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Biological control of *Tetranychus urticae* (Acari: Tetranychidae) using four predatory mites (Acari: Phytoseiidae) on two sweet pea cultivars.

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Studies of biological control were conducted during winter season 2014/2015 at Beheira Governorate to evaluate the efficacy of four phytoseiid predatory mites namely *Phytoseiulus persimilis* (Athias-Henriot), *Neoseiulus californicus* (McGregor), *Euseius scutalis* (Athias-Henriot) and *Cydnoseius negevi* (Swirski and Amitai) in suppressing the population of the two spotted spider mites (TSSM) *Tetranychus urticae* Koch (Acari: Tetranychidae) on two cultivars of sweet pea (Sugar lis and snow pea) under high tunnel of plastic-net condition. The obtained results indicated that the four tested predatory mites differed significantly in the reduction percentages of egg and movable stages of TSSM in the two studied cultivars. Obviously, *P. persimilis* and *N.californicus* were the most effective tested predatory mites in reducing TSSM- population, whereas *E. scutalis* and *C. negevi* were the least effective ones.

Keywords: Predatory mites, *Tetranychus urticae*, Sweet peas, Biological control, *Phytoseiids*.

INTRODUCTION

Sweet pea, (*Lathyrus odoratus*) (Fabaceae), is an annual climbing vine, growing to a height of over 6 feet. Its leaves are pinnate with two leaflets and a terminal tendril, which twines around supporting plants and structures helping the sweet pea to climb. In general, successful cultivation for sweet pea is threatened by several mite pests, such as the two spotted spider mites (TSSM) *Tetranychus urticae* Koch**,** blue oat mite (*Penthaleus major*) (Dugës) and red-legged earth mite (*Halotydeus destructor*) (Tucker). TSSM is considered the most important pest that causes an economic damage to vegetables crops in Egypt (Abdallah, 2002). It causes great loss for more than 150 host plants of vegetables, ornamentals and other agricultural crops in Egypt and worldwide (Zhang, 2003; Alatawi et al., 2005; Salman, 2007). TSSM has a very rapid population growth, short developmental time, high birth rate and long adult survival (Clotuche, 2011) .The over-reliance on conventional acaricides in controlling spider mites led to hazardous to human, environment and domestic animals (Tirello et al., 2012). Herein, it is necessary to minimize the application of conventional pesticides by using biological control agents particularly phytoseiid predators (El-Saiedy and Romeih, 2007). Phytoseiids are generally more effective than predatory insects in controlling mite pests at low population levels. McMurtry and Croft (1997) classified Phytoseiids into four categories based on their feeding habits .Type I consists only of *Phytoseiulus* sp. that are predators of heavily webbing spider mites, mostly *Tetranychus* spp. Type II contains predatory species that feed on spider mites, but are not restricted to *Tetranychus* spp. but feed on other small mites as well as on pollens. Type III prefers preying pests other than spider mites (because of being entangled in prey webs), such as Tarsonemid mites and thrips. Type IV comprises genus *Euseius*, generalist predators that develop and reproduce successfully on pollens (McMurtry and Croft, 1997).

Thus the present study was conducted to determine the efficiency of releasing four phytoseiid predators, *Phytoseiulus persimilis* (Athias-Henriot), *Neoseiulus californicus* (McGregor), *Euseius scutalis* (Athias-Henriot) and *Cydnoseius negevi* (Swirski & Amitai) in controlling the population of TSSM on two cultivars of sweet pea (Sugar lis and snow Pea) under protected cultivation system at Behaira Governorate during winter season of 2014/2015

MATERIALS AND METHODS

Predator sources and sites:

Four phytoseiid predatory mites were used: *Phytoseiulus persimilis* (Athias-Henriot) was collected from the green bean plant, *Phaseolus vulgaris* L .at Acarology unit, National Research Centre, DoKi, Giza .Mass rearing of *P. persimilis* was carried out according to the method described by Afifi et al., (2015) and Heikal and Fawzy (2003). *Neoseiulus californicus* (McGregor) was collected from mulberry trees grown in the Experimental Farm, Faculty of Agriculture, Suez Canal University, Ismailia Governorate. *Euseius scutalis* (Athias-Henriot) and *Cydnoseius negevi* (Swirski & Amitai) were taken from the stock cultures kept in the previous laboratory of Acarology unit. Three pairs of *N. Californicus* , *E. scutalis* and *C. negevi* were transferred by camel hair brush to clean acalypha (*Acalypha marginata*) leaves and placed on cotton piece in a large tray (20 × 40 × 5 cm). Individuals of *Tetranychus urticae* Koch were added as prey then kept in an incubator at 25±1°C and 70 % RH. Mass rearing of the three latter predatory species was carried out under a plastic-net system (3.5 × 8 m) using bean plants, *Phaseolus vulgaris* L. as a host plant.

High tunnel of plastic net experiment and design:

Experiments were conducted in a large high tunnel of plastic net. It was divided into 5 sections (replicates) using plastic sheets. A total of 20 plants were used. Plants were randomly distributed and lined up in two rows (10 m long × 0.75 m wide) with 10 plants/row, in the 1st of September (2014). Plants were daily observed, watered regularly and all other recommended agricultural practices were performed. Sweet pea plants were left for the natural infestation with TSSM and were checked twice a week until the infestation rate was 5 adults/plants. Here, predatory mites were released at the rate of predator- prey of 1:10. Upon releasing, the predatory mites were transferred on kidney bean leaves (with the estimated numbers of each species) and kept in plastic bags, tightly closed with rubber bands, and placed in ice box at (10°C) until releasing. Release started on first of November (2014) at Beheira Governorate. Predator - prey ratio of 1: 10 was adopted (Heikal and Fawzy, 2003). Samples of 30 leaves were randomly taken from each treatment, kept into polyethylene bags, perforated, closed with rubber bands then transferred to the laboratory for examination using a stereomicroscope. Data were recorded in terms of eggs and movable stages of *T. urticae*. Experiments were repeated twice and all collected data were pooled together for statistical analysis.

Statistical analysis:

Data were analyzed by One-way analysis of variance and means were separated using Fisher's least significant difference (LSD) at 5% level of significance (SAS software, 1988) the reduction percentages in number of adult stages of *T. urticae* were calculated according to Henderson and Tilton (1955) as follow:

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

Where: n = mite population , T = treated , Co = control

RESULTS

Effect of releasing four phytoseiid predatory mites on *T. urticae*:

Data presented in Tables 1 and 2 showed that the population of *T.urticae* eggs and movable stages differed significantly (P<0.05) during winter plantation of 2014/2015 season. Population of TSSM in control increased in the 3rd week of November then decreased sharply. *P. persimilis* and *N.californicus* gave satisfactory control of TSSM after four weeks of releasing on both sweet pea cultivars. The density of eggs and mobile stages of *T. urticae* was higher in *E. scutalis* and *C. Negevi* treatments after three weeks. *P. persimilis* release proved to be the most effective in reducing *T.urticae* population.

After the release of the four predators the reduction percentages of *T.urticae* eggs increased on snow pea cultivar than sugar lis. Population of *T. urticae* begin to increase gradually during the winter season, so an additional release was conducted after nine weeks as a second release; populations of *T. urticae* followed the same trend as mentioned before in the first release. The four phytoseiid predatory mites, *P.persimilis*, *N.californicus*, *E. scutalis* and *C. negevi* obviously reduced the number of *T. Urticae* as compared control treatment.

The total numbers of eggs and movable stages of *T. urticae*/inch² in control treatment averaged 67.05 and 61.46 and 41.04 and 46.92 individuals/inch² during winter plantation 2014/2015 on the two cultivars respectively.

Results indicated that the TSSM population and its reduction percentages were significantly different among treatments (LSD; P< 0.05) on both sweet pea cultivars. On contrast, there was no significant difference between the population in the control treatment on both cultivars (LSD; P < 0.05).

Table (1): Effect of releasing four predatory mites on *T. urticae* eggs infesting two sweet pea cultivars under high tunnel of plastic net conditions.

Treatments	Mean number of *T.urticae* eggs/inch ^{2}	
	Sugar lis	Snow pea
Control	67.05 ±8.29 ^{a}	41.04 ±1.46 ^{a}
Cydnoseius negevi	27.11 ±2.13 ^{b}	18.45 ±1.06 ^{b}
Euseius scutalis	24.66 ±1.93 ^{b}	16.92 ±0.95 ^{b}
Neoseiulus californicus	5.53 ±1.14 ^{c}	3.04 ±0.61 ^{c}
Phytoseiulus persimilis	3.14 ±0.83 ^{c}	2.16 ±0.55 ^{c}
LSD	11.150	5.119

Means with different letters in vertical columns are significantly different (LSD test; P<0.05).

Table (2): Effect of releasing four predatory mites on *T. urticae* movable stages infesting two sweet pea cultivars under high tunnel of plastic net conditions.

Treatment	Mean number of *T. urticae* movable stages/inch ^{2}	
	Sugar lis	Snow pea
Control	61.46±5.06 ^{a}	46.92±5.20 ^{a}
Cydnoseius negevi	26.14±1.69 ^{b}	21.12±1.43 ^{b}
Euseius scutalis	26.68±1.83 ^{b}	19.44±1.25 ^{b}
Neoseiulus californicus	4.81±1.00 ^{c}	4.15±0.80 ^{c}
Phytoseiulus persimilis	2.96±0.82 ^{c}	2.09±0.60 ^{c}
LSD	7.261	7.059

Means with different letters in vertical columns are significantly different (LSD test; P<0.05).

Table (3): Mean (±SE) of predatory mites/inch^2 on two sweet pea cultivars under high tunnel of plastic net conditions.

Treatments	Numbers of predatory mites/inch² during winter season	
	Sugar lis	Snow pea
Cydnoseius negevi	8.07±1.16 ^{ab}	8.38±1.17 ^{a}
Euseius scutalis	9.54±1.05 ^{a}	9.53±1.05 ^{a}
Neoseiulus californicus	5.44±0.75 ^{bc}	4.82±0.81 ^{b}
Phytoseiulus persimilis	4.75±1.10 ^{c}	4.31±0.89 ^{b}
LSD	2.980	2.832

Means different letters in vertical columns are significantly different LSD test (P<0.05).

Figure. (1): Effect of releasing the four predatory mites on the reduction percentage of *T. urticae* egg stages on two sweet pea cultivars under high tunnel of plastic net conditions.

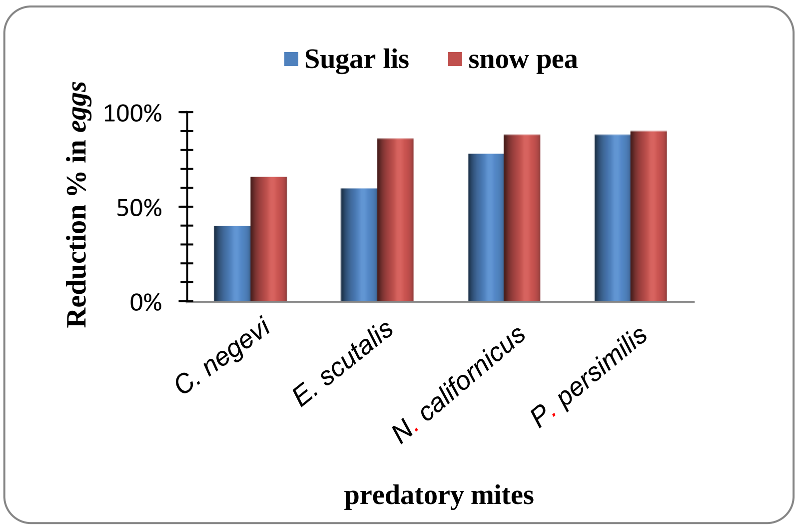
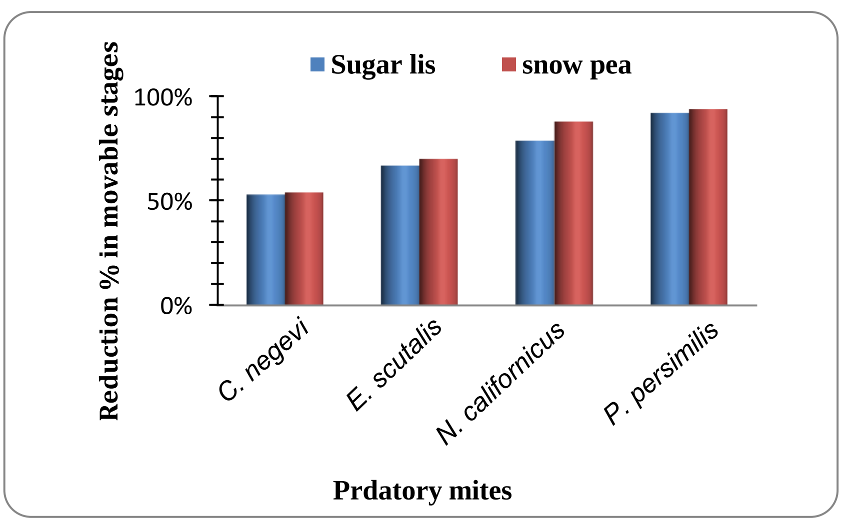


Figure. (2): Effect of releasing the four predatory mites on the reduction percentage of *T. urticae* movable stages on two sweet pea cultivars under high tunnel of plastic net conditions.



Reduction Percentage of *T.urticae* stages:

The efficacy of the four studied predatory mites based on the reduction percentages was in the order of *P.persimilis* > *N. Californicus* > *E. scutalis* > *C. Negevi* (Figs. 1 and 2). The highest reduction percentages in egg stage of TSSM were 88% in sugar lis and 90% in snow pea cultivars after 4 weeks in *P. persimilis,* whereas the lowest one (40% and 66% in the two respective cultivars) was recorded in *C. Negevi* . In case of movable stages the highest reduction percentage (92% and 94% in the two respective cultivars) was observed after 4 weeks in *P. Persimilis* treatment*,* whereas the lowest one (53% and 54% in two respective cultivars) was recorded in *C. Negevi* treatment*.*

Population of predatory phytoseiid mites:

Results in Table (3) revealed that the predatory mites were significantly more numerous per inch² on the two sweet pea cultivars reaching their population for *P.persimilis* (4.75 &4.31), *N. californicus* (5.44 and 4.82), *E. scutalis (*9.54&9.53) and *C. negevi* (8.07 and 8.38). However, *E. scutalis* increased to higher population's levels than *P. persimilis* and *N. Californicus*. Despite the efficiency of *P.persimilis* in reducing tetranychus mite, it was a smaller number than the Predator *E. scutalis*. On the other hand, *E. scutalis* was able to feed and sustain ovipositon on immature of insect pests extremely. Consequently, *E. scutalis* and *C. Negevi* the best potential for biological control of insects in protected cultivation, while *P. persimilis and N. Californicus* superior control of spider mites.

DISCUSSION

Predatory phytoseiid mites differed dramatically in their efficacy in controlling all stages of *T. urticae*. The differences between the four predatory mites might be attributable to their feeding habits. In earlier studies, phytoseiids were used as biological control agents to manage *Bemisia tabaci* (Gennadius). The two predatory mites, *E. scutalis* and *Typhlodromips swirskii* (Athias-Henriot), suppressed *B.tabaci* populations on cucumber plants. The same predators were also found in higher numbers on plants infested with whiteflies than on un infested ones especially *T. swirskii* (Nomikou et al., 2002). However, *N. californicus* and *P. presimils* were the best predators, for controlling *T. urticae* on strawberry where the reduction percentages ranged from 71.78 to 97.20% (El-Saiedy 2003).

On the contrary, El-Saiedy et al. (2008) studied three predatory mite species; *P. persimilis*, Neoseiulus *cucumeris* (Oudemans) and *N. californicus* for controlling the TSSM on two eggplant cultivars in open field. They found that the smallest reduction percentages were recorded by *N. Cucumeris*. Also, amongst the combination treatments, *P. Persimilis* and *N. californicus* treatment significantly reduced the TSSM population as compared to the control treatment (Rhodes et al, 2006).

P. persimilis was a successful bioagent for controlling *T. urticae.* This conclusion is in agreement with that reported by Hassan (2013) who pointed that the release of *P. persimilis* gave the highest reduction percentage with *T. urticae* movable stages and the lowest reduction percentage with eggs during the two successive seasons; while *N. californicus* seemed to prefer eggs of *T. urticae* than movable stages comparing to *P. persimilis*.

In the current study, *P. persimilis* and *N. californicus* gave the highest efficacy as indicated by the greatest reduction percentage of all TSSM stages, whereas moderate efficacy was observed for *E. scutalis* and the least effective one was given by *C. Negevi.* Hassan et al., (2007) came to the same conclusion when used *N. californicus, P. macropilis*, *N. cucumeris* and *N. zaheri* (Yousef and El-Borolossy) for reducing population of *T. urticae* and other sucking insect pests on cucumber plants*.*

Messelink et al., (2006) recorded the same conclusion when used the phytoseiid predatory mite species to control *Frankinella occidentalis* on greenhouse cucumber, but *E. finlandicus* did not establish well and showed low efficacy in the control of the target pest as compared to the other species.

CONCLUSION

The four predatory mites differed extensively in the reduction percentages of egg and movable stages of TSSM in the two sweet pea cultivars (Sugar lis and Snow pea). Clearly, *P. persimilis and N. californicus* were the most successful predatory mites in reducing TSSM population, while *E. scutalis and C. negevi* were the slightest valuable ones.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

M. K. performed the experiment; S. I. A. designed and wrote the manuscript and E. E. data analysis. All authors read and approved the final version.

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