019: $P < 0.05$) and negative (2017/2018: $P < 0.01$ and 2018/2019: $P < 0.01$) relationships with *T. urticae* population, respectively. In all cultivars, the relative humidity didn't significantly influence the population of *T. urticae* during both seasons.

In the two seasons, the regression analysis using the stepwise method revealed that the variable numbers of *A. swirskii* can be better explained in the field by the mean numbers of *T. urticae*, since the correlation between these two variables was significantly positive for all cultivars ($P < 0.01$), while both temperature and relative humidity didn't significantly affected the population of the predatory mite.

Table 3. The linear regression analysis of the relationship between *Tetranychus urticae* population and *Amblyseius swirskii* population, and the climatic factors (means of temperature and relative humidity) on four strawberry cultivars under field conditions.

Strawberry cultivars	Source	R ²	F	P	Coefficient
2017/2018 season					
029	<i>A. swirskii</i> population	0.58	19.59	0.00	0.74**
	Temperature (°C)				- 0.30 ^{NS}
Fortona	<i>A. swirskii</i> population	0.57	18.65	0.00	0.63**
	Temperature (°C)				- 0.53**
Markez	<i>A. swirskii</i> population	0.60	21.20	0.00	0.77**
	Temperature (°C)				- 0.29 ^{NS}
Wanter star	<i>A. swirskii</i> population	0.90	121.59	0.00	0.95**
	Temperature (°C)				- 0.22 ^{NS}
2018/2019 season					
029	<i>A. swirskii</i> population	0.84	72.17	0.00	0.75**
	Temperature (°C)				- 0.33 ^{NS}
Fortona	<i>A. swirskii</i> population	0.63	23.78	0.00	0.36*
	Temperature (°C)				- 0.63**
Markez	<i>A. swirskii</i> population	0.87	94.33	0.00	0.81**
	Temperature (°C)				- 0.26 ^{NS}
Wanter star	<i>A. swirskii</i> population	0.64	25.15	0.00	0.60**
	Temperature (°C)				- 0.43*

Note: * means significant at $P < 0.05$, ** means significant at $P < 0.01$, ^{NS} means non-significant.

DISCUSSION

Seasonal population abundance is one of the main characteristic features required for making a sampling program used for research or controlling purpose of the arthropods (Pedigo and Buntin 1994). Our results showed that *T. urticae* infested all the studied strawberry cultivars in the surveyed area with different levels of infestation. The population of *T. urticae* was initiated in October, progressively increased and the population peaks appeared in February or March (according to the cultivar) then declined later. Similarly in Egypt, the infestation peaks of *T. urticae* on two Faba bean cultivars were observed in March (Romeih *et al.* 2013). In India, the population of *T. urticae* reached its peak on brinjal during March (Rao *et al.* 2018; Patel *et al.* 2020), which is in line with the present study. In New Zealand, Butcher *et al.* (1987) reported that after the beginning of strawberry infestation with *T. urticae*, the mite population increased for three to four months then it quickly declined over a short period. The present results appear to support these findings. On the other hand, Labanowska and Chlebowska (1998) recorded the highest population of *T. urticae* during June on strawberry in Poland. On soybean in Egypt, Waheeb (1998) detected the infestation peak of *T. urticae* in May, although El-Saiedy (1999) noted that the mite infestation was higher in April than in May. Some other workers detected the peak of *T. urticae* infestation during spring on castor bean in Egypt (Ismail *et al.* 2007), orchids and French bean in India, respectively (Meena *et al.* 2013; Chauhan and Shukla 2016).

In the current study, the phytoseiid predatory mite (*A. swirskii*) was collected as a natural enemy usually related to *T. urticae*. This is in agreement with El-Saiedy (1999), Romeih *et al.* (2013) and Kamel *et al.* (2019) who recorded the presence of *A. swirskii* with *T. urticae* in Egypt on soybean, Faba bean and pea, respectively. However, another phytoseiid mite, *Neoseiulus fallacis* (Garman), was detected with *T. urticae* on strawberry in British Columbia (Raworth 1990). In both studied seasons, the population of *T. urticae* reached its peaks in February on 029 and Fortona cultivars, while *A. swirskii* population peaks occurred in March for the same cultivars. In Iran, similar results were

obtained by Rahmani *et al.* (2010) who observed that the highest densities of the tetranychid mite, *Panonychus ulmi* (Koch) occurred in August, while the peak of its stigmaeid predator, *Zetzellia mali* (Ewing) occurred in September on apple. In India, Rao *et al.* (2018) observed that *Neoseiulus longispinus* (Evans) showed a close correlation with *T. urticae* on brinjal. In their study, the highest population of *T. urticae* occurred on March, while the highest population of *N. longispinus* was observed during February.

On Markez and Wanter star cultivars, the population peaks of *T. urticae* occurred in March which is almost simultaneous with the population peaks of its predatory mite during the two studied seasons (Figs. 1–2). Similar conclusion was attained by Patel *et al.* (2020) who noticed that the populations of *T. urticae* and its phytoseiid mite, *Amblyseius alstoniae* Gupta reached their peaks during March on brinjal crop in India. Also in India, the maximum populations of *T. urticae* and its predatory mite, *Euseius* sp. were observed during April on grape (Veerendra *et al.* 2015).

The present results showed a similarity in the seasonal prevalence of *T. urticae* populations on the four cultivars, but its abundances on the cultivars are varied. In the two studied seasons, 029 was infested with the maximum numbers of *T. urticae* followed by Markez and Fortona cultivars, while Wanter star cultivar had the lowest infestation. Our results were in accordance with the results of Afifi *et al.* (2010) who observed variation in the mean densities of *T. urticae* on two strawberry cultivars (Charlie and Camarosa) in Egypt. Likewise, Ali *et al.* (2015) detected variations in *T. urticae* population that infested different tomato hybrids. However, increasing the population of tetranychid mites is affected by different plant cultivars or species, and these differences may be related to nutritional value (van de Vrie *et al.* 1972), chemical contents and/or morphology of the host plant (Afifi *et al.* 2010).

A variety of plants produce toxic chemical compounds such as phenols, alkaloids, quinones and terpenoids that retard the development or kill the plant feeder pests (Hanley *et al.* 2007). Phenolic compounds are believed to be one of the most important chemicals of plant defensive compounds (Norris and Kogan 1980). In our study, Wanter star cultivar was found to contain the highest contents of alkaloids and total phenolic compounds followed by Fortona, Markez and 029 cultivars (Table 2). So, as the foliar concentrations of alkaloids and phenolic compounds increased, the cultivar infestation with *T. urticae* decreased. The present results were in agreement with the findings of Afifi *et al.* (2010) who indicated that an increase in the phenolic compounds of strawberry cultivars results in a reduction in *T. urticae* infestation. A negative association between the level of mite infestation and the foliar alkaloids and phenolic compounds of tomato hybrids was also reported (Ali *et al.* 2015).

Previous studies indicated that increasing the concentrations of foliar phenolic compounds result in a reduction in *T. urticae* fecundity and/or delay in the mite developmental times (Larson and Berry 1984; Luczynski *et al.* 1990; Wermelinger *et al.* 1991). Accordingly, our results supported the findings of Fahim *et al.* (2020) who revealed that 029 strawberry cultivar was more suitable for *T. urticae* development and reproduction compared to Fortona and Wanter star cultivars. Therefore, the selection of strawberry cultivars with high concentrations of phenolic compounds could reduce the population growth rate of *T. urticae* (Luczynski *et al.* 1990).

Generally in both seasons, the regression analysis showed that *A. swirskii* population appeared to be the most important effective factor that positively correlated with *T. urticae* population (Table 3). Similarly, the abundance of the phytoseiid mite, *Amblyseius bicaudus* (Wainstein) showed a positive correlation with abundance of *T. urticae* in Turkey (Kumral and Kovanci 2005). Also, a positive relationship was found between *T. urticae* and its predatory mite, *Euseius* sp. at Atharga ($r = 0.852$) and at Jumnal ($r = 0.913$) on grape in India (Veerendra *et al.* 2015). On brinjal crop, Patel *et al.* (2020) found a positive association between the phytoseiid mite, *A. alstoniae* and its prey, *T. urticae* ($r = 0.898$) in India.

In most cases of the present study, the population of *T. urticae* displayed a non-significant negative relationship with respect to mean temperature during both seasons. However, the average temperature was ranged between 12.9 °C and 28.9 °C during our study, i.e. obviously inside the

temperature range permitting *T. urticae* development (Knapp *et al.* 2006). Our results are compatible with the results of Majeed *et al.* (2016) who concluded that temperature had negative relationship with *T. urticae* population on NIAB-98 ($r = -0.63$) and IR-443 cotton genotypes ($r = -0.54$). Also, the population of spider mites was found to be negatively correlated with temperature (Gupta *et al.* 1976). However, contrary findings were also reported from previous literatures supporting the positive relationship between the population of spider mites and temperature (Meena *et al.* 2013; Chauhan and Shukla 2016).

Natural enemies are recorded as one of the elements that influence the spider mite population dynamics (Huffaker *et al.* 1970). The current study revealed that there was a positive correlation between *T. urticae* and *A. swirskii* abundances in all cultivars, which suggests that predatory mite may regulate *T. urticae* populations; but with an insufficient level of control. One explanation may be regarding the degree of the seasonal synchronization between *T. urticae* and predatory mite populations. Presently, *T. urticae* population was observed in October then followed, with some time delay, by that of *A. swirskii* which appeared in January. Therefore, temporal delay in addition to the low numbers of *A. swirskii* may be responsible for the minor influence of *A. swirskii* in controlling *T. urticae* on studied strawberry cultivars. It is mentioned by previous research that natural enemies occurring late in the season or having their numbers increase too slowly are considered ineffective for spider mites management (Flaherty *et al.* 1981; Kitashima and Gotoh 2003). So, the effective control of spider mites needs to be early existence of the predatory mites when the prey mites are present at low densities and before the prey's damage is observed (Pickett and Gilstrap 1986; Strong and Croft 1995; Skirvin and Williams 1999).

CONCLUSION

Taking into consideration the economic significance of strawberry in Egypt and the destructive effect of *T. urticae* on that crop, the present work offers significant information to those planting strawberry or studying the mite's ecology in Egypt. The present results introduced information about the seasonal abundance of *T. urticae* and its predatory mite on four strawberry cultivars. So, the present results may be considered useful to develop a successful management program of *T. urticae* on strawberry.

REFERENCES

- Affifi, A.M., El-Laithy, A.Y.M., Shehata, S.A. & El-Saiedy, M.A. (2010) Resistance of strawberry plants against the two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae). In: Sabelis, M.W. & Bruin, J. (Eds.), *Trends in Acarology. Proceedings of the 12th International Congress, Amsterdam, The Netherlands*, pp. 505–507.
- Ali, F.S., Affifi, A.M., El-Saiedy, E.M.A. & Ahmed, M.M. (2015) Effect of phytochemical components, morphological and histological leaf structure of five tomato hybrids on *Tetranychus urticae* Koch infestation. *Acarines*, 9: 23–30.
- Azadi-Qoort, A., Sedaratian-Jahromi, A., Haghani, M. & Ghane-Jahromi, M. (2019) Biological responses of *Tetranychus urticae* (Acari: Tetranychidae) to different host plants, an investigation on bottom-up effects. *Systematic and Applied Acarology*, 24(4): 659–674.
- Bostanian, N.J., Trudeau, M. & Lasnier, J. (2003) Management of the two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae) in eggplant fields. *Phytoprotection*, 84: 1–8.
- Butcher, M.R., Penman, D.R. & Scott, R.R. (1987) Population dynamics of two-spotted spider mites in multiple year strawberry crops in Canterbury. *New Zealand Journal of Zoology*, 14(4): 509–517.
- Calvo, F.J., Bolckmans, K. & Belda, J.E. (2011) Control of *Bemisia tabaci* and *Frankliniella occidentalis* in cucumber by *Amblyseius swirskii*. *BioControl*, 56: 185–192.

- Chauhan, R.K. & Shukla, A. (2016) Population dynamics of two spotted spider mite, *Tetranychus urticae* Koch on French bean (*Phaseolus vulgaris* L.). *International Journal of Plant Protection*, 9(2): 536–539.
- Dowd, P.F., Smith, M. & Sparks, T.C. (1983) Detoxification of plant toxins by insects. *Insect Biochem*, 13: 453–468.
- El-Saiedy, E.M.A. (1999) *Integrated control studies on Tetranychus urticae Koch on Soya bean plants*. M.Sc. Thesis, Munufiya University, 144 pp.
- Essa, T.A.A. (2015) Response of some commercial strawberry cultivars to infection by wilt diseases in Egypt and their control with fungicides. *Egyptian Journal of Phytopathology*, 43: 113–127.
- Fahim, S.F., Momen, F.M. & El-Saiedy, E.-S.M. (2020) Life table parameters of *Tetranychus urticae* (Trombidiformes: Tetranychidae) on four strawberry cultivars. *Persian Journal of Acarology*, 9(1): 43–56.
- Flaherty, D.L., Hoy, M.A. & Lynn, C.D. (1981) Spider mites. In: Flaherty, D.L., Jensen, F.L., Kasimatis, A.N., Kido, H. & Moller, W.J. (Eds.), *Grape Pest Management*. California University, Berkeley, Agricultural Scientific Publishing, pp. 111–125.
- Garcia-Mari, F. & Gonzalez-Zamora, J. E. (1999) Biological control of *Tetranychus urticae* (Acari: Tetranychidae) with naturally occurring predators in strawberry plantings in Valencia, Spain. *Experimental and Applied Acarology*, 23: 487–495.
- Gotoh, T. & Gomi, K. (2000) Population dynamics of *Tetranychus kanzawai* (Acari: Tetranychidae) on hydrangea. *Experimental and Applied Acarology*, 24: 337–350.
- Gotoh, T., Yamaguchi, K., Fukazawa, M. & Mori, K. (2004) Effect of temperature on life history traits of the predatory thrips, *Scolothrips takahashii* Priesner (Thysanoptera: Thripidae). *Applied Entomology and Zoology*, 39(3): 511–519.
- Greco, N.M., Liljestrom, G.G. & Sanchez, N.E. (1999) Spatial distribution and coincidence of *Neoseiulus californicus* and *Tetranychus urticae* (Acari: Phytoseiidae, Tetranychidae) on strawberry. *Experimental and Applied Acarology*, 23: 567–580.
- Gupta, S.K., Dhrooria, M.S. & Sidhu, A.S. (1976) Seasonal abundance of *Tetranychus talarius* (Linn.) on castor in the Punjab. *Oilseeds journal*, 6: 16–18.
- Hancock, J.F. (1990) Ecological genetics of natural strawberry species. *Horticultural Science*, 25(8): 869–871.
- Hanley, M.E., Lamont, B.B., Fairbanks, M.M. & Rafferty, C.M. (2007) Plant structural traits and their role in antiherbivore defense. *Perspectives in Plant Ecology, Evolution and Systematics*, 8: 157–78.
- Huffaker, C.B., van de Vrie, M. & McMurtry, J.A. (1970) Ecology of tetranychid mites and their natural enemies: a review II. Tetranychid populations and their possible control by predators: an evaluation. *Hilgardia*, 40: 391–458.
- Ismail, M.S.M., El Naggar, M.H., Soliman, M.F.M. & Ghallab, M.M. (2007) Ecological studies on the two-spotted spider mite *Tetranychus urticae* Koch and its predators. *Egyptian Journal of Natural Toxins*, 4: 26–44.
- James, D.G. & Price, T.S. (2002) Fecundity in two-spotted spider mite (Acari: Tetranychidae) is increased by direct and systemic exposure to imidacloprid. *Journal of Economic Entomology*, 95 (4): 729–732.
- Kamel, M.S., Abou-Zaid, A.M. & Yasin, S.A. (2019) The effectiveness of phytochemical components and climatic factors on population fluctuation of the spider mite, *Tetranychus urticae* Koch on sweet pea and pea crops. *Journal of Applied Plant Protection*, 8: 15–21.
- Khanamani, M., Fathipour, Y., Hajiqanbar, H. & Sedaratian, A. (2014) Two-spotted spider mite reared on resistant eggplant affects consumption rate and life table parameters of its predator, *Typhlodromus bagdasarjani* (Acari: Phytoseiidae). *Experimental and Applied Acarology*, 63: 241–252.

- Kitashima, Y. & Gotoh, T. (2003) Population dynamics of *Panonychus osmanthi* (Acari: Tetranychidae) on two *Osmanthus* species. *Experimental and Applied Acarology*, 29: 227–240.
- Klamkowski, K., Sekrecka, M., Fonyodi, H. & Treder, W. (2006) Changes in the rate of gas exchange, water consumption and growth in strawberry plants infested with the two-spotted spider mite. *Journal of Fruit and Ornamental Plant Research*, 14: 155–162.
- Knapp, M., Sarr, I., Gilioli, G. & Baumgartner, J. (2006) Population models for threshold-based control of *Tetranychus urticae* in small-scale Kenyan tomato fields and for evaluating weather and host plant species effects. *Experimental and Applied Acarology*, 39: 195–212.
- Kumral, N.A. & Kovanci, B. (2005) Seasonal population dynamics of the two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) under acaricide constraint on eggplant in Bursa province (Turkey). *Acarologia*, 4: 295–301.
- Labanowska, B.H. & Chlebowska, D. (1998) Strawberry cultivars infestation with the two-spotted spider mite *Tetranychus urticae* Koch. *Journal of Fruit and Ornamental Plant Research*, 3(4): 129–137.
- Larson, K.C. & Berry, R.E. (1984) Influence of peppermint phenolics and monoterpenes on twospotted spider mite (Acari: Tetranychidae). *Environmental Entomology*, 13: 282–285.
- Luczynski, A., Isman, M.B. & Raworth, D.A. (1990) Strawberry foliar phenolics and their relationship to development of the two-spotted spider mite. *Journal of Economic Entomology*, 83: 557–563.
- Majeed, M.Z., Javed, M., Riaz, M.A. & Afzal, M. (2016) Population dynamics of sucking pest complex on some advanced genotypes of cotton under unsprayed conditions. *Pakistan Journal of Zoology*, 48(2): 475–480.
- McMurtry, J.A. & Croft, B.A. (1997) Life-styles of phytoseiid mites and their roles in biological control. *Annual Review of Entomology*, 42: 291–321.
- McMurtry, J.A., Huffaker, C.B. & van de Vrie, M. (1970) Ecology of tetranychid mites and their natural enemies: a review. I. Tetranychid enemies: their biological characters and the impact of spray practices. *Hilgardia*, 40: 331–390.
- Meena, N.K., Pal, R., Pant, R.P. & Medhi, R.P. (2013) Seasonal incidence of mite and influence of pesticidal application on orchid flower production. *Journal of Plant Protection Research*, 53(2): 124–127.
- Messelink, G.J., van Steenpaal, S.E.F. & Ramakers, P.M.J. (2006) Evaluation of phytoseiid predators for control of western flower thrips on greenhouse cucumber. *BioControl*, 51: 753–768.
- Norris, D.M. & Kogan, M. (1980) Biochemical and morphological bases of resistance. In: Maxwell, F.G. & Jennings, P.R. (Eds.), *Breeding plants resistant to insects*. Wiley, New York, pp. 24–60.
- Patel, N.B., Bhatt, N.A. & Patel, C.C. (2020) Effect of weather parameters on incidence of brinjal mite, *Tetranychus urticae* Koch and its predatory mite, *Amblyseius alstoniae* Gupta. *Journal of Pharmacognosy and Phytochemistry*, 9: 3095–3099.
- Pedigo, L.P. & Buntin, G.D. (1994) *Handbook of sampling methods for arthropods in agriculture*. 1st edition. CRC Press, Boca Raton, 736 pp.
- Pickett, C.H. & Gilstrap, F.E. (1986) Inoculative releases of phytoseiids (Acari) for the biological control of spider mites (Acari: Tetranychidae) in corn. *Environmental Entomology*, 15: 790–794.
- Rahmani, H., Fathipour, Y. & Kamali, K. (2010) Spatial distribution and seasonal activity of *Panonychus ulmi* (Acari: Tetranychidae) and its predator *Zetzellia mali* (Acari: Stigmaeidae) in apple orchards of Zanjan, Iran. *Journal of Agricultural Science and Technology*, 12: 155–165.
- Rao, K.S., Vishnupriya, R., Ramaraju, K. & Poornima, K. (2018) Effect of abiotic factors on the population dynamics of two spotted spider mite, *Tetranychus urticae* Koch and its predatory mite, *Neoseiulus longispinosus* (Evans) in brinjal ecosystem. *Journal of Experimental Zoology India*, 21: 797–800.
- Raworth, D.A. (1986) An economic threshold function for the two-spotted spider mite, *Tetranychus urticae* (Acari: Tetranychidae) on strawberries. *The Canadian Entomologist*, 118: 9–16.

- Raworth, D.A. (1990) Predators associated with the two spotted spider mite, *Tetranychus urticae* Koch on strawberry at Abbotsford, BC, and development of non chemical mite control. *Journal of the Entomological Society of British Columbia*, 87: 59–67.
- Rezaie, M., Saboori, A., Baniamerie, V. & Allahyari, H. (2013) Susceptibility of *Tetranychus urticae* Koch (Acari: Tetranychidae) on seven strawberry cultivars. *International Research Journal of Applied and Basic Sciences*, 4(9): 2455–2463.
- Roininen, H., Vuorinen, J., Tahvanainen, J. & Julkunen-Tiitto, R. (1993) Host preference and allozyme differentiation in shoot galling sawfly, *Euura atra*. *Evolution*, 47: 300–308.
- Romeih, A.H.M., El-Saiedy, E.M.A. & Sholla, S.M.E. (2013) Study the population dynamics of two spotted spider mite *Tetranychus urticae* Koch infesting two Faba bean cultivars. *Life Science Journal*, 10(3): 1328–1333.
- Sabri, N.N., El-Masry, S. & Khafaey, S.M. (1973) Phytochemical investigation of *Hyoscyamus Desertorum*. *Planta Medica*, 23(1): 4–9.
- Sances, F.V., Toscano, N.C., Oatman, E.R., LaPre, L.F., Johnson, M.V. & Voth, V. (1982) Reductions in plant processes by *Tetranychus urticae* (Acari: Tetranychidae) feeding on strawberry. *Environmental Entomology*, 11: 733–737.
- Sato, M.E., Da Silva, M.Z., Filho, M.F., Matioli, A.L. & Raga, A. (2007) Management of *Tetranychus urticae* (Acari: Tetranychidae) in strawberry fields with *Neoseiulus californicus* (Acari: Phytoseiidae) and acaricides. *Experimental and Applied Acarology*, 42: 107–120.
- Schoenig, S.E. & Wilson, L.T. (1992) Patterns of spatial association between spider mites (Acari: Tetranychidae) and their natural enemies on cotton. *Environmental Entomology*, 21(3): 471–477.
- Shehata, S.A., Gharib, A.A., El-Mogy, M.M., Abdel Gawad, K.F. & Shalaby, E.A. (2011) Influence of compost, amino and humic acids on the growth, yield and chemical parameters of strawberries. *Journal of Medicinal Plants Research*, 5(11): 2304–2308.
- Singleton, V.L. & Rossi, J.A. (1965) Colorimetry of total phenolics with phosphomolybdic phosphotungstic acid reagents. *The American Journal of Enology and Viticulture*, 16: 144–158.
- Skirvin, D.J. & Williams, M.D.C. (1999) Differential effects of plant species on a mite pest (*Tetranychus urticae*) and its predator (*Phytoseiulus persimilis*): implications for biological control. *Experimental and Applied Acarology*, 23: 497–512.
- Strong, W.B. & Croft, B.A. (1995) Inoculative release of phytoseiid mites (Acarina: Phytoseiidae) into the rapidly expanding canopy of hops for control of *Tetranychus urticae* (Acarina: Tetranychidae). *Environmental Entomology*, 24(2): 446–453.
- van der Geest, I.P.S. (1985) Aspects of physiology. In: Helle, W. & Sabelis, M.W. (Eds.), *Spider mites: Their biology, natural enemies and control*. World crop pests, Elsevier, Amsterdam, The Netherlands, pp. 171–182.
- van de Vrie, M.J., McMurtry, A. & Huffaker, C.B. (1972) Ecology of tetranychid mites and their natural enemies: a review. III. Biology, ecology and pest status and host plant relations of tetranychids. *Hilgardia*, 41: 343–432.
- Veerendra, A.C, Udikeri, S.S. & Karabhantanal, S.S. (2015) Dynamics of two spotted red spider mite *Tetranychus urticae* Koch (Acari: Tetranychidae) in grape vineyards and its co-relation with abiotic factors and a predator. *Journal of Entomology and Zoology Studies*, 3: 373–376.
- Waheeb, M.I. A. (1998) *Ecological and control studies on Tetranychus urticae Koch infesting some field crops in Gharbia Governorate*. M.Sc. Thesis, Munufiya University, 144 pp.
- Wermelinger, B., Oertli, J.J. & Baumgartner, J. (1991) Environmental factors affecting the life table of *Tetranychus urticae* (Acari: Tetranychidae). II. Host plant nutrition. *Experimental and Applied Acarology*, 12: 259–274.
- Wyman, J.A., Oatman, E.R. & Voth, V. (1979) Effects of varying twospotted spider mite infestation levels on strawberry yield. *Journal of Economic Entomology*, 72: 747–753.

Xu, X.N. & Enkegaard, A. (2010) Prey preference of the predatory mite, *Amblyseius swirskii* between first instar western flower thrips *Frankliniella occidentalis* and nymphs of the two-spotted spider mite *Tetranychus urticae*. *Journal of Insect Science*, 10: 1–11.

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فراوانی فصلی *Tetranychus urticae* و *Amblyseius swirskii* (Acari: Tetranychidae and Phytoseiidae) روی چهار رقم توت‌فرنگی

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چکیده

فراوانی فصلی *Tetranychus urticae* Koch و کنه فیتوزئید *Amblyseius swirskii* Athias-Henriot که به طور طبیعی روی چهار رقم توت‌فرنگی (۰۲۹، فورتونا، مرکز و وانتر استار) پیدا می‌شود در فصل‌های ۲۰۱۸/۲۰۱۷ و ۲۰۱۹/۲۰۱۸ بررسی شدند. در هر دو فصل مورد مطالعه، جمعیت *T. urticae* از اواسط اکتبر تا اوایل می مشاهده شد. اوج آلودگی در فوریه یا مارس (بر حسب رقم) مشاهده و سپس تا پایان مطالعه کاهش یافت. کنه شکارگر (*A. swirskii*) ابتدا در ژانویه ۲۰۱۸ و ۲۰۱۹ ظاهر شد و اوج جمعیت آن روی چهار رقم در مارس دیده شد. در دو فصل مورد مطالعه، رقم ۰۲۹ بیشترین تعداد آلودگی به *T. urticae* را داشت و پس از آن رقم‌های مرکز و فورتونا قرار گرفتند در حالی که رقم وانتر استار کمترین آلودگی را داشت. در مطالعه حاضر، وقتی غلظت ترکیبات آکالوئیدی و فنولی در برگ افزایش یافت، آلودگی رقم به *T. urticae* کاهش یافت. در همه رقم‌ها، رابطه مثبتی بین جمعیت *A. swirskii* و *T. urticae* دیده شد. پژوهش حاضر می‌تواند برای توسعه برنامه موفقیت‌آمیز مدیریت *T. urticae* که آفت مهم توت‌فرنگی است مورد توجه قرار گیرد.

واژگان کلیدی: پویایی جمعیت؛ کنه شکارگر فیتوزئید؛ Rosaceae؛ کنه تارتن دو لکه‌ای؛ Tetranychoida.

اطلاعات مقاله: تاریخ دریافت: ۱۳۹۹/۵/۹، تاریخ پذیرش: ۱۳۹۹/۹/۹، تاریخ چاپ: ۱۴۰۰/۱/۲۶