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Effects of four Control Measures on *Bemisia tabaci* (Genn.) and its Parasitoids on Tomato at Kafr El-Sheikh

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ABSTRACT

Parasitism percentages of the aphelinid parasitoids, *Eretmocerus mundus* (Mercet) and *Encarsia lutea* Masi were highly significantly decreased by four control measures of *Bemisia tabaci* (Genn.) on tomato plants during seasons 2000 and 2001. Jojoba oil exhibited the lowest reduction of parasitism (26.55 and 31.75%) for *E. mundus* and (25.65 and 21.71%) for *E. lutea* during 2000 and 2001, respectively. A mixture of jojoba oil and silicron decreased parasitism percentage of the parasitoids more than mulching of the soil with yellow polyethylene, but without significant differences. However, Silicron insecticide showed the highest reduction of parasitism (67.64 and 68.32%) for *E. mundus* and (68.23 and 58.31%) for *E. lutea* during the two seasons, respectively. Population fluctuations of these aphelinids were obviously decreased by the four measures during treatment periods of 2000 and 2001. A mixture of jojoba oil and silicron decreased greatly numbers of eggs, nymphs and adults of *B. tabaci*, followed by jojoba oil, then silicron and mulching during the two seasons. The highest reduction of eggs, nymphs and adults was 28.41, 29.19 and 52.25%, respectively during 2000, corresponding to 42.69, 41.43 and 59.70% during 2001. However, the lowest reduction was 8.73, 15.68 and 19.42% for the three stages, respectively, during 2000, opposite to 14.24, 11.85 and 36.05% during 2001.

Key words: *Bemisia tabaci, Eretmocerus mundus, Encarsia lutea*, abundance, population fluctuation, control measures.

INTRODUCTION

The cotton whitefly, *Bemisia tabaci* (Genn.) has been hardly controlled with conventional insecticides in agronomic and horticultural production systems. Although, new chemical insecticides have been introduced during the past decade, their intensive use in some production systems has resulted in reduced susceptibility of the pest (Palumbo *et al.*, 2001). Conservation of biological control includes the preservation and enhancement of natural enemies and is the cornerstone of all approaches to biological control. Few researches have evaluated effects of natural enemies on population dynamics of *B. tabaci* in any system and less effort has been exerted on determining factors adversely constraining or potentially enhancing biological control of this pest (Naranjo, 2001). The present work was conducted to evaluate four control measures of *B. tabaci* on the parasitoids *Eretmocerus mundus* (Mercet.) and *Encarcia lutea* Masi and stages of the pest on tomato plants in the field.

MATERIALS AND METHODS

1. Experimental design and treatments :

Field experiments were conducted at the Experimental Farm of the Fac. of Agric., Kafr El-Sheikh region. An area of half feddan was prepared and divided into 15 plots of 140m^2 each (3 plots for each treatment) in a randomized block design.

Mulching of the soil with yellow polyethylene was made before transplanting of tomato (Cohen and Melamed-Madjar, 1978). A yellow polyethylene mulch was perforated for 10 cm diameter at a distance of 35 cm. laid over all rows which were 125 cm wide.

Tomato seedlings were transplanted on Jul., 1st of the two seasons 2000 and 2001. Treatments with jojoba oil, silicron and a mixture of both were weekly applied from Aug., 1st until Sep., 19th (eight times) using a solo motor, at the rate of 400 litres/feddan for complete coverage. This motor was twice cleaned with water and sodium carbonate after such treatments. A mixture of both material was applied at the ratio of 1:1 (V/V). Profenofose (commercially named silicron) 72% EC is used at 0.2%. It was applied at the rate of 750 ml/400 litres water. The natural jojoba oil 96% EC is produced by Egyptian Natural Oil Co. It was applied at the rate of 10 ml/100 litres water. However, some plots were left without treatment to serve as a control.

2. Abundance and population fluctuation of the parasitoids :

A weekly random sample of 15 leaflets from 5 plants (3 leaflets/plant) in each treatment was picked, put in a labelled paper sac and transferred to the laboratory, where nymphs of *B. tabaci* were examined on leaflets surfaces with the aid of a stereo-microscope and living individuals were only counted. Stalks of leaflets were inserted in cotton pieces moistened with water and placed in cages of glass tubes covered with muslin tissues and secured with rubber bands. These cages were daily observed for parasitoids emergence. Parasitic adults were collected by an aspirator, identified and counted.

3. Efficiency of four control measures on *B. tabaci* :

The same previous technique was followed on 21 leaflets from 7 plants in each treatment, where eggs and nymphs of *B. tabaci* were counted. In addition, adults were directly counted on leaflets surfaces with the aid of a glass mirror that reflects the leaflet underside. Samples were taken 20, 40, 60, 80 and 100 days after transplanting, *i.e.* before treatment, after 2, 5 and 8 treatments, as well as 20 days after the last treatment, respectively. Efficacy of such treatments on *B. tabaci* populations was evaluated by numbers of the stages on treated tomato compared with those on untreated ones.

Data were analysed by ANOVA and compared by Duncan's multiple range test. Correlation between

parasitisms of parasitoid species, number of *B. tabaci* nymphs; average temperature and relative humidity were determined. Temperature and relative humidity at Kafr El-Sheikh were kindly supplied by Dept. Entomol.; Rice Res. and Training Center.

RESULTS AND DISCUSSION

1. Abundance of the parasitoids :

Results of season 2000 (Table 1) reveal that the parasitism percentage of *E. mundus* was the highest (52.50%) on untreated tomato. Parasitism percentages decreased to 38.56, 26.57 and 23.72% on tomato treated with jojoba oil, mulching and a mixture of jojoba oil & silicron, respectively. The lowest parasitism (16.99%) was recorded on tomato treated with silicron. Parasitism percentages of *E. lutea* were 15.36, 11.42, 7.88, 7.41 and 4.88% on control and tomato treated with jojoba, the mixture, mulching and silicron, respectively. Total parasitism percentages of parasitic species were 67.86% on untreated tomato, 49.97% on jojoba treatment, 33.98% on mulched tomato, 31.61% on the mixture treatment and 21.87% on silicron treatment.

Total number of individuals of single or combined parasitoid species showed also the same trend as parasitism percentages on the five cases.

Results of season 2001 (Table 1) reveal that parasitism percentages, total number of individuals of single or combined parasitoid species, exhibited the same trend as those mentioned for the season 2000 on the five treatments.

Results of seasons 2000 and 2001 show that four control measures of *B. tabaci* decreased obviously parasitism percentages and total number of individuals of single or combined parasitoid species compared with the control. The highest decrease of these items was found on tomato treated with silicron, whereas the lowest was recorded on that treated with jojoba oil. These decreases were slightly higher during season 2001 than during season 2000. *E. mundus* was more adversely affected than *E. lutea*.

Numbers of *E. mundus* were considerably greater than those of *E. lutea* on five cases during the two seasons. El-Adl *et al.* (1998) found that jojoba oil treated once produced a slight decrease in parasitism percentages of *E. mundus* and *E. lutea* on *B. tabaci* infesting cotton at Kafr El-Sheikh region.

2. Population fluctuation of the parasitoids :

Population fluctuations of aphelinid species represented by weekly parasitism percentages, on five cases of tomato and prevailing temperature and relative humidity during seasons 2000 and 2001 are illustrated in Fig. (1). Results reveal that parasitism percentage of *E. mundus* and *E. lutea* increased gradually until it reached a peak in Sep., 26th during the two seasons on tomato treated with jojoba oil (Fig. 1A). On mulched tomato (Fig. 1B), parasitism increased gradually until Aug., 22nd, then decreased greatly in Aug., 29th and increased again gradually until Sep., 12nd to reach a peak in Sep. 19th followed by a gradual decrease during 2000 and 2001. Parasitism percentage increased gradually until it formed the 1st and lowest peak in Aug., 22nd, then decreased greatly in 29th and increased again rapidly to constitute the 2nd and middle peak in Sep., 5th. Afterwards, the 3rd and highest peak was formed in Sep., 19th, followed by an obvious decrease during the two seasons on tomato treated with the mixture (Fig. 1C). On tomato treated with silicron (Fig. 1D), parasitism decreased considerably almost during treatment periods, then, it increased towards the late season during 2000 and 2001. Parasitism percentage began high, then increased rapidly during untreated tomato flowering to reach the 1st peak in Sep., 5th and 2nd and higher peak in Sep., 26th for *E. mundus* (Fig. 1E). Regarding *E. lutea*, there was one peak in Sep., 12th. It is clear that four treatments except mulching decreased parasitism percentage of aphelinid species during treatment periods. However, parasitism of *E. mundus* was considerably decreased than that of *E. lutea*.

Statistical analysis indicated that differences in parasitisms of single or combined parasitoid species within such treatments were not significant, except those of *E. lutea* during 2001 which were highly significant at 1% (F=15.67**, LSD= 1.94 at 5% and 2.83 at 1%). However, differences in parasitisms of single or combined parasitoid species among five cases were highly significant at 1% (F= 159.55, 83.88 and 239.51 in 2000 and 53.17, 48.96 and 108.02 in 2001 for *E. mundus*, *E. lutea* and combined parasitoid species, respectively). Parasitisms of each parasitic species were highly significantly correlated with those of the other and combined parasitoids (Table 2). Numbers of *B. tabaci* nymphs showed highly significant correlations with the parasitisms of single or combined parasitoid species on jojoba oil treatment during 2000 and 2001 and with those on the mixture treatment and untreated tomato during 2001. Temperature and relative humidity were negatively insignificantly correlated with numbers of single or combined parasitoid species, except with those on silicron treatment.

3. Efficiency of four control measures on *B. tabaci* :

Data of four control measures of *B. tabaci* stages during seasons 2000 and 2001 are presented in Table (3). Results show that at 20th day, (before treatment except mulching), mean numbers of eggs were significantly different, whereas those of nymphs and adults were slightly variable in most cases during 2000 and 2001. At 40th day (after 2 treatments), a mixture of jojoba oil and silicron exhibited the highest reduction in numbers of *B. tabaci* stages, followed by jojoba oil (except on nymphs in 2001, where silicron was the 2nd), then silicron and mulching. At 60th and 80th days (after 5 and 8 treatments, respectively), approximately similar results as those at 40th day were mostly obtained during 2000 and 2001. However, there were two exceptions: the 1st, silicron was more effective on numbers of nymphs than jojoba oil at60th day in the two seasons and the 2nd, mulching was more potent on numbers of eggs and nymphs than silicron at 60th and 80th days, respectively, in 2001. At 100th day (20 days after the last treatment except mulching) , the mixture showed the highest reduction in numbers of the three stages in the two seasons, followed by jojoba oil (except on nymphs in 2000, where silicron occupied the

Table (1): Effect of four control measures of *B. tabaci* on total number, parasitism percentage and mean number per sample of *E. mundus* and *E. lutea* during seasons 2000 and 2001 at Kafr El-Sheikh region.

Treatments	Year	*B. tabaci* nymphs	*E. mundus*				*E. lutea*				Two parasitoid species			
			Individuals		Parasitism		Individuals		Parasitism		Individuals		Parasitism	
		Total no.	Total no.	*R%	%	R%	Total no.	R%	%	R%	Total no.	R%	%	R%
Jojoba oil	2000	1901	733	43.70	38.56c	26.55	217	43.04	11.42c	25.65	950	43.55	49.97c	26.36
	2001	1978	800	33.22	40.44c	31.75	259	23.37	13.09b	21.71	1059	31.05	53.54c	29.52
Mulching	2000	2416	642	50.69	26.57b	49.39	179	53.02	7.41b	51.76	821	51.22	33.98b	49.93
	2001	2232	653	45.49	29.26ab	50.62	199	41.12	8.92a	46.65	852	44.53	38.17b	49.75
Jojoba oil+silicron	2000	2626	623	52.15	23.72b	54.82	207	45.67	7.88b	48.70	830	50.68	31.61b	53.42
	2001	1996	546	54.42	27.35b	53.84	149	55.92	7.46a	55.38	695	54.75	34.82b	54.16
Silicron	2000	2378	404	68.97	16.99a	67.64	116	69.55	4.88a	68.23	520	69.10	21.87a	67.77
	2001	2366	444	62.94	18.77a	68.32	165	51.18	6.97a	58.31	609	60.35	25.74a	66.11
Control	2000	2480	1302	0.00	52.50d	0.00	381	0.00	15.36d	0.00	1683	0.00	67.86d	0.00
	2001	2022	1198	0.00	59.25d	0.00	338	0.00	16.72c	0.00	1536	0.00	75.96d	0.00

Percentages in a column for each year followed with the same letter are not significantly different at 5% level by DMRT.
*R% = Reduction percentage than the control.

Table (2): Correlation coefficient (r) among parasitisms of single or combined parasitoid species, numbers of *B. tabaci* nymphs, average temperature and relative humidity in four treatments and control during tomato seasons 2000 and 2001.

Variables	Years	Jojoba oil	Mulching	Mixture	Silicron	Control
E. mundus × *E. lutea*	2000	0.861**	0.837**	0.860**	0.847**	0.823**
	2001	0.910**	0.882**	0.883**	0.767**	0.775**
E. mundus × combined	2000	0.992**	0.986**	0.992**	0.996**	0.968**
	2001	0.994**	0.993**	0.994**	0.991**	0.987**
E. lutea × combined	2000	0.920**	0.917**	0.917**	0.892**	0.926**
	2001	0.949**	0.931**	0.927**	0.837**	0.865**
E. mundus × *B. tabaci* nymphs	2000	0.966**	0.465	0.699*	0.219	0.178
	2001	0.928**	0.832**	0.847**	0.611*	0.878**
E. lutea × *B. tabaci* nymphs	2000	0.941**	0.381	0.725*	0.286	0.936
	2001	0.939**	0.618*	0.762**	0.418	0.918**
combined × *B. tabaci* nymphs	2000	0.985**	0.456	0.722*	0.235	0.256
	2001	0.947**	0.798**	0.839**	0.602	0.927**
E. mundus × temperature	2000	- 0.497	- 0.469	- 0.317	- 0.422	- 0.618*
	2001	- 0.562	- 0.180	- 0.132	- 0.871**	- 0.514
E. lutea × temperature	2000	- 0.598	- 0.476	- 0.466	- 0.783**	- 0.391
	2001	- 0.202	- 0.187	- 0.143	- 0.698*	- 0.236
combined × temperature	2000	- 0.536	- 0.488	- 0.358	- 0.494	- 0.584
	2001	- 0.480	- 0.186	- 0.136	- 0.866**	- 0.467
E. mundus × relative humidity	2000	- 0.298	- 0.027	- 0.036	- 0.587	- 0.316
	2001	- 0.476	- 0.015	0.043	- 0.675*	- 0.540
E. lutea × relative humidity	2000	- 0.181	- 0.202	- 0.378	- 0.599	- 0.155
	2001	- 0.184	- 0.078	- 0.039	-0.707*	- 0.283
combined × relative humidity	2000	- 0.276	- 0.082	- 0.117	- 0.602*	- 0.331
	2001	- 0.410	- 0.031	0.027	- 0.729**	- 0.499

* Correlation is significant at 0.05 level.
** Correlation is significant at 0.01 levels.

Table (3): Mean numbers and reduction percentages of *B. tabaci* stages at five intervals on tomato treated with four control measures during seasons 2000 and 2001 at Kafr El-Sheikh region.

Treatments	Year		*B. tabaci*																	
			Eggs					TM***	Nymphs					TM	Adults					TM
			Days after transplanting																	
			20	40	60	80	100		20	40	60	80	100		20	40	60	80	100	
Jojoba oil + silicron	2000	M*	1.35a	3.99a	6.11a	22.15a	32.38a	16.16	2.43a	4.43a	6.89a	24.61a	35.70a	17.91	1.22a	2.99a	5.53a	11.01a	17.33a	9.22
		R%**	55.74	34.80	23.72	26.97	28.16	28.41	31.55	38.73	26.70	34.06	17.25	29.19	57.64	49.06	38.07	62.60	59.43	52.25
	2001	M	0.85a	3.05a	3.33a	14.88a	20.10a	10.34	1.33a	3.72a	4.16a	14.61a	23.88a	11.59	0.83a	2.50a	3.44a	8.55a	11.72a	6.55
		R%	53.55	46.58	45.94	40.60	37.62	42.69	53.82	45.05	39.71	49.52	31.42	41.43	68.80	55.36	50.00	66.39	67.03	59.70
Jojoba oil	2000	M	2.00c	4.12b	6.38b	25.07b	35.88b	17.86	2.55b	5.70b	8.14c	26.33c	39.14d	19.83	1.43b	3.17b	6.24b	14.33b	19.73b	10.87
		R%	34.43	32.68	20.35	17.34	20.39	22.69	28.17	21.16	13.40	29.26	9.27	18.27	50.35	46.00	30.12	51.32	54.52	45.49
	2001	M	0.71b	3.00b	4.05b	14.83a	23.33b	11.30	1.54b	5.55c	6.16b	19.83b	29.49b	15.26	1.38b	2.66b	4.05b	12.49b	15.94b	8.79
		R%	61.20	47.46	34.25	40.80	27.59	37.53	46.53	18.02	10.72	31.48	15.31	18.88	48.12	52.50	41.13	50.91	55.16	49.93
Silicron	2000	M	1.93bc	4.49c	6.88c	27.00c	36.14bc	18.63	2.83b	6.24c	7.59b	25.40b	37.43b	19.17	1.35b	3.98c	6.12b	15.22c	22.41c	11.93
		R%	36.72	26.64	14.11	10.98	19.81	17.89	20.28	13.69	19.26	31.76	13.24	19.49	53.13	31.20	31.47	48.30	47.55	39.88
	2001	M	1.05c	5.02c	4.27c	20.44b	24.66c	13.60	1.55b	5.05b	6.00b	23.72cd	31.88bc	16.66	1.72c	3.01c	4.05b	16.83c	18.55c	10.61
		R%	42.62	12.08	30.68	18.40	23.46	21.16	46.18	25.41	13.04	18.04	8.44	16.23	35.34	46.25	41.13	33.84	47.82	42.26
Mulching	2000	M	1.72b	5.90d	7.14d	27.99cd	39.33d	20.09	2.72b	6.12c	8.55d	26.92c	38.55c	20.04	2.33c	5.16d	8.24c	22.33d	28.33d	16.01
		R%	43.61	3.59	10.86	7.72	12.74	8.73	23.38	15.35	9.04	27.67	10.64	15.68	19.10	12.10	7.73	24.15	33.68	19.42
	2001	M	1.27d	6.60d	4.10b	22.33c	29.33d	15.59	2.27c	6.11d	6.24b	23.16c	32.00cd	16.88	1.94d	3.66d	4.22bc	16.94c	22.22d	11.76
		R%	30.60	3.68	33.44	10.86	8.97	14.24	21.18	9.75	9.57	19.97	8.10	11.85	27.07	34.64	38.66	33.41	38.50	36.05
Control	2000	M	3.05d	6.12e	8.01e	30.33e	45.07e	0.00	3.55c	7.23d	9.40e	37.22d	43.14e	0.00	2.88d	5.87e	8.93d	29.44e	42.72e	0.00
	2001	M	1.83e	5.71cde	6.16d	25.05d	32.22	0.00	2.88d	6.77e	6.90bc	28.94e	34.82e	0.00	2.66e	5.60e	6.88d	25.44d	35.55e	0.00

Means in a column for each year followed with the same letter are not significantly different at 5% level by DMRT.
* M = Mean number
** R% = Reduction percentage than the control.
*** TM = Mean total reduction during treatment period.

2nd position), then silicron with considering the previous exception and mulching.

The variance of results at 20th day, (before treatment except mulching), may be interpreted by starting of *B. tabaci* infestation which pointed out the diversification of this pest. Therefore, the highest reductions in numbers of *B. tabaci* stages were obtained by spraying a mixture of jojoba oil and silicron, followed by jojoba oil, then silicron and lastly mulching. In general, the mixture reduced considerably the number of adults, followed by nymphs, then eggs during 2000, whereas its effect on the eggs and nymphs was similar during 2001. Jojoba oil reduced greatly the number of adults, followed by eggs and lastly nymphs during the two seasons. Silicron and mulching decreased obviously adults during the two seasons, followed by nymphs, then eggs during 2000 and the reverse during 2001. Sammour *et al.* (1993) reported that silicron reduced *B. tabaci* nymphs, adults and eggs on tomato by 92.7, 83.4 and 73.0%, respectively. Broad spectrum insecticides including silicron were commonly used on field and vegetable crops to kill mostly whitefly adults. Narrow range of oils and insecticidal soaps controlled eggs and nymphs of the pest, but they killed only a portion of the population even under the best conditions (Anonymous, 1995). El-Bessomy (1998) reported that jojoba oil killed 88.86% of the pest stages on tomato and its efficiency differed insignificantly with insecticides Admire, Nextar and Reldane. Abdel Megeed *et al.* (1998) sprayed alternatively 3 different insecticides including silicron every 4 and 7 days in the nursery and the field, respectively. They reported that the insecticide occupied the 2nd rank after seedling coverage.

In conclusion, the use of jojoba oil enhanced potentially *E. mundus* and *E. lutea* and controlled satisfactorily *B. tabaci* populations on tomato.

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