LARGE SCALE PRODUCTION AND RELEASE OF THE PREDATORY MITE, *PHYTOSEIULUS MACROPILIS* (BANKS) TO CONTROL *TETRANYCHUS URTICAE* KOCH ON COMMERCIAL STRAWBERRY PLANTATIONS (ACARI: PHYTOSEIIDAE & TETRANYCHIDAE)

IBRAHIM H. HEIKAL[1]; MOSTAFA H. MOWAFI[2] AND AHMED A. EBRAHIM[1]

[1]*Plant Protection Research Institute, Agric. Res. Center.*
[2]*Zoology and Nematology Dep., Fac. Of Agric., Al-Azhar Univ.*

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INTRODUCTION

The two-spotted spider mite, *Tetranychus urticae* Koch is considered one of the main pests of strawberry in Egypt and many countries, that often causes severe damages to plants and consequently to quality and quantity of the yield (Masis&Aguilar,1990; Decou, 1994; Heikal *et al.*, 1999; Heikal, &Ibrahim, 2001). It is difficult to control spider mites by chemical acaricides alone because of developing resistance to repeated applications (Cranham & Helle, 1985; Geoghiou, 1990). Thus, there has been an increasing interest in controlling spider mites with bio-control agents. The phytoseiids are considered to be among the most important natural enemies of spider mites (Takahashi & Chant, 1994; McMurtry&Croft, 1997). The successful trials which carried out in Egypt by Heikal, 2001 and Heikal & Ibrahim, 2002 for mass rearing the predatory mite, *Phytoseiulus macropilis* (Banks) encouraged to increase its application as a bio-control agent on strawberry plantations. Therefore, the present work is an attempt to expand the application of producing and releasing the predatory mite, *P. macropilis* on a large scale in a commercial strawberry farm.

MATERIAL AND METHODS

Large scale production of the predatory mite, *P. macropilis*

Four special net greenhouses were established at a chosen commercial farm in Abo-Sower district (Ismailia Governorate, Egypt). Each of the greenhouse dimensions was 6.5m (width) by 40m (length) and 3.5m (height), with a trapped-door in one side. Roof and all sides of the greenhouse were covered with dark net

plastic (500 mesh). The soil of each greenhouse was well- ploughed, fertilized and treated with the recommended fungicides according to the standard commercial practices. Kideny bean seeds, *Phaseolus vulgaris* (L.) (var. Nebraska) were sown by using the double-row per bed method. The area consisted of five beds each of about 40m long. Sowing bean seeds occurred according to a special schedule, to produce the predator yield at the desired time of release on strawberry plants. The first and second dates of sowing were at September3, 2004 and November13, 2004, respectively. Two screenhouses were planted on each date, one of these was for mass production of the two-spotted spider mite *T. urticae* as preferable prey; while the other was for of the predatory mite *P. macropilis* mass production. Three beds of each greenhouse were planted firstly and the fourth and fifth ones were planted after 10, and 20 days, respectively. About 260 plants were grown in each bed side. Plants were watered as required using a rubber tube nozzle system. When bean seedlings reached about two weeks old, leaves infested with *T. urticae* were distributed over the new foliages. The two-spotted spider mites moved off the infested leaves to the bean seedlings 2-3 days later, then the dried bean leaves were removed. When the spider mite population in the predator greenhouse reached a reasonable level (*i.e.* 40-60 moving stages/leaflet), bean plants were inoculated with bean leaves harboring the predator's individuals (2000-3000 predator/bed). Yellow and blue plastic sheets covered with a special sticky material were used as insect traps specially; white flies and leaf miners to reduce insect contamination.

Ten leaflets per bed were randomly sampled weekly where both the predator and prey moving stages were counted using a hand lens (20x) to determine the prey-predator ratios. When the number of spider mite was few (less than 10 individuals of prey per one predator) heavy infested leaves with *T. urticae* were collected from the prey greenhouse and distributed over the bean foliage to augment the prey density. Ideal spider mite: predator (*Metaseiulus occidentalis* (Nesbitt)) ratio was between 20 to 40 spider mite per one predator (Hoy *et al.*, 1982).

The predator yield was also estimated; randomized samples of twenty leaflets/bed were collected and directly examined by a hand lens where the predator moving stages were counted. Numbers of plants present and leaflets per plant were also estimated. By this way the predator yield (population) was nearly evaluated every week in the predator greenhouse.

Collecting the predator individuals

Predators in the first three beds were used for the first release on strawberry; while predators of the fourth and fifth beds were used for additional

release on the same field specially the hot spot areas. To reduce spider mites on the collected leaflets, bean plant in the desired bed usually left without adding additional *T. urticae* several days before the collecting date to reduce its density in the release area. Bean leaflets harboring the predator individuals were collected early on the date of release in plastic bags and tied with rubber bands. The collected predators were transferred to the field using ice boxes.

Predator release

The same commercial farm in Abow-Sower district (Ismailia Governorate) was chosen for releasing the predatory, *P. macropilis*. Eight plots, each five feddan cultivated with different strawberry varieties (Diamond, Vestival and Camarosa) were chosen. Four strawberry plots were employed for early predator release on November 27, 2004; while the other four plots for the late release on January 8, 2005. The predators were released at the previous date with the rate of 3-5 predators/bit (60000-100000 predators/feddane). Randomized samples of fifty leaflets were taken at weekly intervals. Counts of moving stages of *P. macropilis* and *T. urticae* were estimated in the field by a special magnified hand lens (x 20). Biweekly averages were then calculated.

RESULTS AND DISCUSSION

Data of autumn production of the predatory mite, *P. macropilis* are presented in Table 1. The predator population increased gradually after the predator inoculation. The estimated numbers of the predator after one week of the predator inoculation were 15100, 11800, 13400, 16200 and 17300 predators in beds A,B,C,D and E, respectively. After the fourth week of predator inoculation these values were 700000, 601100, 590300, 830000 and 690200 in the previous beds, respectively. Accordingly, the obtained yield of the predator in the greenhouse increased towards the end of the production period. Therefore, about 3400000 predator moving stages could be produced after four weeks of rearing the predator in a 6.5 x 40m greenhouse area.

Data of the winter mass production of the predatory mites *P. macropilis* are presented in Table 2. The estimated numbers of the predator after one week of the predator inoculation were 10000, 13200, 12600, 11900 and 15200 in beds A, B, C, D and E, respectively. After the fourth week of predator inoculation, these numbers increased to 690900, 550100, 610300, 513200, and 640400 in the previous beds, respectively. Accordingly, about 3000000 moving stages of the predator could be

obtained after four weeks of the predator inoculation. It could be noticed that the yield of the predator in the winter mass production was relatively lower than those of the autumn cycle. This agreed with those obtained by Heikal 2001 who stated that mass production of the predatory mite, *P. macropilis* under greenhouse conditions was easy and suitable allover the year seasons with comparatively high increase during autumn and spring months. The prey – predator ratios seemed to be suitable during the first three weeks of the predator rearing period, however, the supplement of additional prey individuals thereafter was not sufficient because of the predator reached its ultimate population. In such case, the predator collection has to be done. This technique of producing this mite was carried out with less labor requirements compared with those applied by Heikal and Ali 1996 when the same predatory mite species was reared on the two-spotted spider mite on bean plants grown in plastic pots or trays under laboratory conditions.

In the early release of the predatory mite, *P. macropilis* on strawberry plants, the two-spotted spider mite populations were at their low density on the day of the predator release (Table3). They were 0.1 – 0.2 motile stages/leaflet in plots A,B,C, and D. After the date of predator releasing, the *T. urticae* populations gradually increased in all released plots to reach their highest density on January 22, 2005 (the eighth week of predator release). They were 7.3, 6.2, 4.2 and 6.5 motile stages/leaflet in plots A, B, C, and D, respectively. However, these levels of mite infestation are known to be less injurious to plants and are considered within the economic threshold level Heikal, 1977. It is worth to mention that hot spots of mite infestation were occasionally recorded in the release plots, and in such instance, additional predator release was usually applied. Then, the *T. urticae* population slowly decreased to attain its lowest level until the end of strawberry season in late May.

The predator individuals began to appear in strawberry plants after two weeks of the predator release. Yet, scattered spots were usually detected. Then, the predator densities increased gradually to reach their highest peak on Feb. 19, 2005 in plot A(10.0 predators/leaflet) and at next sampling on March 5, 2005 in plot D (3.5 predators/leaflet).

In the late release of the predatory mite, *P. macropilis* on strawberry plants, the two-spotted spider mite densities were at relatively high level on the date of release compared with those recorded in early release (Table 4). They were 3.3, 21.7, 8.5 and 7.2 motile stages/leaflet in plots A,B,C and D, respectively. Then, the mite populations increased keeping their densities at moderate levels during the next four sampling dates to reach maximum populations of 16.2 and 19.2 motile

stages/leaflet in plots B and C, respectively on February 19, 2005 and 20.7 and 22.2 motile stages/leaflet in plots A and D, respectively on March 5, 2005. These levels of mite infestation are known to be moderate and relatively higher than the economic threshold level. Yet, low symptoms of damages appeared on strawberry plants especially in several hot spots. However, two additional predator releases were applied to suppress the mite infestations. The mite population then declined to attain very low levels by the end of strawberry season at late May.

TABLE (I)

Estimated yield of the predatory mite *P. macropilis* during autumn mass production.

Sampling date	No. bed	Estimated No. of the predator on each bed	Prey : Predator ratio
Oct. 31, 2004	A*	-	-
	B*	-	-
	C*	-	-
	D	-	-
	E	-	-
Nov. 6	A	15100	57.5:1
	B	11800	41.2:1
	C	13400	46.4:1
	D*	-	-
	E	-	-
Nov. 13	A	60000	28.1:1
	B	59200	36.2:1
	C	57600	27.6:1
	D	16200	40.3:1
	E*	-	-
Nov. 20	A	200	7.9:1
	B	181000	8.2:1
	C	172100	6.7:1
	D	61200	25.9:1
	E	17300	39.9:1
Nov. 27	A**	700000	1:4.5
	B**	601100	1:3.1
	C**	590300	1:5.1
	D	182000	3.9:1
	E	68200	24.8:1
Dec.4	D**	830000	1:5.3
	E	164100	6.1:1
Dec.11	E**	690200	1:3.8
Total No. of collected predator		3411600	

*Date of predator inoculation.

**Date of predator collection.

TABLE (II)

Estimated yield of the predatory mite, *P. macropilis* during winter mass production.

Sampling date	No. bed	Estimated No. of the predator on each bed	Prey : Predator ratio
Dec. 11, 2004	A*	-	-
	B*	-	-
	C*	-	-
	D	-	-
	E	-	-
Dec. 18	A	10000	37.3:1
	B	13200	40.1:1
	C	12600	37.5:1
	D*	-	-
	E	-	-
Dec. 25	A	54700	31.4:1
	B	55300	23.8:1
	C	56000	29.1:1
	D	11900	35.9:1
	E*	-	-
Jan. 1, 2005	A	170000	6.3:1
	B	153500	4.7:1
	C	141800	2.9:1
	D	57200	21.6:1
	E	15200	30.3:1
Jan. 8, 2005	A**	690900	1:3.5
	B**	550100	1:2.9
	C**	610300	1:4.0
	D	171300	5.2:1
	E	60400	19.8:1
Jan. 15, 2005	D**	513200	1:3.9
	E	158500	5.8:1
Jan., 22 2005	E**	640400	1:3.3
Total No. of collected predator		3004900	

*Date of predator inoculation.

**Date of predator collection.

Similar trends were obtained in the late release of the predator. Nevertheless, the highest peak of the predator occurred on March 5, 2005 with relatively high densities than those recorded in the early predator release. They were 7.7, 8.5, 9.3 and 12.1 in plots A, B, C, and D, respectively. These findings agreed with those obtained by Heikal & Ibrahim 2001.

The prey: predator ratios were also estimated (Table 3&4). In the early release of the predator; the prey: predator ratios ranging between 3 and 39 mite per one predator in the first three post counts; while in the late predator release they ranged between 8 and 167 mites per one predator. Thus, additional releases of predators were

TABLE (III)

Early release of the predatory mite, *P. macropilis* on a commercial strawberry field to control the two-spotted spider mite *T. urticae*.

Sampling date	Plot	No. mites/leaflet		Prey: Predator ratio
		T. urticae	*P. macropilis*	
Nov. 27, 2004, Pre – count, date of 1st release.	A	0.1	-	-
	B	0.1	-	-
	C	0.1	-	-
	D	0.2	-	-
Dec. 11	A	0.3	0.0	-
	B	1.0	0.0	-
	C	2.0	0.1	20:1
	D	1.1	0.1	11:1
Dec. 25	A*	2.9	0.2	14:1
	B*	1.4	0.0	-
	C*	2.0	0.2	10:1
	D*	1.0	0.0	-
Jan. 8, 2005	A	3.2	0.6	5:1
	B	1.1	0.6	2:1
	C	3.3	1.3	3:1
	D	7.8	0.2	39:1
Jan. 22	A*	7.3	0.7	10:1
	B*	6.2	0.7	9:1
	C*	4.2	0.5	8:1
	D*	6.5	0.4	16:1
Feb. 5	A	5.1	1.4	4:1
	B	3.9	0.3	13:1
	C	3.1	1.2	3:1
	D	5.1	0.4	13:1
Feb. 19	A	9.0	10.0	1:1
	B	0.7	0.1	7:1
	C	2.9	1.8	2:1
	D	5.6	1.3	4:1
Mar. 5	A	5.2	4.7	1:1
	B	0.3	1.1	0.3:1
	C	0.3	0.1	3:1
	D	8.5	3.5	2:1
Mar. 19	A	0.3	0.3	1:1
	B	0.1	0.0	-
	C	0.1	0.0	-
	D	0.1	0.1	1:1
Apr. 2	A**	0.0	0.0	-
	B**	0.2	0.0	-
	C**	0.0	0.0	-
	D**	0.1	0.1	1:1

*Additional predator release was applied.

** Similar data were observed until the end of strawberry season in late May.

TABLE (IV)

Late release of the predatory mite, *P macropilis* on a commercial strawberry field to control the two-spotted spider mite, *T. urticae*.

Sampling date	Plot	No. mites/leaflet		Prey: Predator ratio
		T. urticae	*P. macropilis*	
Jan. 8, 2005 Pre – count, date of 1st release	A	3.3	-	-
	B	21.7	-	-
	C	8.5	-	-
	D	7.2	-	-
Jan. 22	A	4.4	0.1	44:1
	B	27.5	0.0	-
	C	20.0	0.3	67:1
	D	11.3	0.1	113:1
Feb. 5	A	4.9	0.1	49:1
	B	10.1	0.1	101:1
	C	15.0	0.7	21:1
	D	17.3	0.5	35:1
Feb. 19	A*	16.7	0.1	167:1
	B*	16.2	0.4	41:1
	C*	19.2	2.0	10:1
	D*	20.0	2.4	8:1
Mar. 5	A*	20.7	7.7	3:1
	B*	14.3	8.5	2:1
	C*	13.2	9.3	1:1
	D*	22.2	12.1	2:1
Mar. 19	A	17.6	4.8	4:1
	B	5.2	0.7	7:1
	C	2.0	2.1	1:1
	D	6.7	2.9	2:1
Apr. 2	A**	1.0	1.5	1:1
	B**	0.0	0.0	-
	C**	0.0	0.0	-
	D**	0.5	1.0	1:1

*Additional predator release was applied.

**Similar data were observed until the end of strawberry season in late May.

applied in both times of predator releases to correct these ratios and to increase the predator efficacy. Then, the prey: predator ratios decreased in the next inspection week (in both early and late predator releases) to become within the suitable ratios. Several authors emphasized the importance of releasing the mites early in the season and suitable rate. Bravenbaer & Dosse 1962 indicated that the best control with *P. persimilis* preying on *T. cinnabarinus* was obtained when the predators were liberated at rather low prey populations. Strong & Croft, 1995 released the predatory mite *Metaseiulus occidentalis* (Nesbitt) to control *T. urticae* on hops, *Humulus lupulus* L., and indicated that the higher the predator- prey ratio, the better the spider mite control

was achieved. Heikal *et al.* 2004 advised to release the predatory mite, *P. macropilis* to control *T. urticae* on rose bushes early in the season.

The foregoing results emphasized the possibility of large scale producing and releasing the predatory mite, *P. macropilis* to control spider mites in commercial strawberry plantations. Additional predator releases were usually required to reduce the pest population, especially in the hot spot areas.

SUMMARY

A commercial strawberry farm in Abo-Sower district (Ismailia Governorate, Egypt) was chosen for large scale production and releasing of the predatory mites *P. macropilis* (Banks) for controlling the two-spotted spider mite, *T. urticae* Koch on commercial strawberries in the same farm. Two screenhouses (6.5m wide x 40m long x 2m high) were established for producing the predators in early and late production periods (November –December, 2004 and January-February, 2005) where about 3.4 and 3 million moving stages of predators were collected in the two previous producing periods, respectively. Augmentative releases of the predator were applied on a commercial strawberry field of about 40 feddans in the same farm to control the two-spotted spider mites *T. urticae*. The predator was released in the early or late season with a rate of 3-5 predators/bit (about 60000-100000predators/feddan). In the early predator release, the *T. urticae* densities remained near or within the economic threshold levels, while in the late predator release the spider mite infestations were relatively higher than those in the early predator release. In the two predator release times, several hot spot areas were detected where additional predator releases were applied to reduce the pest populations. The highest predator populations occurred on both times of release on late and early March with relatively high densities in late predator release.

REFERENCES

BRAVENBAER, L. and G. DOSSE (1962): *Phytoseiulus riegeli* Dosse as a predator of red spider mites of the *Tetranychus urticae* group in Germen. (*Entomol. Exp. Appl. 5: 291-304*).

CRANHANA, J. E. and W. HELLE (1985): Pesticide resistance in Tetranychidae. In spider mites. Their Biology, Natural enemies and Control. (*Vol. B. Elsevier, Amsterdam, PP. 405-421*).

DECOU, G. C. (1994): Biological control of the two-spotted spider mites (Acarina: Tetranychidae) on commercial strawberries in Florida with *Phytoseiulus persimilis* (Acarina: Phytoseiidae). (*Flo. Entomo.l., 77 (1): 33-41*).

GEOGHIOU, G. P. (1990): Overview of insecticide resistance in *Managing Resistance to Agrochemicals* (M.B. Green, H. M. LeBaron and W. K. Moberg eds). (*American Chemical Society Symposium Series 421, 18-41*).

HEIKAL, I. H. (1977): Ecological and biological studies on mites occurring on some deciduous fruit trees. (*Ph.D. Thesis Fac. Agric. Al-Azhar Univ. 109pp*).

HEIKAL, I. H. (2003): Two preliminary methods for mass production of the predatory mite, *Phytoseiulus macropilis* (Banks) at different season (Acari: Phytoseiidae). (*Egypt. J. Res., 79 (3): 907-914*).

HEIKAL, I. H. and F. S. ALI (1996): Mass rearing of the predaceous mite, ***Phytoseiulus macropilis*** (Banks) (Acari: Phytoseiidae). (*Egypt J. Biol. Pest control, 6 (2): 143-145*).

HEIKAL, I. H. and G. A. IBRAHIM (2001): Releases of *Phytoseiulus macropilis* (Banks) to control *Tetranychus urticae* Koch on strawberry in Ismailia Governorate (Acari: Phytoseiidae and Tetranychidae). (*Egypt. J. Res. 79 (3): 839-906*).

HEIKAL, I. H. and G. A. IBRAHIM (2002): Mass production of the phytoseiid predator, *Phytoseiulus macropilis* (Acari: Phytoseiidae). (*Egypt. J. Agric. 80 (3): 1173-1179*).

HEIKAL, I. H.; K. M. El-SAYED; M. M. FAWZI and MONA, S. El-GHOBASHY (2004): A preliminiary biological control study on *Tetranychus urticae* Koch on rose bushes (Acri: Tetranychidae). (*Annals of Agric. Soc. Moshtohor. Vol. 42(1): 365-371*).

HEIKAL, I. H.; M. M. FAWZI; H. M. EBRAHIM and G. A. IBRAHIM (2000): Biological control of *Tetranychus urticae* Koch on strawberry by the predatory mite, *Phytoseiulus macropilis* (Banks) (Acari: Tetranychidae and Phytoseiidae). (*Egypt. J. Agric. Res., 78(4):1517-1523*).

HOY, M.; D. CASTRO and D. CAHN (1982): Two methods for large scale production of pesticide resistance of the spider mite predator *Metaseiulus occidentalis* (Nesbitt) (Acri: Phytoseiidae). (*Z. angew. Entomol., 94:1-9*).

MASIS, C. and H. AGUILAR (1990): Control of the mite *Tetranychus urticae* Koch in strawberries (*Fragaria* sp.) in Costa Rica. (*Manjo integrado de plagas., 17: 5-7*).

McMURTRY, J. A. and B. A. CROFT (1997): Life-styles of phtyseiid mites and their roles in biological control. (*Annual. Rev. Entomol, 42: 291-321*).

STRONG, W. B. and B. A. CROFT (1995): Inoculative releases of phytoseiid mites (Acarina: Phytoseiidae) into rapidly expanding canapy of hops of control of *Tetranychus urticae* (Acarina: Tetranychidae). (*Environ. Entomol., 24: 446-453*).

TAKAHASHI, F. and D. A. CHANT (1994): Adoptive strategies in the genus *Phytoseiulus* Evans. (Acari: Phytoseiidae). (*Geographic distribution, Int. J. Acarol. 19: 15-22*).