Egyptian Journal of Biological Pest Control, 23(1), 2013, 79-85

Compatibility of Bio-control Agents and Unconventional Pesticides against Mealy Bugs Infesting Medicinal and Ornamental Plants

Sayed[*], A. M. M.; A. M. M. El-Adawy[**] and S. A. Ahmed[**]
[*]Plant Protection Research Institute, Agricultural Research Center, Giza, Egypt
[**]Faculty of Environ. Agricultural Sciences, Suez Canal University, El-Arish, Egypt
(Received: February 12, 2013 and Accepted: March 16, 2013)

ABSTRACT

Compatible efficacy of certain biorational pesticides, the predator, *Rodolia cardinalis* (Muls.), the parasitoid *Anagyrus kamali* (Mani) and integration among them against the two mealy bug species; the Seychelles mealy bug, *Icerya seychellarum* (Westw.) and the hibiscus mealy bug, *Maconellicoccus hirsutus* (Green) on medicinal and ornamental plants were studied under field conditions at Ismailia, Egypt in year 2012. Means of reduction percentages of the mealy bugs populations throughout four weeks reached 61.93, 65.02, 89.0, 54.6, 91.2 and 76.2 % for the biorational pesticides against *I. seychellarum* on ficus trees, *M. hirsutus* on hibiscus shrubs, releasing the predator, *R. cardinalis*, the parasitoid, *A. kamali*, the pesticides integrated with releasing of *R. cardinalis* and of *A. kamali*, respectively. It was clear that release of *R. cardinalis* had a highly significant effect on suppressing the infestation of *I. seychellarum*. The results suggest that the combined use of certain biorational pesticides and each of the predator and/or the parasitoid on of the two mealy bug species showed better control than using single tool. Therefore, it can be concluded that the biorational pesticides application of the mealybugs can be successfully integrated with biological control agents.

Key words: Biorational pesticides, mealy bugs, medicinal and ornamental plants, *Rodolia cardinalis*, *Anagyrus kamali*, Egypt.

INTRODUCTION

Medicinal and ornamental plants are important crops in agricultural production for human health, indigenous pharmaceutical, perfumery, flavor, cosmetic industries as well for exportation. (Kumar *et al.*, 2004). Egypt possesses a great potential for growing different medicinal, ornamental and aromatic plants. Various pests associated with these plants, especially piercing sucking pests. Mealy bug species are one of them. Feeding activity of these pests cause weakens, stunts plants, leaf distortion, yellowing, gall production and reduce aesthetic and marked value (Meyerdirk *et al.*, 2002). Growers relay on pesticides to suppress the population of the ornamental and medicinal plant pests (El-Borollosy *et al.*, 1990 and Negm *et al.*, 2000). Insect resistance, residues pollution, wide toxicity spectrum and adverse effects of the widespread use of pesticides for pest control warrant for a change in control tactics. Biological control of pests has been proposed as available safe solution to these problems (Hodges and Haydu, 2000). Therefore, integrated pest management (IPM), as a combination between use of pesticides and biological control agents, is necessary.

The present study was conducted to clarify the efficacy of biorational pesticides and biocontrol agents against mealybug species infesting certain medicinal and ornamental plants and in order to test compatibility between both in an integrated mealy bug management program.

MATERIALS AND METHODS

Maintenance of cultures

a. Rearing of the mealy bugs

Two mealy bug species; *I. seychellarum* and *M. hirsutus*, were reared at the Plant Protection Department of Ismailia Agricultural Research Station, Ismailia, Egypt. Leaves and branches of mulberry trees, heavily infested with *I. seychellarum* were collected from different areas at Ismailia Governorate and placed on seedlings of ficus, *Ficus nitida* one-year old, grown in clay pots (20 cm diameter). The seedlings were set inside aluminium cheese cloth cages (60 x 60 x 20 cm.). Branches of hibiscus shrubs, heavily infested with pink hibiscus mealy bug, *M. hirsutus* were also collected from Ismailia and reared on sprouted potatoes in aluminium cheese cloth cages (60 x 60 x 100 cm.). The two cultures were maintained away from pesticides contamination under laboratory conditions of 26°C ± 2 and 65±5% RH. and 12 hrs daily illuminations by using fluorescent tubes (40 watt) for six months.

b. Rearing of the predator

Adults of the predator, *R. cardinalis* were collected from the fields and kept in glass tubes (4x12 cm.) covered with muslin. Each tube was provided daily with ficus leaves, heavily infested with *I. seychellarum* as a sufficient food supply of prey. Leaves carrying-newly-deposited eggs of the predator were collected and kept in Petri dishes (9 cm. diameter). The eggs were examined daily until

hatching. Directly after hatching, larvae were transferred singly into plastic tubes (3.5x7 cm.), where they were provided by sufficient leaves infested with prey. Amount of food was increased as the larvae developed until pupation. Pupae were kept in glass tube (4 x 12 cm.) covered with muslin and held in place with rubber bands till adults emergence. The rearing was maintained for six months to obtain sufficient number of individuals of the predator.

c- Rearing of the parasitoid

The source for the culture of the parasitoid, *A. kamali* was collected from different areas at Ismailia Governorate and it was set on sprouted potatoes as the method described by Fisher (1963). The culture was kept in cages (60 x 60 x 100 cm.) covered with cheese cloth away from pesticide contamination under the laboratory conditions of 25°C ± 2 and 65±5% R.H. and 12 hrs. daily illumination. Adult females of the parasitoid were collected and released weekly into cages containing infested sprouted potatoes (3-week old) with mealy bug population. Two-day old, mated females were used for experiments. Emerged parasitoids were collected after 20-25 days.

Bio-rational pesticides

1. Biofly $3x10^6$ conidia/ml L. (*Beauveria bassiana*): Entomopathogenic fungi.
2. Biovar $32x10^6$ spore/gm WP (*Beauveria bassiana*): Entomopathogenic fungi.
3. Bioransa $32x10^6$ spore/gm WP (*Metarrihizium anisoplae*): Entomopathogenic fungi.
4. Kz-oil 95 % EC (mineral oil) In Miscible type formulated by Kafr El-Zayat Pesticides and Chemicals Co.
5. Prev-AM, a micro-emulsion (ME) containing 6% orange oil. Orange-oil is a common name for an extract from the rind of *Citrus aurantium*. It is a complex mixture of chemical substances, the main component being D-limonene: (R)-4-isopropenyl-1-methylcyclohexene or p-mentha-1, 8-diene (IUPAC).

Experimental techniques

Five experiments were performed at Suez Canal University Farm at Ismailia district, Ismailia Governorate, Egypt in year 2012. The experimental area was designed in a complete randomized block design and divided into plots for each trail. Each plot contained twenty ficus trees or hibiscus shrubs. Four replicates (each of five trees or shrubs) for each treatment, beside an untreated plot (control) were adopted. Ficus trees or hibiscus shrubs were heavily infested with the mealybugs, *I. seychellarum* or *M. hirsutus,* respectively. The trees or shrubs were similar in size, age, shape, height and vegetation.

The first trial (or plot) was applied to study the effect of certain biorational pesticides on mealy bugs infesting ficus and hibiscus plants. Tested compounds were applied only once at recommended rates using motor sprayer 300 litters capacity. Samples (represented by one hundred branches, 15 cm length) were collected at random from each replicate, just before spraying and four counts at weekly intervals after spraying.

The second trial was conducted to study the effect of releasing *R. cardinalis* against *I. seychellarum* infesting ficus trees. Adults of *R. cardinalis* were released once (inundative release). Plastic vials (1.5x10 cm) were used for transporting the predator. Fifty adults of *R. cardinalis* (females + males) were released per tree by early March, 2012. They were placed in the core of the trees to minimize predator's dispersion. Releases were made in the evening to encourage the predator to settle down and to begin feeding following morning as described by Tirumala and David (1958). Three time monthly samples of five branches (15 cm. length) were randomly picked up from each tree started from March to October 2012.

The third trial was carried out to study the effect of the parasitoid *A. kamali* against *M. hirsutus* infesting hibiscus plants. Parasitoid adults were collected, using an aspirator, in plastic tubes, provided with a piece of rock wool containing honeybee for feeding and then transferred for releasing. Twenty five individuals (one day old) of *A. kamali* were released once in March, 2012. Five branches (15 cm. length) were randomly picked up from each tree, three times monthly, started from March to October 2012.

The fourth trial was conducted to study integrated effect of certain biorational pesticides and biological control agents through releasing the predator, *R. cardinalis* against *I. seychellarum* infesting ficus trees and releasing *A. kamali* against *M. hirsutus* infesting hibiscus plants. The same experiment, aforementioned in the first trial was carried out. After one week from the pesticides applications, the experiments that previously mentioned in each of the trials two and three were conducted. The control plot (four replicates) was not treated at all.

Collected samples from each trial were kept in paper bags, transferred to the laboratory and examined using a stereo-binuclear microscope. Numbers of living individuals of each mealy bug species and its natural enemies (predators and parasitoids) were recorded. Also, additional samples were kept in plastic jars (25 cm long and 15 cm diameter), covered with fine muslin cloth, for

emergence of parasitoid adults. Rate of parasitism was estimated and recorded.

Statistical analysis

Percentages of reduction of the mealy bug populations were estimated, according to the equation of Henderson and Tilton (1955). Statistical analysis was performed as covariance. Comparisons of means were done according to the LSD test at 0.05 level of probability using CoStat-Software (1990).

RESULTS AND DISCUSSION

Effect of certain biorational pesticides against *I. seychellarum* and *M. hirsutus*

Data presented in table (1) show the effect of tested compounds on the two mealy bug species under field conditions. Percentages of reduction in *I. seychellarum* were 50.3, 65.8, 75.4, 82.1 and 79.4%, one week after application; 73.3, 74.9, 56.3, 79.3 and 68.0%, two weeks after application; 75.2, 74.2, 77.6, 80.7 and 81.3%, three weeks after application and 59.4, 68.3, 74.4, 81.4 and 69.7 %, four weeks after application for the Biofly, biover, Bioranza, Kz oil and orange oil, respectively. Kz oil was the most effective compound (80.9%), followed in descending rank by Orange oil (74.6%), Bioranza (70.9) and Biover (70.8%) with insignificant differences among of them. The least percentage of reduction (64.6 %) was found in the Biofly treatment.

Data in table (1) showed also that effect of the five tested compounds on *M. hirsutus* gave the same trend on *I. seychellarum*. Percentages of reductions were 77.6, 68.4, 71.0, 90.8 and 88.8%, one week after application; 68.7, 76.1, 85.6, 81.6 and 90.7%, two weeks after application; 66.1, 55.4, 64.3, 86.0 and 86.5%, three weeks after application and 41.2, 44.4, 58.1, 75.7 and 77.4%, four weeks after application for the Biofly, biover, Bioranza, Kz oil and orange oil, respectively.

Highest mean percentages of reduction were 85.9, 83.5 and 69.7% for the orange oil, Kz oil and Bioranza, respectively, with insignificant differences among them. The least percentages of reduction (63.4 and 61.1%) were obtained in Biover and Biofly treatments, respectively and they showed significant effect comparing with the other compounds. Kz oil and orange oil were the most effective used compounds against mealy bugs. These findings correspond with the results of Negm *et al.*, (2000) who concluded that highest percentage of reduction in the mealy bug *I. seychellarum* population infested mulberry trees was 76.5% using by KZ-oil and 69.6% was achieved by Capl-2 oil. El-Saedi *et al.*, (2006) mentioned that the percentages reduction of the two mealy bug species, *I. seychellarum* and *M. hirsutus* 68.0% and 79.1% were obtained by Kz-oil treatment.

Effect of *R. cardinalis* on the population of *I. seychellarum*

Results in fig. (1) illustrate the mean total numbers of *I. seychellarum* before and after releasing the predator. As indicated, the pest population was gradually decreased. Minimum population was recorded in the third sample of April (1.9 individuals/ branch), compared with 23.2 individuals/ branch in the control. It began to increase gradually reaching 11.3 individuals/ branch in the third sample of September, opposed to 41.9 individuals/ branch in the control. The overall mean number of total population (nymphs and adults) was 14.3 individuals/ branch in the treatment and 14.6 individuals/ branch in the control, just prior to release of the predator, *R. cardinalis*. From the previous results, *R. cardinalis*, as a biological control agent showed highly significant effect to suppress the infestation of *I. seychellarum*. Over the last 120 years, *Icerya* spp. populations have been suppressed in numerous countries by *R. cardinalis*, as it is a oligophagous predator that has a very restricted prey range, probably limited to the family Monophlebidae and possibly the tribe Iceryini. These results agree with comparative analysis obtained by Caltagirone and Doutt, (1989); Dixon *et al.*, (1997) and Hirose (2006) who stated that the control of *Icerya* spp., with *Rodolia* spp. was highly successful and proved very effective as bio-control agent.

Obtained data in the release area indicated that the predator *R. cardinalis* had two peaks; (2.1 individuals/ branch) existed in third sample of May, while the second peak (2.2 individuals/ branch) was recorded in the third sample of September. It was 0.6 and 1.3 individuals/ branch in the control at the same dates, respectively. However, monthly percent of reduction in the population of *I. seychellarum* by the predator *R. cardinalis* varied from one month to another and the maximum significant percent (89.0%) was recorded in April, followed by 87.1% in May, 74.0% in September, 69.5% in October, 61.5% in June and 61.3% in August. The least percent (53.1%) was obtained in July (Table, 2).

Effect of releasing *A. kamali* on the population of *M. hirsutus*

Results in fig., (2) represent the mean total numbers of *M. hirsutus*. Data revealed that the mean total population reached its minimum on treated shrubs in the first sample of April 4.2 individuals/

Table (1): Effect of five compounds on the population of the mealy bug species, *I. seychellarum* and *M. hirsutus* under field conditions at Ismailia Governorate, year 2012

Compunds	Rate application ml/100 liters water	Mean no. of individuals / branch and % reduction indicated days after treatment.									Mean Reduction Percentage**
		Pre-treatment	7		14		21		28		
		No.*	No.	%	No.	%	No.	%	No.	%	
Icery seychellarum											
Biofly	150 ml	79.2	29.6	50.3	18.0	73.3	17.6	75.2	26.6	59.4	64.6 b
Biover	200 gm	105.8	27.2	65.8	22.6	74.9	24.2	74.5	27.8	68.3	70.8 ab
Bioranza	200 gm	143.6	26.6	75.4	53.4	56.3	28.8	77.6	30.4	74.4	70.9 ab
K z oil	1500 ml	62.4	8.4	82.1	11.0	79.3	10.8	80.7	9.6	81.4	80.9 a
Prev	800 ml	47.8	7.4	79.4	13.0	68.0	8.0	81.3	12.0	69.7	74.6 ab
Untreated		115.2	86.6		98.0		103.2		95.4		
Means		92.3	31.0	92.0	36.0	70.4	32.1	77.9	33.6	70.6	72.4
$LSD_{0.05}$											11.75
Maconellicoccus hirsutus											
Biofly	150 ml	328.8	76.0	77.6	95.4	68.7	105.0	66.1	156.6	41.2	63.4 b
Biover	200 gm	210.4	68.6	68.4	46.6	76.1	88.2	55.4	94.8	44.4	61.1 b
Bioranza	200 gm	314.0	94.2	71.0	41.8	85.6	105.6	64.3	106.6	58.1	69.7 ab
K z oil	1500 ml	225.8	21.4	90.8	38.6	81.6	29.8	86.0	44.4	75.7	83.5 a
Prev	800 ml	240.8	27.8	88.8	20.8	90.7	30.6	86.5	44.0	77.4	85.9 a
Untreated		303.8	313.8		281.6		285.8		246.0		
Means		270.6	100.3	92.3	87.5	80.5	107.5	71.7	115.4	59.4	72.7
$LSD_{0.05}$											17.25

* No. = mean number of individuals / branch

** Means reductions within a column followed by the same letter are not significantly different (P> 0.05) Duncan's multiple range at 5% level of significance was used.

Table (2): Reduction percentages of *Icerya seychellarum* population post release of the predator *Rodolia cardinalis* on ficus trees at Ismailia Governorate, year 2012

Month	Mean no. individuals /branch						Reduction Percentage*
	Control			Treatment			
	Nymphs	Adults	Total	Nymphs	Adults	Total	
Pre-count	11.3	3.0	14.3	12.0	2.6	14.6	-
April	17.3	3.9	21.2	1.8	0.6	2.4	89.0 a
May	22.3	3.2	25.5	2.2	1.2	3.4	87.1 a
June	18.2	1.8	19.9	6.5	1.4	7.8	61.5 b
July	17.6	2.8	20.4	7.6	2.2	9.8	53.1 b
August	20.5	4.3	24.8	5.5	4.3	9.8	61.3 b
September	34.8	5.9	40.7	8.9	2.0	10.8	74.0 b
October	24.1	5.4	29.5	7.8	1.5	9.2	69.5 b
L.S.D. at 0.05							11.42

Table (3): Reduction percentages of the population of *M. hirsutus* populations post release of the parasitoid, *Anagyrus kamali* on hibiscus shrubs at Ismailia Governorate, year 2012

Month	Mean percent parasitism /branch						Reduction Percentage*
	Control			Treatment			
	Nymphs	Adults	Total	Nymphs	Adults	Total	
Pre-count	5.6	2.3	7.9	4.6	2.4	6.7	--
April	11.5	1.9	13.4	2.7	2.5	5.2	54.7 b
May	14.7	2.5	17.2	3.0	2.1	5.1	65.6 a
June	13.1	4.2	17.3	6.1	3.4	9.5	35.4 c
July	32.7	15.8	48.4	14.8	8.4	23.2	43.8 c
August	37.0	19.1	56.2	17.1	12.4	29.6	38.2 c
September	49.7	13.0	62.6	22.8	8.2	31.0	42.0 c
October	28.4	7.5	36.0	20.9	5.6	26.4	13.7 d
L.S.D. at 0.05							8.72

* Means reductions within a column followed by the same letter are not significantly different (P> 0.05), Duncan's multiple range at 5% level of significance was used.

Table (4): Effect of five pesticides on the mealybugs, *I. seychellarum and M. hirsutus* under field conditions at Ismailia Governorate, year 2012

Insecticides	Rate application ml/100 liters water	Mean no. of individuals / branch and % reduction at indicated days after treatment												Mean Reduction Percentages
		Pre-Treatment	7			14		21		28		35		
		No.*	No.	%		No.	%	No.	%	No.	%	No.	%	
Seychelles mealybug, *I. seychellarum*														
Biofly	150 ml	61.0	21.6	66.5		13.2	82.2	1.5	98.0	1.0	98.6	1.7	97.6	88.6
Biover	200 gm	65.8	22.8	67.2		11.4	85.8	1.0	98.8	1.3	98.3	2.7	89.2	87.8
Bioranza	200 gm	75.2	22.2	72.0	Release *Rodolia cardinalis*	15.0	83.6	1.3	98.7	1.0	98.9	1.0	95.8	89.8
K z oil	1500 ml	62.4	11.6	82.4		4.8	93.7	0.0	100	0.0	100	0.0	100	95.2
Orange Oil	800 ml	47.8	10.2	79.8		3.8	93.5	0.0	100	0.0	100	0.0	100	94.7
Untreated		75.2	79.4			91.6		93.8		88.0		86.0		
Means			17.7	73.6		9.6	87.8	0.76	99.1	0.66	99.2	1.1	96.5	91.2
Pink hibiscus mealybug, *M. hirsutus*														
Biofly	150 ml	277.2	108.4	62.8		65.8	70.6	60.6	77.5	85.2	68.3	86.0	63.9	68.60
Biover	200 gm	221.2	100.4	56.8		56.2	68.5	39.8	81.5	67.8	68.4	75.0	60.5	67.14
Bioranza	200 gm	271.4	101.6	64.4	Release *Anagyrus kamali*	57.4	73.8	52.8	80.0	79.0	70.0	80.4	65.5	70.72
K z oil	1500 ml	195.6	39.4	80.8		19.4	87.7	20.0	89.5	21.2	88.8	22.4	86.7	86.70
Orange Oil	800 ml	228.0	43.8	81.7		18.8	89.8	21.6	90.2	24.4	89.0	22.6	88.5	87.83
Untreated		231.6	243.2	62.8		187.0		225.0		224.6		198.8		
Means			106.1	68.2		43.5	78.1	39.0	83.7	55.5	76.9	57.3	73.0	76.2

* No. = mean number of individuals / branch

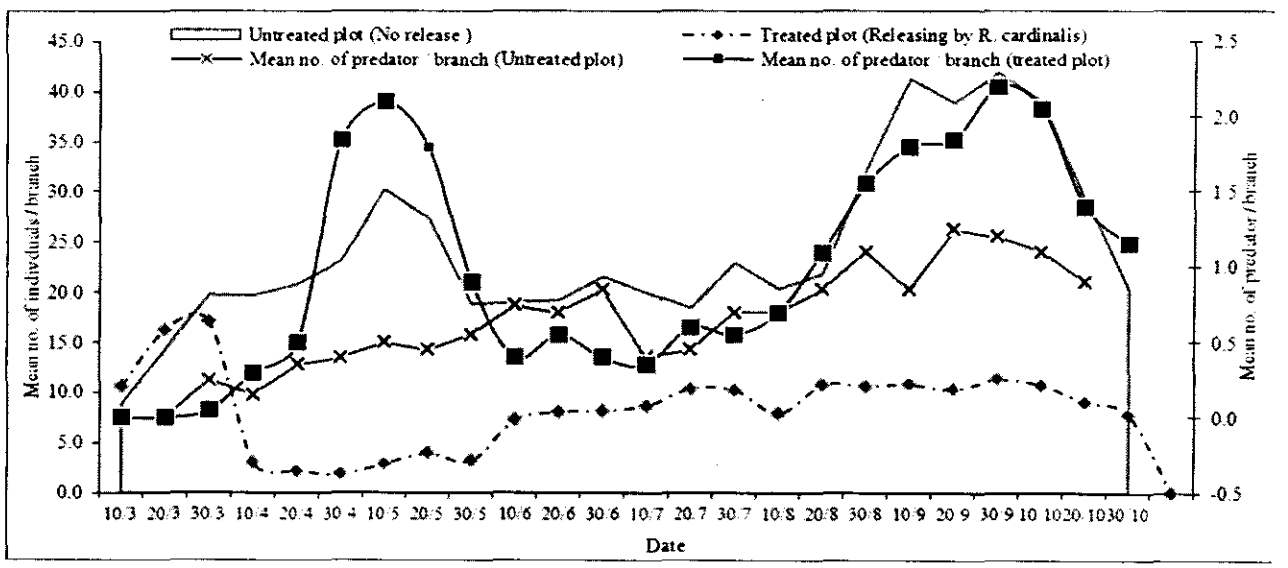

Fig. (1): Population of the mealy bug, *I. seycellarum* and its predator *R. cardinalis* in treated and untreated ficus trees at Ismailia Governorate, year 2012.

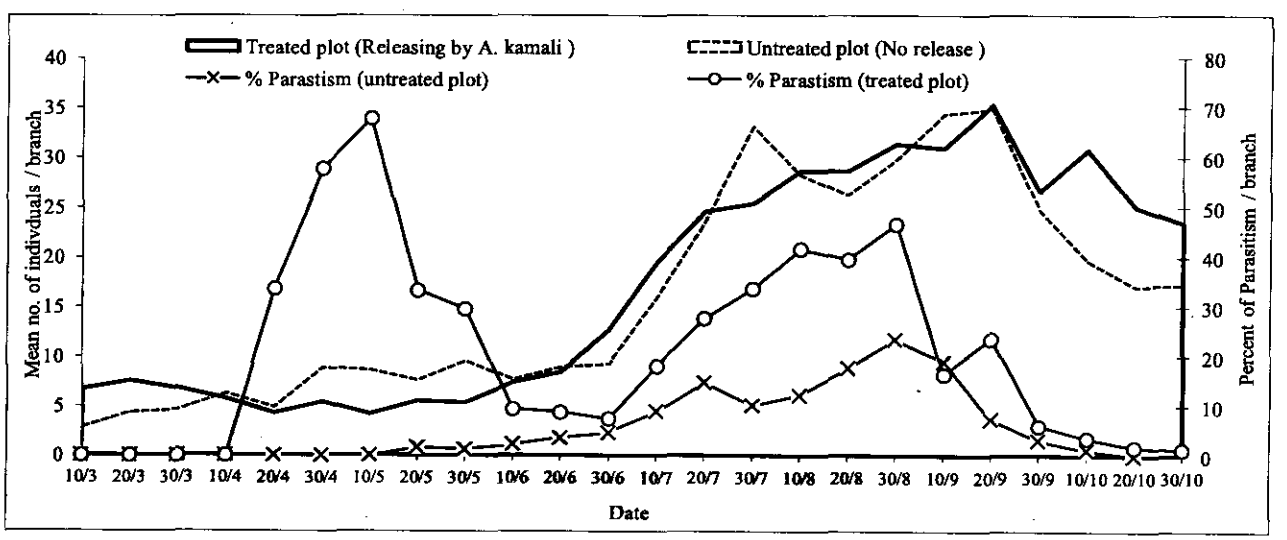

Fig. (2): Mean population of the mealybug, *M. hirsutus* and percent of parasitism of the parasitoid, *A. kamali* in treated and untreated plots of hibiscus shrubs at Ismailia Governorate, year 2012.

branch, while it was 17.3 individuals/ branch in the control. Subsequently, it began to increase reaching 25.3 individuals/branch in the second sample of September. It was 69.8 individuals/ branch in the control at the same date. The mean number of total population (nymphs and adults) 6.7 individuals/ branch was recorded in the treatment and in the control 7.9 individuals/ branch, just prior to release of the parasitoid, *A. kamali.*

Data obtained in treated trees indicated that the mean percentages of parasitism by the parasitoid, *A. kamali,* after releasing, had three peaks; the first 67.9% was recorded in the first sample of May, the second 46.7% was in the third sample of August and the third 23.7% was estimated in the second sample of September. On the other hand, it was 0.0, 23.5 and 7.4 % in the control at the same dates, respectively. Monthly percent of reduction in the population of *M. hirsutus* by the parasitoid, *A. kamali* varied significantly from one month to another. It reached the highest percentage 65.6% in May, followed by 54.7% in April, 43.8% in July, 42.0% in September, 38.2% in August and 35.4% in June. The least significant percent 13.7% was estimated in October (Table, 3).

Combined effect of biorational pesticides and each of the predator, *R. cardinalis* and the parasitoid, *A. kamali*

Data presented in table (4) show the combined effect of tested biorational pesticides and each of the predator *R. cardinalis* on the population of *I. seychellarum* and the parasitoid, *A. kamali* on the population *M. hirsutus.* It was obvious that the reduction percentages ranged between 66.5% (Biofly) to 82.4% (Kz oil) and from 56.8% (Biover) to 81.7% (Orange oil), after first week from application directly before the release of the predator and the parasitoid, respectively. The population of the two mealy bug species declined continually after releasing the two biocontrol agents. Percentages of reduction were 82.2, 85.8, 83.6, 93.7 and 93.5%, one week after release of the predator, *R. cardinalis*; 98.0, 98.8, 98.7, 100 and 100%, two weeks after release; 98.6, 98.3, 98.9, 100 and 100%, three weeks after release and 97.6, 89.2, 95.8, 100 and 100%, four weeks after release for Biofly, biover, Bioranza, Kz oil and orange oil, respectively. The mean reduction percentages of the four weeks after release of the predator, *R. cardinalis* were 88.6, 87.8, 89.8, 95.2 and 94.7% for the Biofly, biover, Bioranza, Kz oil and orange oil, respectively.

On the other hand, the percentages of reduction were 70.6, 68.5, 73.8, 87.7 and 89.8%, one week after release of the parasitoid, A. *kamali*; 77.5, 81.5, 80.0, 89.5 and 90.2%, two weeks after release; 68.3, 68.4, 70.0, 88.8 and 89.0%, three weeks after release and 63.9, 60.5, 65.5, 86.7 and 88.5%, four weeks after release for the Biofly, biover, Bioranza, Kz oil and orange oil, respectively. The mean reduction percentages of the four weeks after release of the parasitoid, *A. kamali* were 68.60, 67.14, 70.72, 86.7 and 87.83% for the Biofly, biover, Bioranza, Kz oil and orange oil, respectively.

Regarding the comparison among different control tools after four weeks of treatments, the overall means of biorational pesticides on *I. seychellarum* and *M. hirsutus* were 30.07±8.6, 77.7±16.3 individuals/ branch, respectively. Whereas, biocontrol with the predator, *R. cardinalis,* the parasitoid, *A. kamali,* the pesticides with *R. cardinalis* and the pesticides with *A. kamali* were, 2.7±0.3, 5.3±0.3, 3.0±0.8 and 48.8±11.5 individuals/ branch, respectively. Respective mean percentages of reduction were 61.93, 65.02, 89.0, 54.6, 91.2 and 76.2 %. It is apparent that there was variability in the compatibility of natural enemies with biorational pesticides based on the type of pesticide, the natural enemy (parasitoid or predator) and developmental stage. However, it is important to know which biorational pesticide is compatible with each of the target natural enemies in order to avoid disrupting successful biological control programs (Cloyd, 2005). Biorational pesticides are generally more specific in pest activity and more physiologically safe to natural enemies than conventional pesticides (Croft, 1990).

Roltsch *et al.*, (2006) and Garcia-Valente *et al.*, (2009) reported that the parasitoid, *A. kamali* regulated population growth of pink hibiscus mealybug on teak shoots covered with sleeves made of organza under field conditions. Average reduction of the pest was 96.5 % in.

Obtained results suggest that the combined use of certain biorational pesticides and each of the predator and/or the parasitoid against of the two mealy bug species gave better control than using a single tool. These findings are in agreement with that obtained by Cloyd, (2005) found that the insecticides azadirachtin and pyriproxyfen are compatible with the citrus mealybug parasitoid, *Leptomastix dactylopii.* Necetic *et al.*, (2001) suggested that combining petroleum spray oil with *Phytoseiulus persimilis* gave better control of the two spotted spider mite than using *P. persimilis* alone and gave equally effective control with that of synthetic miticides on plants. Also, Mangoud (2006) indicated that the conjunction between the predator *Cryptolaemus montrouzieri* and encyrtid parasitoid *Leptomastix dactylopii* was good to reduce the population of the citrus mealy bug, *Planococcus citri.*

It could be concluded that biorational pesticides application against the mealybugs can be successfully integrated with biological control agents.

REFERENCES

Cloyd, R. 2005. Compatibility conflict: Is the use of biological control agents with pesticides a viable management strategy? Proceedings for the 2nd International Symposium on Biological Control of Arthropods, September 12-16, 2005, Davos, Switzerland, pp: 546-554.

Croft, B. A. 1990. Arthropod Biological Control Agents and Pesticides. Wiley- Interscience, New York.

El-Borollosy, F. M., M. M. El-Bolok, A. I. Ezz and Shadia M. M. Assem, 1990. Efficiency of certain insecticides and Insect Growth Regulator (IGR) in controlling three homopterous insects on ornamental plants. Bull. Entomol. Soc. Egypt, Econ. Ser., 18: 185-194.

El-Saedi, A. A., H. M. Ahmed, S. A. Ahmed and A. M. Sayed 2006. Efficiency and selectivity of certain insecticides on mealybug and their natural enemies. Egypt. J. Applied Sci., 22: 691-703.

Fisher, T. W. 1963. Mass culture of *Cryptolaemus* and *Leptomastix*: Natural enemies of citrus mealybug. California Agricultural Experiment Station, Bulletin No. 797, Berkeley, CA., USA., pp: 1-38.

Garcia-Valente, F., L. D. Ortega-Arenas, H. Gonzalez-Hernandez, J. A. Villanueva-Jimenez, J. Lopez-Collado, A. Gonzalez-Hernandez and H. C. Arredondo-Bernal 2009. Natural and induced parasitism of *Anagyrus kamali* against pink hibiscus mealybug on teak shoots in Bahia de Banderas, Nayarit. Agrociencia, 43: 729-738.

Henderson, D. F. and E. W. Tilton 1955. Tests with acaricides against the brown wheat mite. J. Econ. Ent., 84: 157-161.

Hirose, Y. 2006. Biological control of aphids and coccids: A comparative analysis. Population Ecol., 48: 307-315.

Hodges, A. W. and J. J. Haydu 2000. Economic impact of Florida's environmental horticulture industry. J. Environ. Hortic., 18: 123-127.

Kumar, N., J. M. Abdulkhade, P. Rangaswami and I. Irulappan 2004. Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants. Oxford and IBH Publ., New Delhi, India, pp: 6.

Mangoud, A. A. H. 2006. Manipulation of *Leptomastix dactylopii* and *Cryptolaemus montrouzeri* for augmentative release for controlling the citrus mealy bug, *Planococcus citri* on citrus under green house conditions. Egypt. J. Agric. Res., 84, (3): 803-813.

Meyerdirk, D. E., R. Warkentin, B. Attavianl, E. Gersabeck, A. Francis, M. Adams and G. Francis 2002. Biological control of pink hibiscus mealy bug, project manual. United States Dept. of Agric., Animal and Plant Health Inspection Service, Plant Protection and Quarantine, pp: 1-194.

Negm, M. F., S. M. Assem and A. G. El-Sisi 2000. Comparison between some mineral oils and cidial for controlling mealy bug, *Icerya seychellarum* (Westwood) on mulberry trees by using knapsack motor sprayer. Egypt. J. Agric. Res., 79: 453-461.

Necetic, O., D. M. Watson, G. A. C. Beattie, A. Meats and J. Zheng 2001. Integrated pest management of two-spotted mite, *Tetranychus urticae* on greenhouse roses using petroleum spray oil and the predatory mite, *Phytoseiulus persimilis*. Experimental and Applied Acarology, 25:37-53

Roltsch, W. J., D. E. Meyerdirk, R. Warkentin, E. R. Andress and K. Carrera 2006. Classical biological control of the pink hibiscus mealy bug, *Maconellicoccus hirsutus* (Green), in Southern California. Biol. Control, 37: 155-166

Tirumala, R. V. and A. L. David 1958. The biological control of a coccid pest in South India by use of the beetle *Cryptolaemus montrouzieri* Muls. Indian. J. Agric. Sci.,28: 545-552.