Integrated Control of the Two-Spotted Spider Mite *Tetranychus urticae* Koch on Strawberry under low Tunnels in Egypt

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ABSTRACT

The efficacy of the predatory mite, *Phytoseiulus persimilis* Athias-Henriot, against *Tetranychus urticae* Koch, the main pest of Sweet Charlie and Tamar strawberry cultivars at Behera Governorate, was studied for two successive seasons 2006 and 2007. Results revealed that the reduction percentage of different stages of *T. urticae* achieved after releasing *P. persimilis* at prey-predator ratio of 1/10 & 1/7, ranged between 50-80%. Reduction percentage recorded using Macomite and Rohmactin approached that of *P. persimilis*. Results showed that the populations of *T. urticae* stages were more abundant on Tamar than on Sweet Charlie cultivars.

Key Words: Strawberry, *Tetranychus urticae*, *Phytoseiulus persimilis*, biological control.

INTRODUCTION

Strawberry, *Fragaria* x *ananassa* Duch, is produced in Egypt as early as the 1930. The indigenous cultivar Balady, a juicy cultivar, characterized by strong scent, high sugar content, and small fruit size, was the dominant species. However, since the last two decades of the twentieth century strawberry farmers have replaced this cultivar by several exotic ones. These exotic cultivars surpassed Balady because of their high yield, extended fruiting period (from November till June), and larger fruit size but lower sugar content. The most serious acarine pests attacking strawberry plantations is the two-spotted spider mite *Tetranychus urticae* Koch (Oatman & McMurtry, 1966; Wysoki, 1985 and Price, 2002). Spider mite population may build up rapidly during the growth season causing strawberry leaf damage which reduces the quantity and quality of harvestable fruits (Kunimoto, 2000; Mckinlay & Thomson, 1987 and Walsh *et al*. 2002). In Egypt *T. urticae* is considered the key pest of strawberry; infestation starts early during transplantation in September and continues until the end of season in June. Biological control of *T. urticae* on strawberry has been studied worldwide either through mass release of phytoseiid predatory mites or through testing naturally-occurring predatory mites or insects (Waite, 1988 and Garcia-Mari & Gonzalez-Zamora, 1999). A comprehensive experiments were carried out by Elsaidy, 2003 and EL-Laithy *et al*., 2004 on biocontrol of *T. urticae* using different phytoseiid species on strawberry planted in high and low plastic tunnels. The results of these experiments have encouraged further field studies. Thus, the present study aims to evaluate the impact of the predatory mite *Phytoseiulus persimilis* (Athias-Henriot) when released on Sweet Charlie and Tamar cultivars of high tolerance and high susceptibility respectively for infestation with *T. urticae* grown in new reclaimed lands, Behera governorate.

MATERIALS AND METHODS

Two newly exotic cultivars of strawberry were chosen for this study i.e. Tamar and Sweet Charlie, which are characterized by moderate vegetative growth, early ripening fruits with bright shape and sweet taste. Tamar is characterized by high susceptibility to spider mite infestation while, Sweet Charlie is relatively resistant Walsh *et al*. (2002).

An experiment was conducted at Behera governorate for two successive seasons 2005/2006 and 2006/2007 using a complete randomized block design. The effect of different biological and chemical control methods on the spider mite infesting the two strawberry cultivars was studied. Treatments included releasing the predatory mite, *P. persimilis* and spraying the two acaricides, Macomite and Romactin. Each treatment was replicated three times. The replicate consisted of two raised beds 4m x 1.2m, each having four lines of strawberry plants. The total number of strawberry plants in each replicate was 128 (16 x 4 x 2). A vertical plastic sheet of 70 cm long to fit with tunnel cover sheet isolated the replicates from one another. However, two consistent control methods were followed biweekly over all treatments except check plots 1, defoliation of old strawberry leaves adjacent to mulch covering the raising bed which were almost heavily infested with *T. urticae* 2-spray with micronized sulfur 2.5 g/L.

Sampling procedure

Ten leaves were randomly collected weekly from each replicate, making a sum of 30 leaves for each treatment. Collected samples were transferred for examination in the laboratory and counts were made for active stages of *T. urticae* and the predatory mite.

A. Chemical control:

Two acaricides Macomite and Romactin (1.8 % Abamectin) were used. The rate of application was 0.25 ml/L. and 0.4 ml/L respectively. Acaricides were applied as the population density approached an average of 2-5 *T. urticae* individuals/strawberry leaf. Repetition of application occurred according to *T. urticae* population growth. As shown in the following schedule, weekly samples were taken randomly before and after spraying. Reduction percentages of *T. urticae* active stages were estimated following Henderson and Tilton (Fleming and Retnakaran, 1985).

Temporal description of the treatment strategies adopted for combating *T. urticae*.

Date	Treatments	
	Chemical control plots	Biocontrol plots
4/12/2006	spraying of Macomite	release of predatory mites
14/1/2006	--	release of predatory mites
2/1/ 2007	re-spraying of Macomite	rerelease of predatory mites
19/2/2007	spraying of Romactin	--
12/3/2007	re-spraying of Romactin	--

B- Biological control:

The predatory mite *P. persimilis* was used as a biological control agent against *T. urticae*. It is a crossbreeding colony of Italian strain (Prof Ragusa 1998 and Moroccan strain Prof. El-Osmani, 2007, personal communications).

1. Colony of *T. urticae*:

A stock culture of *T. urticae* was maintained on potted beans, namely *Phaseolus vulgaris* L., in a rearing experimental glasshouse (1.5 x 2 x 3 m).

2. Rearing of the predatory mite:

The predatory mites *P. persimilis*, was reared using methods modified by McMurtry and Scriven (1965). Large plastic boxes (26 x 15 x 10 cm) were used. Cotton pads were put in the middle of each box, leaving a space containing water to act as a barrier preventing predatory mites from escaping. Tangle foot strips were further placed at the edges of the box. Cotton pads were kept saturated with water. Excised bean leaves highly infested with *T. urticae* were provided every other day as a food source. Plastic boxes were kept in an incubator at 28 °C ± 2 and 70 ± 10% relative humidity.

3. Releasing of the predatory mite:

Releasing was initiated when the population density of *T. urticae* on strawberry samples averaged 2-5 individuals / leaflet. The ratio between predator and prey ranged between 1:10 to 1:7. The required population size of predatory mite individuals was estimated according to the formula derived by El-laithy *et al*. (2008). Bean leaves with predatory mites were transferred in an ice box (10- 3 °C) to strawberry fields. Distribution was carried out on infested strawberry plants. Repetition of releasing depended on the population size of *T. urticae.* After releasing, samples were taken weekly. Active stages of each of *T. urticae* and predatory mites were counted. The reduction percentage of spider mite densities was determined following Henderson and Tilton (Fleming and Retnakaran, 1985).

Statistical analysis:

A two-sample t-test was used to test the difference between Sweet Charlie and Tamar cultivars in relation to infestation with the two-spotted spider mite *T. urticae* infestation. Assessing of significance was taken at 0.05 level probability.

RESULTS AND DISCUSSION

2005/2006 season

Population density of *T. urticae* recorded on Sweet Charlie cv. was almost moderate as it is characterized by relative tolerance to spider mite infestation Walsh *et al.* (2002). Peak density recorded for adult, immature and egg stages was 7.5, 24.5 & 25.1 individuals/leaf in *P. persimilis* release plots respectively (Fig. 1a). However population of *T. urticae* on Tamar cv. reached its maximum density of 7.5, 50 & 67.8. individuals/leaf for the aforementioned stages respectively during end February / early March 2006 in *P. persimilis* release plots. In cheek plots population densities were increasing over the season and reached its peak of 90.3 328.5 & 359 individuals/compound leaf in April (Fig. 1b). Values recorded for Sweet Charlie check plots were incomparable of 54.8, 182.1 & 159.9 individuals/leaf respectively (Fig. 1a). Densities of *T. urticae* stages reflected obviously higher susceptibility of Tamar cv. than Sweet Charlie considering density of egg stage particularly (159.9 versus 359 individuals / leaf Fig. 1a & b) as mentioned in Kibritci and Kazak (2004). Findings obtained herein revealed that mean population

density of *T. urticae* noted on Sweet Charlie cv approached half that on Tamar cv (Table1). Similarly population density of the predatory mite *P. persimilis* recorded on Tamar was twice that on Sweet Charlie cv. Fig. 1a & b (20.6 & 10.7 individuals/leaf). This may indicate variable positive interaction between *P. persimilis* and leaf characteristics of both cultivars (Dicke 1996).

2006/2007 season

Several sandy windows occurred that increased infestation with the *T. urticae* .This required additional curative spraying with micronsied sulfur before start of control experiments. Release of *P. persimilis* and Macomite application started early December when population of *T. urticae* averaged 5-7 adults/leaf on Sweet Charlie cv. and Tamar (Table 2 & 3). Four weeks later population increased and reached in *P. persimils* plots 10.8, 27.6 & 20.7 individuals/leaf of Sweet Charlie and 12.7 25.1 & 35.8 on Tamar cv. for adult immature and egg stages respectively (Table 2 & 3). Therefore, 2nd release was performed and spray with Macomite was repeated. Thereafter, until end of January when temporal increase in temperature occurred *T. urticae* population started to flourish (Tables 2 & 3). On February 19 Romactin replaced Macomite in spraying to reduce predatory mite mortality in release plots. Therefore, *T. urticae* population density declined to 6.9 ,14.5 & 20.7 and 15.2, 52.7 & 41.0 individuals for adult , immature and egg stages, in Sweet Charlie in release and Macomite plots respectively (Tables 2 & 3).On Tamar cv. mean population densities increased to 13.1, 40.0 & 38.9 and , 21.9, 36.4& 54.0 individuals/leaf of *T.urticae* adult, immature and egg stages in *P. persimilis* and Macomite plots respectively (Table 2). After spraying with Romactine population density in *P. persimilis* plots slightly declined until the end of the experiment without any treatment. However, resurgent *T.urticae* population at Macomite plot in both cultivars. (Tables 2 & 3) required another spraying on March 12.

In check plots, *T. urticea* populations recorded in early December were 4.68, 20.62& 24 in Sweet Charlie plots and 7.0, 21.0 & 32.6 individuals /leaf in Tamar cv. for adult, immature and egg stages respectively (Tables 2&3). Along the experimental period *T. urticea* population remarkably increased and maximum numbers recorded were 43.7, 224.9 & 237.5 individuals /leaf on Sweet Charlie and 64.42, 475.9 & 415.9 on Tamar respectively. These values vastly exceeded population peaks recorded in Sweet Charlie cv. release plots 10.8, 27.55 & 25.35 individuals/ leaf and on Tamar 15.6, 40.0& 38.9 for adult, immature and egg stages on Tamar respectively. In Macomite plots, *T. urticea* population peaks were 19.1, 52.7& 41.1 and 21.9, 47.6 & 69.1 individuals /leaf on Sweet Charlie and Tamar respectively.

Population density of the released predatory mite *P. persimilis* during the first season 2005/2006 as shown in Fig.1a & b reached the maximum density of 10.7 at end of March on Sweet Charlie, but it was more abundant on Tamar of 20.7 individuals /leaf. Populations averaged 11.3-20.7 from mid February until end of April on Tamar, while it averaged on Sweet Charlie in the same period 6.7-2.7 individuals/leaf. The estimated reduction percent are shown in Table 4 revealed a slight difference between either of the two strawberry cultivars or the two treatments i.e. release of *P. persimilis* or acaricides which enhanced utilizing of the predatory mite in IPM programs.

Concerning releasing rate, which was 1/10 & 1/7 as predator/prey ratio herein, and pre-release mean number of *T. urticae* are a topic of discussion. Several factors are relevant in this concern such as the prevailing climatic factors, percentage of infested leaves, times of pruning, mulching time which influence dispersing of predatory mites and wind velocity and direction as mentioned by Coop and Croft (1995) using *Neoseiulus fallacis* (Garman). The studies of Oatman *et al.* (1968, 1976 &1977) in California are very interesting because of its similarity with the Egyptian climatic conditions. Two releasing rates of 5 and/or 10 individuals/plant of *P. persimilis* did not lead to a significant difference in *T. urticae* population or fruit yield of strawberry Tufts cultivar. They compared between *P. persimilis, A. californicus* and *Metaseiulus occidentalis* released at 10 individuals/plant of strawberry when *T. urticae* averaged 1 active stage/leaflet. The highest fruit yield was recorded with *P. persimilis* and the lowest with *M. occidentalis.*

The present investigation revealed the efficiency of *P. persimilis* for biocontrol of *T. urticae* in strawberry farms in arid areas. However, comprehensive research dealing with integration between predatory mites and selective acaricides, strawberry yield and cost benefit ratio analysis are very needed for private sector. The lower population density of *T. urticae* stages recorded on

Table1. Mean population density *of Tetranychus urticae* stages and *Phytoseiulus persimilis* individuals/leaf of strawberry Sweet Charlie and Tamar cv. and mean reduction percentage obtained after release of the predatory mite.

Cultivar		*T. urticae* release plots			Predatory mite	*T. urticae* check plots		
		adult	immature	egg	*P. persimilis*	adult	immature	Egg
Sweet	Mean ± SE	5.0±0.55	14.18±1.628	14.92±1.74	5.61±0.831	25.88±3.78	78.11±12.79	84.92±11.25
Charlie cv	Mean % reduction	62.2	60.46	55.6	-	-	-	-
Tamar cv	Mean ± SE	4.97±0.53	32.152±3.72	35.74±4.50	10.76±1.542	42.65±5.54	142.2±22.81	162.46±24.8
	Mean % reduction	37.17	45.9	45.42				

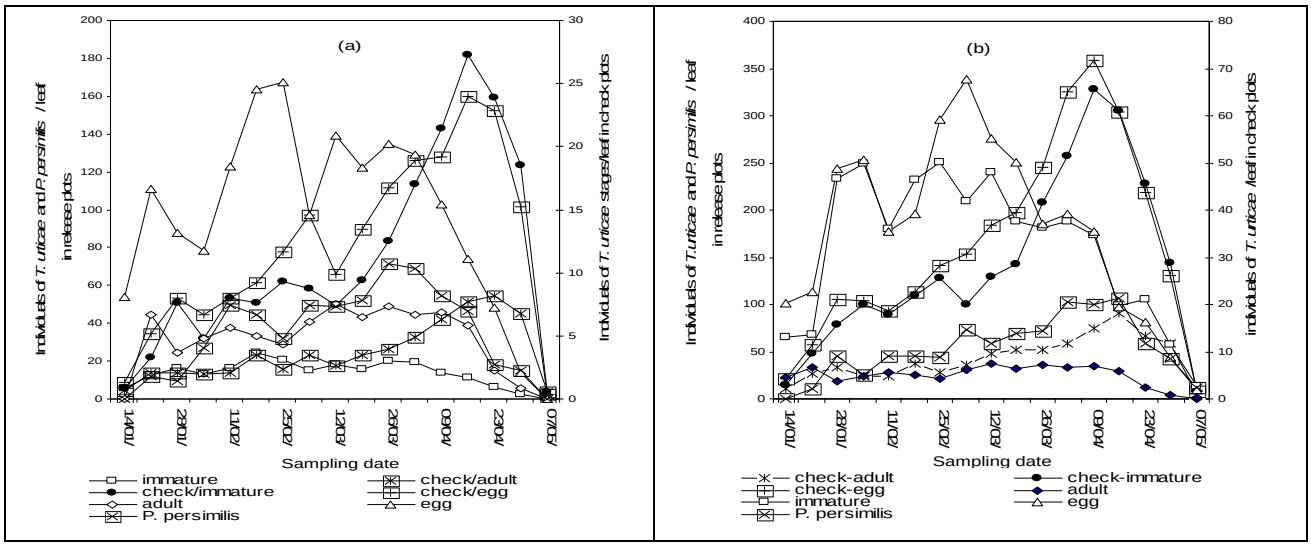

Fig. (1): Mean population densities of *T. urticae* stages (adult, immature and egg) /leaf of (a) Sweet Charlie cv. and (b) Tamar cv. in release plots, *P. persimilis* and check plots.

Table 2 .Mean population densities of *T. urticae* stages / leaf of Sweet Charlie (SC) cv. in *P. persimilis* release, Macomite and Check plots respectively during 2006/2007 Season.

sampling date	Egg			Immature			Adult		
	P. persimilis	Macomite	check	*p. persimilis*	Macomite	check	*p. persimilis*	macomite	check
04/12/2006**	24.1	24	23.95	20.55	20.6	20.62	4.7	4.82	4.68
11/12/2006	23.2	2	62.25	8.9	1.9	40	3.35	0.9	10.8
18/12/2006	25.35	26	46.05	15.05	1.8	39.15	5.9	1.1	10.85
25/12/2006	24.75	5.6	43.05	17.8	6.55	35.75	7.65	2.6	14.45
01/02/2007	20.7	10.2	59.9	27.55	9.2	44.75	10.8	3.9	17.9
08/02/2007	20.45	2.45	64.8	24.1	1.8	49.95	8.6	1.35	20.5
15/02/2007	18.75	4.5	35.15	24.95	3.55	30.45	8.25	2.2	12.6
22/02/2007	21.05	6.55	47.05	16.05	6.5	41.2	8.25	3.95	20.8
01/03/2007	11.95	10.55	45.1	8.1	11.9	36.15	3.95	3.6	13.7
08/03/2007	12.4	12.45	87.5	9.55	13	61.55	3.55	4.4	14
15//03/2007	14.2	16.45	115.85	11.55	14.55	75.33	4.75	6.55	16.75
22//03/2007	20.65	41.05	138.05	14.45	52.7	124.2	6.9	15.15	20.45
29//03/2007	1.85	3.6	134.2	2.25	3.45	129.3	1.75	1.85	22.3
05/04/2007	4.2	20.7	222.5	3.85	17.15	189.7	2.3	8.25	31
12/04/2007	5.75	26.95	237.5	5.6	21.75	206.1	2.6	19.1	29.9
19/04/2007	5.05	0.55	212.3	3.85	0.2	181.2	2.5	0.35	43.3
26/04/2007	2.9	1.9	230.8	2.25	1.5	224.9	1.4	0.65	43.72
03/05/2007	6.85	4.25	194	4.3	2.6	181	1.3	1.7	20.6
10/05/2007	1.35	13.35	164.3	1.52	9.55	168.8	1	4.6	44.1
17/05/2007	1.15	7.75	70.9	1.05	7.75	62.2	0.25	2.75	12.8
24/05/2007	0	2.5	41	0	2.05	43.2	0	75	6.9
31/05/2007	0	1.45	7.55	0	2.13	6.88	0	0	2.33
Mean± SE	12.12±1.9	11.13±2.27	104±16.01	10.15±1.8	9.64±2.41	90.6±14.9	4.07±0.6	7.48±3.36	19.74±4.47

** the first release date and followed treatments are seen in M&M section.

Table 3 Mean population densities of *T. urticae* stages / leaf of Tamar(T) cv. in *P. persimilis* release , Macomite and Check plots respectively during 2006/2007 Season.

Sampling date	Egg			Immature			Adult		
	P. persimilis	Macomite	check	*p. persimilis*	Macomite	check	*p. persimilis*	Macomite	check
04/12/2006**	32.85	32	32.55	21.2	21	20.98	7.15	7.25	7
11/12/2006	23.6	3	49.95	18.35	3.85	43.25	5.25	0.95	8.65
18/12/2006	24.7	5.15	101.46	24.7	5.5	69.46	8.3	2.5	25
25/12/2006	27.5	12.2	93.1	22.95	7.1	81.65	9.5	5.6	16.4
01/02/2007	35.8	37.6	120.5	25.1	40.65	115.25	12.65	14.45	32.3
08/02/2007	34.25	4.05	133.65	20	4.2	130.55	10.95	2.65	36.1
15/02/2007	38.6	5.2	124.8	30.05	5.45	117.85	15.55	4.4	32.5
22/02/2007	26.45	18.5	118.45	27.95	13.65	101.25	11.69	4.69	21.15
01/03/2007	14.95	12.95	141.5	14.4	9.8	120.41	6.45	4.4	32.91
08/03/2007	20.45	20.5	124.75	27.6	13.75	112.85	8.85	6.3	31.1
15//03/2007	23.2	26.15	152.65	30.85	21.9	147.25	9.25	8.6	36.9
22//03/2007	38.9	53.95	204.2	40	36.4	148.13	13.1	21.85	37.08
29//03/2007	6.35	7.85	214.8	5.05	5.95	191.75	3.2	3.85	39.2
05/04/2007	20.85	49.5	364.3	16.05	34.05	337.27	7.75	18.8	56.09
12/04/2007	19.55	69.1	398.7	11.66	47.45	412.5	8.05	33.3	64.42
19/04/2007	16.1	0.95	415.9	13.5	1.25	424.9	5.25	0.4	73.4
26/04/2007	10.05	6.8	386.1	5.4	6.25	475.9	3.95	2.8	83.3
03/05/2007	5.5	25.8	315.6	6	13.75	333.1	2.85	8.25	60
10/05/2007	3.85	26.8	156.5	6.55	29.1	204	1	16.75	54.1
17/05/2007	6.9	18.05	59.3	0	18.55	123.4	2	5.6	20.1
24/05/2007	0	3.95	45.18	0	2.65	65.14	0	0.9	8.55
31/05/2007	0	0.95	9.14	0	1.65	36.18	0	0	4.88
Mean± SE	19.56±2.64	20.05±4.00	171±26.76	16.7±2.43	15.6±2.94	173±28.65	6.94±0.9	7.92±0.93	35.5±17.76

** the first release date and followed treatments are seen in M&M section.

Table (4): Mean population density of *T . urticae* individuals/leaf of Sweet Charlie and Tamar cvs. and mean percent reduction obtained after release of the predatory mite and acaricide applications.

T .urticae stage	Cultivar	Sweet Charlie			Tamar		
	Treatment	*P. persimilis*	Macomite	Check	*P. persimilis*	Macomite	Check
Adult	Mean ± SE	4.08± 0.676	7.49±3.36	19.7± 2.40	6.94±0.94	7.92±1.77	35.5± 4.47
	Mean % Reduction	46.1	53.9	--	56.3	64.4	--
Immature	Mean± SE	10.15±1.85	9.64±2.47	90.6±14.95	16.7±2.43	15.6±2.94	173±28.65
	Mean % Reduction	68.8	54.9	--	60.7	66.1	
Egg	Mean± SE	12.12±1.99	11.13±2.27	104± 16.01	19.56±2.64	20.05±4.00	171±26.76
	Mean % Reduction	65.3	51.7	-	62.6	59.5	

Table (5): t values (at 0.05) calculated for differences between means population density of *T. urticae* on Sweet Charlie and Tamar cvs check plots.

T. urticae stage	Calculated t value	Critical t value	means value
Adult	-2.6 8	1.69*	(80.42-62.45)
Immature	-2.61	1.69*	(73.87-142.2)
Egg	-3.01	1.69*	(24.63-42.65)

* Refers to significance difference between the population density of *T. urticae* adult, immature and egg stages in the strawberry cultivars.

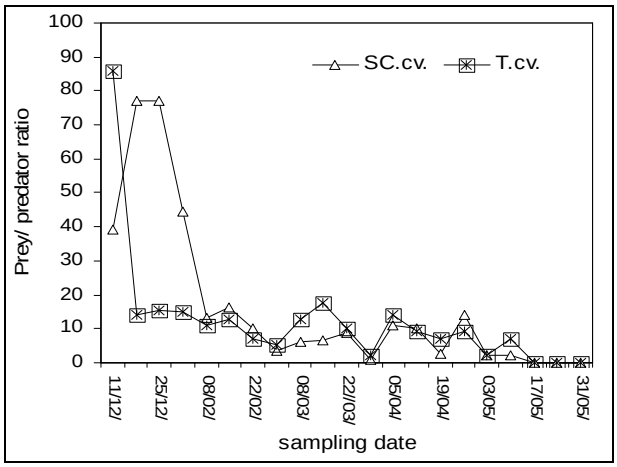

Fig.2 .Predator prey ratio (1predator: number of prey) between *T. urticae and P. persimilis* on Sweet Charlie (SC) and Tamar (T) strawberry cultivars during 2006/2007 season.

Sweet Charlie cv in check plots than on Tamar on herin coincided with the significant difference shown in table 5 and are agreement with finding of Walsh (20020.

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