Pestic. Phytomed. (Belgrade), 29(1), 2014, 55–65
DOI: 10.2298/PIF1401055M

UDC 632.937.3:632.7+632.937.1:632.95.021
Original scientific paper

Efficacy of eco-smart insecticides against certain biological stages of jasmine moth, *Palpita unionalis* Hb. (Lepidoptera: Pyralidae)

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Received: December 9, 2013
Accepted: March 11, 2014

SUMMARY

The efficacy of six eco-smart insecticides, Dipel 2x 6.4% WP (*Bacillus thuringensis* AI), Biofly 100% WP (*Beauvaria bessiana* AI), Radiant 12% SC (*Saccharopolyspora spinosa* AI), Mectin 1.8% EC (*Streptomyces avermitilis* AI), Nimbecidine 0.03% EC (Azadirachtin AI) and Bio-Power 50% EC (*Beauvaria bessiana* AI), were tested against eggs, larvae and pupae of the jasmine moth, *Palpita unionalis* Hb. and its parasitoid *Apanteles syleptae* under laboratory conditions. Data indicated that all tested insecticides had ovicidal activity against *P. unionalis*. Mectin was the most toxic among the tested insecticides against the egg stage, followed by Radiant or Dipel 2x, and their respective values of LC_{50} were 0.005 cm/l, 0.006 cm/l and 0.055 g/l. Dipel 2x was the most toxic insecticide to the 1st instar larvae of *P. unionalis*, whereas Mectin was the most toxic to both the 3rd and 5th instar larvae. Also, the results revealed that Mectin was the most effective against the pupal stage, followed descendingly by Radiant and Dipel 2x. The toxicity index values showed a superior efficiency of Mectin at LC_{50} (100%) against eggs, 3rd and 5th instar larvae, and pupal stage, whereas Dipel 2x showed such superior efficiency at LC_{50} (100%) only against 1st instar larvae. The results showed that the percents of pupation and emergence of moths were significantly different in all treatments compared to control, while deformed pupae and malformed adults were insignificantly different when fifth instar larvae were treated with the tested insecticides. Moreover, the rate of *P. unionalis* adult emergence from treated pupae was concentration-dependent and significant differences were found between insecticide treatments and control. Generally, Mectin, Radiant and Dipel 2x caused the highest impacts on adult emergence and malformed adults percentages. Regarding the toxicity of insecticides to the endoparasitoid *A. syleptae*, the treated cocoons developed to adult stages with no significant differences compared to control. Meanwhile, the longevity of the emerged parasitoid adults did not differ among the insecticides treatments and control.

Keywords: *Palpita unionalis; Apanteles syleptae*; Botanical insecticides; Microbial pesticides; Toxicity.

INTRODUCTION

The olive (*Olea europaea* L.) has been one of the first fruit trees cultivated by man. Nowadays it is grown in North America, South Africa, China, Japan and Australia (Budia, 2012), although it is considered that around 98% of all olive heritage is located in the Mediterranean area (Budia, 2012). The average world olive production is estimated at 24 million tonnes, of which 90% go to oil production and the other 10% to table olives (IOOC, 2013). Olive has been a major and economically important crop for newly reclaimed lands in Egypt. Its cultivated area has expanded largely in the last decade, particularly in reclaimed arid areas (Western side of the Nile). The area reached 49,000 ha in 2010 (productivity = 6327 kg/ha) (Sabbour, 2013). According to IOOC (2013), Egypt olive production in 2013 was estimated at 357.000 tonnes.

Olive trees are infested by many insect pests that affect yield quality and quantity. The most common pest species observed in Egypt include: *Bactrocera oleae* (Gmelin) (Diptera: Tephritidae), Prays oleae Bern. (Lepidoptera: Yponomeutidae), *Palpita unionalis* Hb. (Lepidoptera: Pyralidae), *Zeuzera pyrina* (L.) (Lepidoptera: Cossidae), *Saissetia oleae* Olivier (Homoptera: Coccidae) and *Parlatoria oleae* (Colvee) (Homoptera: Diaspididae) (El-Basha, 2002; Mahmoud, 2009). Losses caused by pests have been estimated to reach 30%, of which 15% are due to the activities of insects, and 10% are attributed to the main olive grove insects (Haniotakis, 2005).

The jasmine moth, *Palpita unionalis* (Lepidoptera: Pyralidae) is an important pest in Mediterranean olive orchards. It originates in the Mediterranean basin (Tzanakakis, 2003; Noori and Shirazi, 2012). It is considered as a destructive pest of young olive groves (El-Basha 2002) and new branches of old trees (El-Basha and Mandour, 2006). Larvae of this moth are increasingly damaging to young shoots, causing severe harm to olive trees in fields and in nurseries, and damaging the ripening olive fruits (Athanassiou et al., 2004; Kumral et al., 2007). It is a polyphagous pest attacking the genera Jasminum, Ligustrum, Olea, Fraxinus, Phyllyrea (Tzanakakis, 2003 and Athanassiou et al., 2004), strawberries and Viburnum (Khaganini and Pourabad, 2009). The development of *P. unionalis* is temperature-dependent and all immature stages of this pest are present during the growing season (Lopez-Villalta 1999; Shehata et al., 2003). According to Fodal's studies, if 90% of all branches have been damaged, the loss rate of yield will not be more than 20% (Fodal et al., 1990).

Until recently, the control of jasmine moth, *P. unionalis,* on olive trees has relied upon the use of traditional insecticides. Residues of insecticides have been detected in olive oil and in the environment where olives are grown (Montiel and Jones, 2002). This has caused concern in most olive growing countries that has led to concentrated efforts to reduce the amount of insecticides being used in olive groves.

The present experiments demonstrate the comparative efficacy of eco-smart insecticides against different stages of jasmine moth, *Palpita unionalis* Hb., and its parasitoid, *Apanteles syleptae* Ferriere, intending to find the best eco-smart insecticide for controlling this economic pest through integrated pest management programs.

MATERIALS AND METHODS

Insect maintenance

Immature stages of *P. unionalis* were first collected from infested olive branches in the Experimental Farm, Faculty of Agriculture, Suez Canal University, and kept in the Laboratory of Entomology at 25± 2°C; 60± 10% RH and photoperiod of 14:10 (L:D) h. The lower parts of *P. unionalis* infested branches were inserted in glass vials 2 × 10 cm containing fresh water to keep the branches fresh as long as possible. After the completion of immature development, pupae were collected, kept in clean Petri dishes and placed in clean glass jars (30 × 15 cm) until emergence. Upon emergence, moths were fed on sucrose solution (10%) and fresh olive leaves were provided as an ovipositional substrate. Olive leaves bearing *P. unionalis* eggs were collected and located over small seedlings (60-70 cm height) to maintain the culture.

Insecticides

Commercial formulations of the following insecticides were tested against eggs, 1st, 3rd , 5th instar larvae and pupae of the jasmine moth, *Palpita unionalis,* and its endoparasitoid, *Apanteles syleptae*: Dipel 2x 6.4% WP (*Bacillus thuringensis* var. *kurstaki* 22000 IU/mg), Biofly (*Beauvaria bessiana* 100%, 30×106 cell), Radiant 12% SC (spinosyns A and D, *Saccharopolyspora spinosa*) DowAgrosciences Egypt, Mectin 1.8% EC (*Streptomyces avermitilis*, 80% avermectin B1a and 20% avermectin B1b), Nimbecidine EC (0.03% Azadirachtin) T. Stanes & Company Ltd (Coimbatore, India) and Bio-Power (*Beauveria bassiana* 1x10^9 CFU's/ml) T. Stanes & Company Ltd (Coimbatore, India). The formulations of eco-smart insecticides were prepared in distilled water according to their producers' instructions at field rate, half of field rate and quarter of field rate.

Experiments

Ovicidal effect experiment

Eggs laid on olive leaves under laboratory conditions were recorded. The eggs were divided into batches of 100 eggs for an ovicidal test and each batch of eggs (up to 24 h old) was placed on olive leaves in a Petri dish and treated with one of the insecticides by direct spraying using a small handle sprayer. In a control group, eggs on olive leaves were sprayed with distilled water. The treated olive leaf disks were dried at room temperature for 2 h. Then, the leaf disks were placed in Petri dishes (10 cm diameter, 1.5 cm depth) and incubated at 23 ± 2°C until hatching. The treated eggs were then checked daily until all larvae hatched or the eggs died. Each treatment had four replicates.

Toxicity of insecticides to different larval instars and their impact on certain biological aspects

Small olive branches were dipped into the tested concentrations of insecticides for 5 seconds by gentle agitation. The treated olive branches were then left to dry out for at least 2 h prior to being used in treatments. All tested larvae were starved for at least 4 h prior to the experiment. Larvae were transferred gently by a fine brush and placed into Petri dishes (12 cm diameter) containing small olive branches. To record mortality, *P. unionalis* larvae were checked 3, 5 and 7 days after insecticide application. In this bioassay, 50 larvae of each tested instar were used with 5 replicates. Larvae were considered dead if they gave no response to stimulation by touch. The obtained pupae were placed separately into Petri dishes. Pupation, deformed pupae, adult emergence and malformed adults were recorded.

Toxicity of insecticides to pupal stage

New pupae were collected from the next generation and treated with different concentrations of the tested insecticides by direct spraying, using a small handle sprayer. Treated pupae were then removed, kept on clean Petri dishes (12 cm in diameter) and observed until adult emergence. In this bioassay, 5 replicates were used with 10 pupae in each replicate. Control treatments were also conducted using the same protocol and sprayed with distilled water.

Effects of insecticides on *Apanteles syleptae* parasitoid

Newly formed parasitoid cocoons (≤ 2 day old) were collected from the laboratory colony, placed into clean Petri dishes and sprayed with the field rates of all tested insecticides. The treated cocoons were kept under laboratory conditions and checked daily until parasitoid emergence. The emerged adults were then collected, confined in 7 × 2 cm glass tubes and fed on 20% honey solution until death. Data were recorded in terms of percents of adult emergence and longevity of the emerged adults.

Statistical analysis

Data obtained in the present study was subjected to an analysis of variance (ANOVA) with the honestly significant difference value calculated as Tukey's statistic at $P \leq 0.05$ (SAS Institute 2002). A standard probit analysis was used to calculate LC_{50} and slopes for the tested insects (SAS Institute 2002).

Table 1. Names and concentrations of tested insecticides

Name	Concentration		
	Field rate	Half of field rate	Quarter of field rate
Mectin	0.4 cm/l	0.2 cm/l	0.1 cm/l
Biofly	5 cm/l	2.5 cm/l	1.25 cm/l
Bio-Power	5 cm/l	2.5 cm/l	1.25 cm/l
Dipel 2x	0.5 g/l	0.25 g/l	0.125 g/l
Radiant	0.4 cm/l	0.2 cm/l	0.1 cm/l
Nimbecidine	5 cm/l	2.5 cm/l	1.25 cm/l

RESULTS

Data in Figure 1 show that all tested insecticides had ovicidal activity against *P. unionalis* eggs. The percent of egg hatching decreased significantly with increasing insecticides' concentrations from ($F= 648.8$; $P \leq 0.0000$) at field rate, to ($F= 247.4$; $P \leq 0.0000$) at ½ field rate and to ($F= 172.1$; $P \leq 0.0000$) at ¼ field rate. Also, data revealed that Mectin was the most effective insecticide against *P. unionalis* eggs at the three tested concentrations.

Data presented in Table 2 show that mortality rates decreased as *P. unionalis* larvae aged, but increased with time after treatment at all concentrations of the tested insecticides. There were significant differences among the tested insecticides at field rate in their mortality rates in the 1st instar cohorts 3, 5, and 7 days after treatment. The same trend of significance was observed in the 3rd and 5th instar larvae 3, 5 and 7 days after treatment. Generally, Dipel 2x and Mectin caused the highest mortality to all tested larval instars at all tested concentrations, whereas Bio-Power was the least efficient insecticide (Table 2). Data in Figure 2 show the latent effects of insecticides on

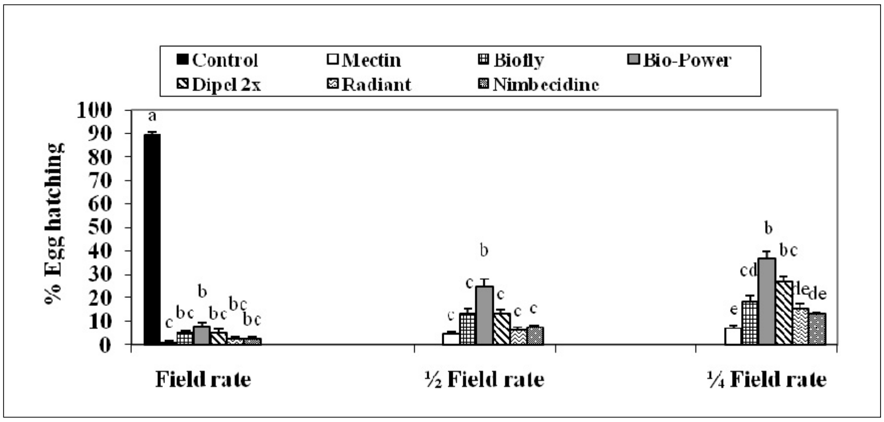
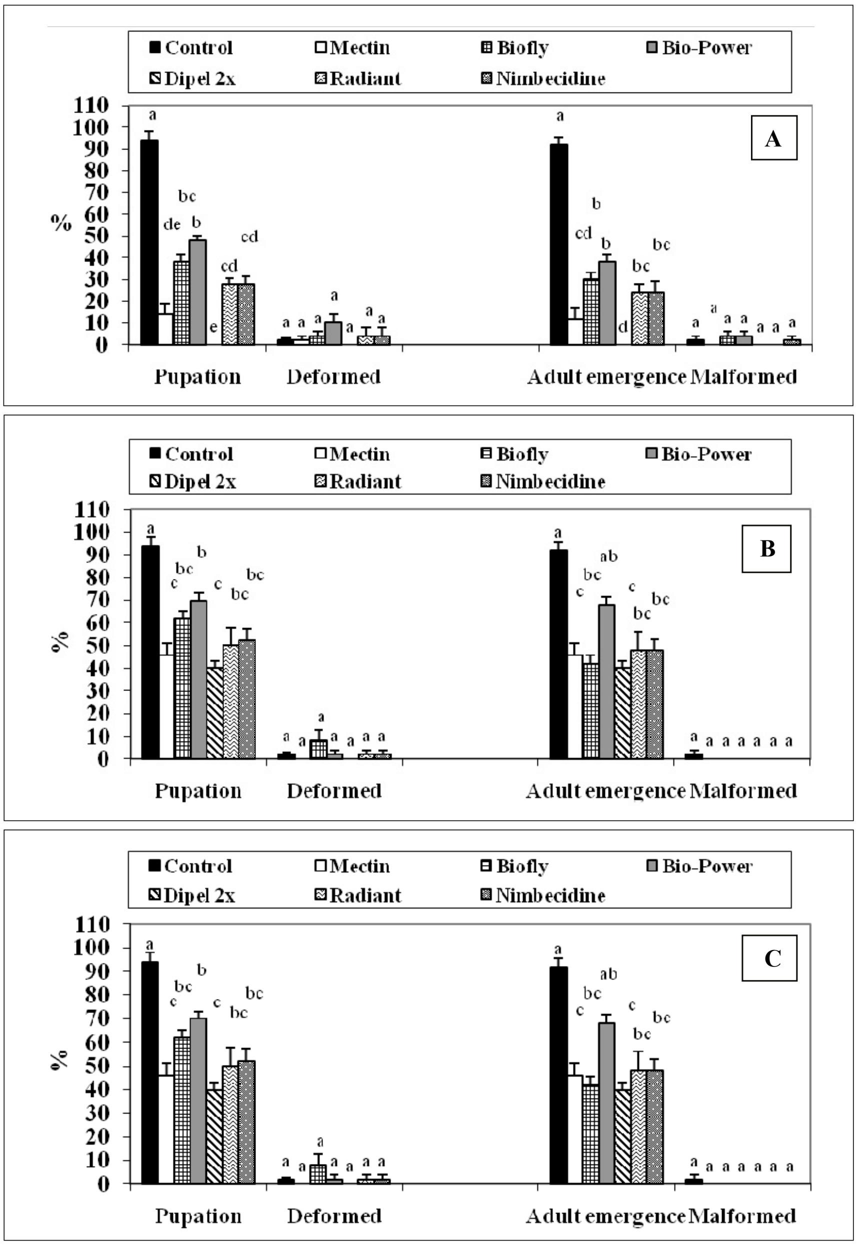


Figure 1. Percent of hatched *P. unionalis* eggs after treatment with three concentrations of insecticides

Table 2. Mortality percentage of different larval instars of *Palpita unionalis* treated with three concentrations of insecticides three, five and seven days after treatment

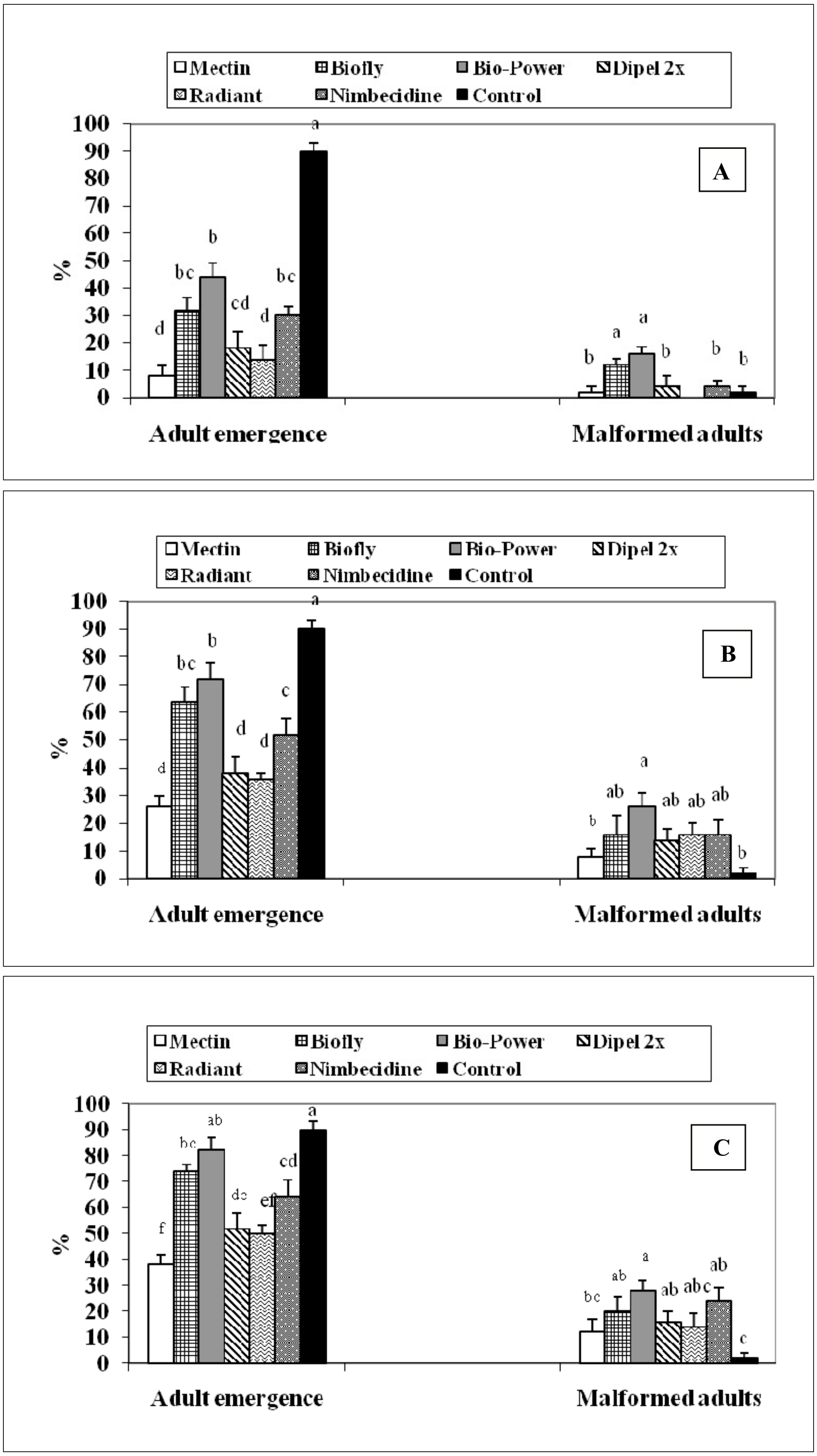
Insecticide	Dose	1st instar			3rd instar			5th instar		
		3 days	5 days	7 days	3 days	5 days	7 days	3 days	5 days	7 days
Biofly	FR (5 cm/l)	68 cd	100 a	100 a	50 bc	70 b	82 bc	32 c	50 c	62 cd
	½ FR (2.5 cm/l)	48	76	90	32	58	68	24	42	60
	¼ FR (1.25 cm/l)	22	40	68	20	34	50	14	24	38
Nimbecidene	FR (5 cm/l)	76 bcd	100 a	100 a	56 bc	74 b	92 ab	48 b	62 b	72 c
	½ FR (2.5 cm/l)	62	76	100	44	56	72	36	56	64
	¼ FR (1.25 cm/l)	48	66	84	38	48	56	28	36	48
Dipel 2x	FR (0.5 g/l)	100 a	100 a	100 a	78 a	90 a	100 a	72 a	88 a	100 a
	½ FR (0.25 g/l)	82	96	100	64	82	92	54	68	80
	¼ FR (0.125 g/l)	78	88	94	50	60	70	38	48	60
Bio-Power	FR (5 cm/l)	68 d	76 b	90 b	42 c	56 c	70 c	28 c	42 c	52 d
	½ FR (2.5 cm/l)	46	68	76	28	40	50	14	32	40
	¼ FR (1.25 cm/l)	32	54	70	18	30	36	12	22	30
Radiant	FR (0.4 cm/l)	78 bc	92 a	96 ab	62 b	76 b	86 ab	52 b	62 b	72 c
	½ FR (0.2 cm/l)	68	82	92	50	54	64	38	50	56
	¼ FR (0.1cm/l)	54	64	74	36	44	56	28	38	50
Mectin	FR (0.4 cm/l)	90 ab	96 a	100 a	64 b	80 ab	92 ab	56 b	66 b	86 b
	½ FR (0.2 cm/l)	82	94	96	64	76	82	52	62	70
	¼ FR (0.1cm/l)	66	78	84	50	62	70	36	48	54
Control	-	4 e	4 c	4 c	6 d	8 d	8 d	4 d	4 d	6 e
F value =		43.96	118.72	211.20	24.50	28.12	43.31	22.80	44.13	64.51
P value ≤		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

*Means (only at FR) followed by the same letters (column wise) are not significantly different (Tukey's HSD; P ≤ 0.05) the percent of pupation, deformed pupae, adult emergence and malformed adults after the 5th instar larvae of *P. unionalis* on small olive branches treated with three concentrations (FR, ½ FR and ¼ FR). Figure 2 shows that the percents of pupation and emergence of moths were significantly different in all treatments compared to the control. The percentage of pupation was (F= 58.5; P ≤ 0.0000) at FR, (F= 24.8; P ≤ 0.0000) at ½ FR and (F= 15.08; P ≤ 0.0000) at ¼ FR, while the percentage of adult emergence was (F= 58.2; P ≤ 0.0000) at FR, (F= 22.4; P ≤ 0.0000) at ½ FR and (F= 11.2; P ≤ 0.0000) at ¼ FR. Both deformed pupae and malformed adults were insignificantly different at all tested concentrations of the insecticides. The percent of deformed pupae was (F= 1.05; P ≤ 0.4148) at FR, (F= 0.66; P ≤ 0.6771) at ½ FR and (F= 1.26; P ≤ 0.3042) at ¼ FR. The percent of malformed adults was (F= 1.13; P ≤ 0.3691) at FR, (F= 1.73; P ≤ 0.1501) at ½ FR and (F= 1.0; P ≤ 0.4448) at ¼ FR.



*Means followed by the same letters (column wise) are not significantly different (Tukey's HSD; P ≤ 0.05)
**A= Field rate (FR), B= Half of field rate (½ FR) and C= Quarter of field rate (¼ FR).

Figure 2. Effects of eco-smart insecticides on some biological aspects of 5th instar larvae of *P. unionalis*.



*Means followed by the same letters (column wise) are not significantly different (Tukey's HSD; P ≤ 0.05)
**A= Field rate (FR), B= Half of field rate (½ FR) and C= Quarter of field rate (¼ FR).

Figure 3. Percents of adult emergence and malformed adults of *P. unionalis* treated at pupal stage with field rate, ½ field rate and ¼ field rate of insecticides.

Data presented in Figure 3 show the percents of adult emergence and malformed adults of *P. unionalis* treated at the pupal stage. Data clearly revealed that the percent of adult emergence and malformed adults decreased as insecticide concentrations increased. A significant decrease in the percentage of adult emergence was observed in insecticide treatments compared to the control at FR ($F= 38.2; P \le 0.4148$), at ½ FR ($F= 22.5; P \le 0.0000$) and at ¼ FR ($F= 17.13; P \le 0.0000$). Moreover, different concentrations of the insecticides showed significant effects on malformed adults, compared to control. A significant increase in malformed adults was observed ($F= 6.16; P \le 0.0003$) at FR, ($F= 2.64; P \le 0.0367$) at ½ FR and ($F= 3.64; P \le 0.0084$) at ¼ FR. Generally, Mectin, Radiant and Dipel 2x caused the highest impacts on adult emergence and malformed adults percentages.

The LC_{50} values are shown in Table 3 with corresponding slopes and toxicity indexes for each insecticide tested against eggs, 1st, 3rd and 5th instar larvae, and pupae of jasmine moth, *P. unionalis*. The results showed that Mectin was the most toxic among the tested insecticides against the egg stage, followed by Radiant and Dipel 2x. The respective values of LC_{50} of those insecticides were 0.005 cm/l, 0.006 cm/l and 0.055 g/l, respectively. The toxicity index showed corresponding superior efficiency values of Mectin at LC_{50} (100%), followed by Radiant (83.33%) and Dipel 2x (9.09%). As for the slope values, Bio-Power had the steepest toxicity line, whereas Nimbecidene had the flattest one.

Dipel 2x was the most toxic insecticide to the 1st instar larvae of *P. unionalis*. Its LC_{50}, toxicity index and slope were 0.035 cm/l, 100% and 1.96, respectively. On the other hand, Mectin was the most toxic to both 3rd and 5th instar larvae. The values of LC_{50}, toxicity index and slope were 0.044 cm/l, 100% and 4.88 for 3rd instar larvae and 0.089 cm/l, 100% and 4.14 for 5th instar larvae, respectively.

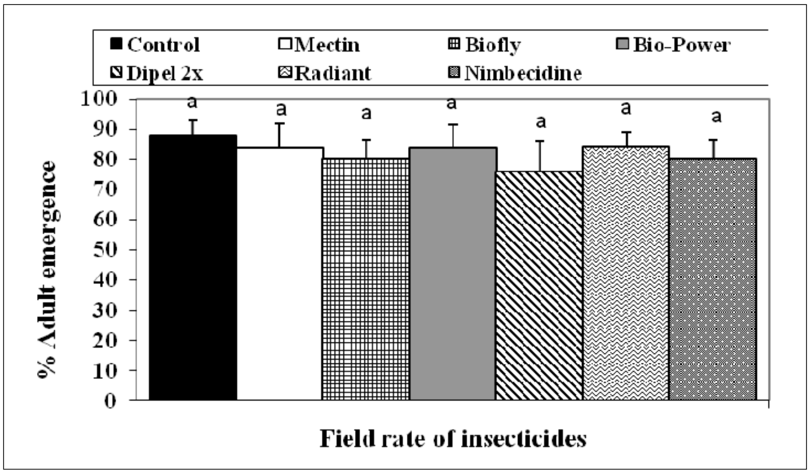
Also, data in Table 2 showed that Mectin was the most effective insecticide against the pupal stage followed descendingly by Radiant and Dipel 2x. The respective values of LC_{50} of those insecticides were 0.072 cm/l, 0.107 cm/l and 0.142 g/l. Toxicity index values at LC_{50} level showed a superior efficiency of Mectin (100%), followed by Radiant (67.28%) and Dipel 2x (50.7%). The slope values show that Nimbecidene had the highest slope value (5.29), whereas Biofly had the lowest value (3.41)

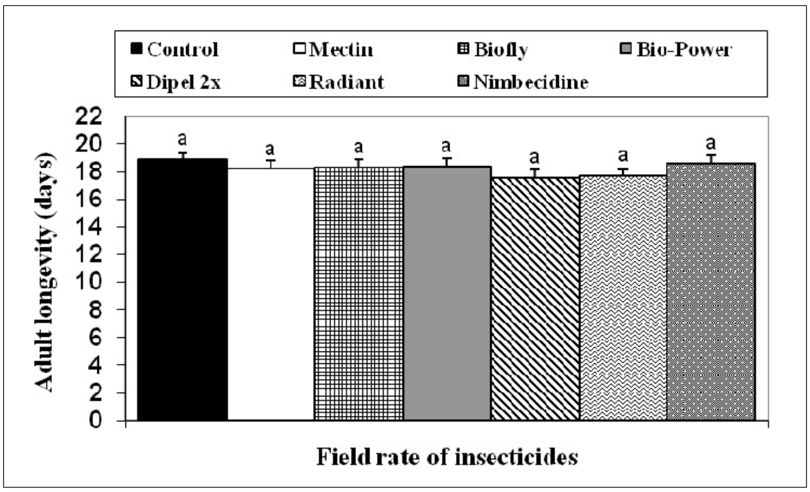
The effect of the field rate of insecticides on the emergence rates and adult longevity of the parasitoid *A. syleptae* is presented in Figure 4. The data indicate that, when cocoons of *A. syleptae* were treated with all tested insecticides, no significant differences were observed between the insecticides treatments and control, neither in rates of adult emergence ($F= 0.97; P\le 0.4615$) nor in the longevity of emerged adults ($F= 0.80; P\le 0.5723$).

Table 3. The toxic effects of insecticides to different developmental stages of *Palpita unionalis*

Insecticide	Eggs			Larvae									Pupae		
				1st instar			3rd instar			5th instar					
	slope	LC_{50} (95% CI)*	TI (%)**	slope	LC_{50} (95% CI)*	TI (%)	slope	LC_{50} (95% CI)	TI (%)	slope	LC_{50} (95% CI)	TI (%)	slope	LC_{50} (95% CI)	TI (%)*
Mectin	7.46	0.005 (0.001-0.030)	100	2.18	0.047 (0.027-0.089)	74.46	4.88	0.044 (0.021-0.092)	100	4.14	0.089 (0.062-0.128)	100	3.73	0.072 (0.040-0.129)	100
Biofly	3.44	0.458 (0.312-0.679)	1.09	2.00	0.925 (0.721-1.185)	3.78	4.50	1.244 (0.882-1.755)	3.53	9.51	2.06 (1.461-2.902)	4.32	3.41	3.207 (2.428-4.236)	2.24
Bio-Power	3.80	0.850 (0.683-1.059)	0.58	6.75	0.508 (0.206-1.251)	6.88	4.77	2.297 (1.892-2.892)	1.91	10.99	4.487 (2.741-7.346)	1.98	3.54	4.447 (3.077-6.427)	1.61
Dipel 2x	3.82	0.055 (0.040-0.076)	9.09	2.26	0.035 (0.010-0.124)	100	1.96	0.089 (0.069-0.115)	49.43	2.12	0.110 (0.090-0.136)	80.90	4.25	0.142 (0.094-0.215)	50.7
Radiant	6.78	0.006 (0.001-0.035)	83.33	3.20	0.045 (0.025-0.081)	77.77	4.69	0.089 (0.060-0.132)	49.43	10.89	0.112 (0.068-0.182)	79.46	3.70	0.107 (0.072-0.159)	67.28
Nimbecidine	6.28	0.158 (0.062-0.403)	3.16	1.66	0.749 (0.516-1.089)	4.67	3.14	1.114 (0.830-1.496)	3.94	8.70	1.308 (0.817-2.095)	6.80	5.29	2.28 (1.614-3.231)	3.15

*Confidence interval,
**Toxicity index at LC_{50}





*Means followed by the same letters (column wise) are not significantly different (Tukey's HSD; $P \leq 0.05$)

Figure 4. Rates of adult emergence and longevity of *Apanteles syleptae* treated as cocoons with the field rate of insecticides.

DISCUSSION

This paper provides information on the biological efficacy of six eco-smart biorational insecticides against eggs, larvae and pupae of an important pest of olive crops, *Palpita unionalis,* and its parasitoid, *Apanteles syleptae*. The study, carried out in the laboratory, showed that Mectin, Dipel 2x and Radiant had good ingestion effects and powerful toxic effects on *P. unionalis*. Also these insecticides showed ovicidal impact. In this study, Mectin, Dipel 2x and Radiant had higher ovicidal impact than Biofly, Bio-Power and Nimbecidine. It may be due to the former insecticides' ability to remove egg cortex. These findings are in conformity with those reported by Osman and Mahmoud (2009), who reported that Mectin and Spinosad had significant effects on the percentage of egg hatching of the Egyptian cotton leafworm, *Spodoptera littoralis* (Boisd.).

In the larvicidal bioassay, ingestion effects of the insecticides were evaluated and they were significantly higher in Mectin, Dipel 2x or Radiant than the other tested insecticides. Larval age and the duration of exposure were significant factors affecting the response of *P. unionalis* to insecticides. Mandour et al. (2008) had investigated the effects of Spinosad on different larval instars of *P. unionalis*. They reported that Spinosad had been toxic to the tested larval instars and mortality was in the order of first instar > third instar > fifth instar with the respective LC_{50} values of 0.019, 0.025 and 0.040 ml/l. Mahmoud and Osman (2007) and Osman and

Mahmoud (2009) had tested some biorational insecticides against onion thrips, (*Thrips tabaci* Lind.), green peach aphid (*Myzus persicae* Sulzer) and Egyptian cotton leafworm, *S. littoralis*. They found Mectin and Spinosad to be very toxic among the tested insecticides against the second instar larvae and adults of onion thrips and different larval stages of *S. littoralis*. In contrast to this result, Osman and Mahmoud (2009) had reported that Dipel 2x was less toxic to larvae of *S. littoralis*.

The results of this study show good toxic effects of Dipel 2x, Mectin and Radiant on the fifth instar larvae and latent effects on pupation, deformed pupae and adult emergence. But, toxic effect was insignificant on malformed adults. The results obtained in this experiment are similar to those reported by Osman and Mahmoud (2009) working with Mectin, Dipel 2x and Neemix against *S. littoralis*, or by El-Ghar et al. (1995) who reported that Abamectin treatment intensified a decrease in pupation (36 %).

Eco-smart insecticides are known to have low toxicity to arthropod predators and parasitoides (Cisneros et al 2002; Mahmoud 2004; Mahmoud and Osman 2007; Mahmoud and Loutfy 2012). The low toxicity of these insecticides to *A. syleptae* in this study might be due to the presence of silken cocoon that reduces insecticides uptake in parasitoid cocoons. Dipel 2x or Neemix have been reported to be harmless to the predator *Orius albidipennis* (Mahmoud and Osman 2007). Spinosad has been reported harmless to scores of natural enemies (Cisneros et al 2002; Mandour et al. 2008). In contrast of this result, Mahmoud and Osman (2007) reported that Mectin was harmful to the predator *O. albidipennis*. Schneider et al (2004) indicated that direct spray of Spinosad was harmful to the Ichneumonid parasitoid *Hyposoter didymator* (Thunberg) with a significant reduction in adult longevity.

In conclusion, the results of this study indicate that the impacts of certain eco-smart biorational insecticides differed considerably in their age specific toxicity. The differences can be attributed to different modes of action of the products and also to the developmental stage of jasmine moths, *Palpita unionalis.* The best overall results were obtained with Mectin, Radiant and Dipel 2x, which provided excellent control in 7 days of treatment. The eco-smart insecticides look promising and could be alternative insecticides in the future for controlling *P. unionalis* and be safe at the same time for natural enemies, such as the parasitoid *Apanteles syleptae*. Additional field experiments should be performed to confirm the preliminary evaluation of presented insecticides, in order to recommend them into the IPM strategy.

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Delovanje bioinsekticida na neke biološke stadijume moljca *Palpita unionalis* Hb. (Lepidoptera: Pyralidae)

REZIME

Ispitivano je delovanje šest bioinsekticida - Dipel 2x 6.4% WP (*Bacillus thuringensis* AI), Biofly 100% WP (*Beauvaria bessiana* AI), Radiant 12% SC (*Saccharopolyspora spinosa* AI), Mectin 1.8% EC (*Streptomyces avermitilis* AI), Nimbecidine 0.03% EC (Azadirachtin AI) i Bio-Power 50% EC (*Beauvaria bessiana* AI) - na jaja, larve i lutke moljca *Palpita unionalis* Hb. i njegovog parazitoida u laboratorijskim uslovima. Dobijeni rezultati su pokazali da su svi testirani insekticidi imali ovicidno delovanje na *P. unionalis.* Mectin je bio najtoksičniji od ispitivanih insecticida u stadijumu jaja, a zatim Radiant i Dipel 2x, a respektivne vrednosti njihovih LC_{50} bile su 0,005 cm/l, 0,006 cm/l i 0,055 g/l. Dipel 2x je bio najtoksičniji za larve *P. unionalis* prvog stupnja, dok je Mectin bio najtoksičniji za larve drugog i trećeg stupnja. Takođe, rezultati su pokazali da je Mectin bio najefikasniji protiv stadijuma lutke, a za njim opadajućim redom Radiant i Dipel 2x. Indeks toksičnosti je pokazao visoku efikasnost Mectin-a na LC_{50} (100%) za jaja, larve drugog i trećeg stupnja, kao i lutke, dok je Dipel 2x pokazao visoku efikasnost na nivou LC_{50} (100%) samo za larve prvog stupnja. Podaci pokazuju da su procenti formiranja lutke i izlaska bili značajno različiti u svim tretmanima u poređenju sa kontrolom, dok su razlike bile bez značaja za deformisane lutke i malformacije odraslih jedinki kada je tretman insekticidima bio u petom stadijumu larve. Pored toga, izletanje adulta *P. unionalis* nakon tretiranja u stadijumu lutke zavisilo je od koncentracije, a značajne razlike su dobijene između tretmana insekticidima i kontrole. Mectin, Radiant i Dipel 2x su imali najjači efekat na izletanje adulta i procenat malformacija kod adulta. Što se tiče toksičnosti insekticida za endoparazitoid *A. syleptae*, tretirane lutke razvile su se u stadijum odraslih jedinki bez značajnih razlika u poređenju sa kontrolom. Takođe, životni vek adulta tog parazitoida nije se razlikovao između tretmana insekticidima i kontrole.

Ključne reči: *Palpita unionalis; Apanteles syleptae;* botanički insekticidi; mikrobiološki pesticidi; toksičnost