Latent Effects Of Emamectin Benzoate Formulations On *Spodoptera Littoralis* Boisd. (Lepidoptera: Noctuidae)

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BSTRACT

Chemical control is used as a rapid and reliable method for insect control, but there is an ongoing need to replace older conventional insecticides with new insecticides to maintain efficacy and environmental protection. Emamectin benzoate is a bioinsecticide insecticide, which is used widely for the control of lepidopteran insects. In the present study, the latent effects of four emamectin benzoate formulations including; Absoluota 5% microencapsulated emulsion (ME), Emi-Mainar 5.7% Water Dispersible granule (WG), Camaro 5% Emulsifiable concentrate (EC), and Proclaim 5% Water Soluble Granules (SG). Second instar larvae of *Spodoptera littoralis* that survived after exposure to LC_{10}, or LC_{50} values of each formulation were maintained in the laboratory for larval and pupal development, reproductive activity, and oxidative stress enzymes assessed. Results exhibited that Emi-Mainar was more toxic (LC50= 0.007 µg/ml) than Absoluota and Proclaim (0.015 and 0.019 µg/ml). The toxicity of Camaro was comparable with the other formulations. The activity of superoxide dismutase (SOD) was significantly high when 2nd instar larvae were treated with LC_{50} concentrations of Emi-Mainar and Camaro formulations and significantly low with LC_{50} values of Absoluota, Proclaim and LC_{10} concentrations of Emi-Mainar, Camaro, and Absoluota formulations. While no effect was observed in the catalase enzyme (CAT) activity in all tested larvae with LC_{10} and LC_{50} of all formulations. Moreover, all tested formulations increased the development times of larval and pupal stages. The results suggest that Emi-Mainar formulation may have the largest impact on *S. littoralis* populations compared to other tested form of emamectin benzoate formulations.

Key words: Latent effects, chemical control, emamectin benzoate, *Spodoptera littoralis*

INTRODUCTION

Spodoptera littoralis (Boisd) attacks field and vegetable crops including cotton, alfalfa and tomato (Kandil *et al*., 2003, Pineda *et al*., 2007; El-Sheikh, 2015). Insecticides are used extensively to manage this insect, leading to the development of resistance to a significant proportion of the available active ingredients from several groups including organophosphates, carbamates and pyrethroids. Currently, resistance to a wide enormous of insecticides has been reported (Tabashnik *et al*., 2014), illustrating the need for management practices that utilize variety of insecticides with different modes of action.

Emamectin benzoate, which belongs to the avermectin family of 16-membered macrocylic lactones generated by the soil-dwelling microorganism, *Streptomyces avermitilis* (Crouch *et al*., 1997; Jansson *et al*., 1997; Lopez *et al*., 2010), is a promising insecticide for lepidopteran insect control. Emamectin benzoate is used against several species of lepidopteran such as; *Heliothis virescens*, *Plutella xylostella*, *Pseudoplusia includes, Spodoptera frugiperda*, *Trichoplusia ni*, *S. littoralis*, *Spodoptera exigua* and *Mamestra Brassicae* (Trumble *et al*., 1987; Argentine *et al*., 2002, Firake and Pande 2009; Bengochea *et al*., 2014; El-Sheikh, 2015; Moustafa *et al*., 2016), with low toxicity to non-Lepidopteran and most beneficial insects (Jansson *et al*.,, 1997).

Emamectin benzoate is composed of ~90% avermectin B1a and ~10% of avermectin B1b (Mushtaq *et al*., 1997). It belongs to class 6 of the Insecticide Resistance Action Committee (IRAC) mode of action, affecting the GABA gated chloride channels, stimulating the flow of chloride ions into neuronal cells with hyperpolarization, sweep of signal transmission, and disrupt of nerve impulses, which leads to death at the end (Jansson *et al*., 1997; Ishaaya 2002; Grafton-Cardwell *et al*., 2005). As a result of its efficiency against lepidopteran insects (Jansson *et al*., 1997), emamectin benzoate is marketed in different formulations, but there is a shortage of data establishing the relative efficacy of these formulations for pest control. For example, no information has been documented on the effect of the sublethal concentrations of these formulations of emamectin benzoate on the oxidative stress enzymes in *S. littoralis*. Generally, the repletion of oxidants (such as superoxide anion radicals, hydroxyl radical and hydrogen peroxide) and/or a deficit of antioxidants results in oxidative stress that may lead to uncontrolled lipid peroxidation, protein oxidation and even apoptosis. The insecticides often induces

the production of reactive oxygen species (ROS) in insects, which may be the cause of death (Felton and Summers 1995; Büyükgüzel, 2009). During normal oxidative processes, the oxidative radicals are generated in eukaryotic cells and extracellular fluids. Superoxide dismutase (SOD) transforms the radicals of superoxide into oxygen and hydrogen peroxide, which in turn requires another enzyme, such as catalase (CAT), for its conversion into water and oxygen (Ahmad *et al*., 1991).

The current work investigates the latent effect of lethal and sublethal effects of four different emamectin benzoate formulations on development, fecundity, fertility, as well as oxidative stress enzymes in *S. littoralis*.

MATERIALS AND METHODS

Emamectin benzoate formulations

Four emamectin benzoate formulations were used, including Absoluota 5% ME (Agro-group Co., Egypt) Agrochemical Industries Corporation – Jordan; Emi-Mainar 5.7% WG (Cairo Chemistry for Agricultural Services, Egypt) Anhui Fengle Agro Chemical Co. LTD – China; Camaro 5% EC (Astrachem Co., Egypt) Astra Industrial Fertilizer and Agricultural Pesticides Complex – Egypt; and Proclaim 5% SG (Syngenta Agro-Egypt) Syngenta – Switzerland.

Spodoptera littoralis culture

S. littoralis used in the study were reared in the laboratory with the absent of insecticides for a minimum of 30 generation as described by El-Defrawi *et al*., (1964). Larvae were reared on fresh castor bean leaves at 25±1°C, 75±5% RH. Emerged adult moths were fed with a 10% sugar solution.

Bioassays

Insecticidal effects of different emamectin benzoate formulations were tested using early 2nd instar larvae of *S. littoralis*. Six different concentrations (0.0009, 0.0019, 0.0039, 0.0078, 0.0156, and 0.0312 µg/ml (ppm)) of each formulation were used. Excised castor bean leaves were dipped in each concentration for 20 seconds, then air dried for 30 minutes A pair of treated leaves were then set into a glass jar (0.5 L), and twenty five larvae were added and left to feed *ad libitum* for 24h. Each jar was lined with white paper and closed with fine mesh covering the opening. Larval control were fed on untreated leaves. There were four replicates (25 larvae/ rep.) for each concentration. After the 24h feeding period all larvae were offered untreated leaves *ad libitum*, and mortality% was recorded for 4 days (96 hours) post treatment to calculate the lethal and sublethal concentrations of each formulation on *S. littoralis* larvae. The bioassay was repeated twice.

Effects of emamectin benzoate formulations on development of *S. littoralis*

Early 2nd instar larvae of *S. littoralis* were exposed to the selected formulations using the method described above. Insects surviving exposure to LC_{10} and LC_{50} equivalent concentrations of each formulation were used for studying the effect of the product on development time of larval and pupal stages, percent successful pupation and adult emergence. Larval duration and mortality were recorded daily until the last instar larval stadium. Non-feeding last instar larvae were transferred individually to a clean cup containing sawdust for pupation. After three days, each pupa was gently removed from the sawdust, sexed, weighed, and maintained individually in the same cup with moist cotton, and the total pupal duration, percent pupation, and percent emergence recorded.

Studies on fecundity and fertility

After emergence, groups of five females and seven males were transferred to glass jars (1 L) and fed as described above (Moustafa *et al*., 2016). Each jar was lined with white paper and closed with fine mesh covering the opening at the top. There were three replicates (5 females +7 males / rep.) for each concentrations of LC_{10} and LC_{50}. Deposited eggs were taken and counted from day's two to six in the mating jars. The eggs were transferred to a clean Petri dish with a piece of wet cotton and kept for three to five days to record the percent hatching.

Effects of emamectin benzoate formulations on the oxidative enzymes of *S. littoralis*

At four days post treatment, surviving *S. littoralis* larvae that had been exposed to the LC_{10}, and LC_{50} equivalent concentrations of each emamectin benzoate formulation using the method described above, were transferred to a clean jar and kept at -20 °C prior to the biochemical assays. Larvae from the controls were also subjected to the same procedure.

Catalase activity

The activity of CAT was measured using Biodiagnostic Kit No., CA 2517 using the method described by Aebi (1984). The activity of CAT enzyme was estimated by measuring the rate of H_2O_2 consumption via absorbance at 240 nm.

Superoxide Dismutase (SOD) activity

SOD activity was measured using Biodiagnostic Kit No., 2521 based on the inhibition of the phenazine methosulphate-mediated reduction of nitroblue tetrazolium dye by SOD enzyme (Nishikimi *et al.*, 1972).

Statistical analyses

Probit analysis Version 1.5, EPA Probit Analysis Program (U.S. Environmental Protection Agency, Cincinnati, OH, USA) was used to estimate the

lethal and sublethal concentrations; LC_{10}, LC_{50} and LC_{90} for all formulations. The data analysis of the biological parameters, reproductive activity and oxidative stress enzymes were done using one-way ANOVA (SAS, 2001) and Duncan's multiple range test.

RESULTS

Determination of lethal and sublethal concentrations of different emamectin benzoate formulations

Toxicity results show that emamectin benzoate of Emi-Mainar 5.7% WG exhibited higher toxicity to the 2nd instar larvae of *S. littoralis* than other formulations, with LC_{50} value of 0.007 µg/ml, compared to 0.013, 0.015, and 0.019 µg/ml for Camaro 5% EC, Absoluota 5% ME, and Proclaim 5% SG, respectively. The LC_{90} values ranged from 0.080 to 0.230 µg/ml, and LC_{10} values from 0.001 to 0.004 µg/ml (Table 1).

Effects of different emamectin benzoate formulations on *S. littoralis* development

Larvae surviving exposure to LC_{10} and LC_{50} equivalent concentrations of the four emamectin benzoate formulations were used to determine the latent effects on development of *S. littoralis* (Table 2). Results presented that all emamectin benzoate formulations significantly increased larval (from 2nd instar) and pupal developmental period contrasted to the control (F Value= 304.68, P= <0.0001, and F Value= 106.44, P= <0.0001 respectively). Larval durations were significantly longer in the Emi-Mainar 5.7% WG treatment than other tested formulations. Pupal duration was also longer when compared with equivalent exposures to other formulations where significant differences occurred.

The pupal weight of females following exposure the 2nd instar larvae with Emi-Mainar 5.7% WG was significantly lower than for other formulations, (Table 2). The percent successful pupal emergence was similar to the controls following exposure to all emamectin benzoate formulations and concentrations except for the LC_{50} concentration of Emi-Mainar 5.7% WG (90.19%) which was significantly lower (Table 2). There were no effects of the tested formulations of emamectin benzoate on either the percentage of larvae that successfully pupated or the sex ratio of emerging adults (Table 2).

Fecundity and fertility

All formulations of emamectin benzoate significantly decreased the fertility at the concentrations tested (LC_{10} and LC_{50} values) when contrasted with the control (F Value= 15.43, P= <0.0001), with the exception of Absoluota 5% ME at LC_{10} (Table 3). Fertility following exposure of larvae to the LC_{10} concentration of Emi-Mainar 5.7% WG, Camaro 5% EC and Proclaim 5% SG were closed, but all were lower than recorded following LC_{10} of Absoluota. A similar trend followed the equivalent LC_{50} treatments. When compared with untreated controls, fecundity decreased significantly (F Value= 3.80, P= 0.0089) in all treatments except for LC_{10} of Camaro 5%EC and Proclaim 5% SG when 2nd instar larvae of *S. littoralis* were treated with the tested formulations as shown in Table (3).

Oxidative stress enzymes activity

Activity of CAT and SOD enzymes in larval tissues of *S. littoralis* at four days post treatment of the 2nd instar larvae with LC_{10} and LC_{50} concentrations of the four tested emamectin benzoate formulations are shown in Figure 1.

The SOD activity was high in larvae treated with the LC_{50} concentration of Emi-Mainar and Camaro formulations (15.23±5.5 and 14.93±2.6 IU/g of protein), followed with Proclaim and Absoluota formulations (11.78±1.8 and 9.90±1.1 IU/g of protein) compared to the untreated larvae with 6.66±0.8 IU/g of protein (F Value= 1.83, P= 0.1271). The SOD activity of the larvae treated with LC_{10} concentrations of Emi-Mainar, Camaro, and Proclaim were low (13.44±1.2, 11.48±1.2 and 10.33±3.4 IU/g of protein, respectively) compared to the corresponding values of LC_{50} treatments. In contrast, there was no significant difference in the CAT activity (F Value= 1.31, P= 0.2899) in the treated larvae with LC_{10}, and LC_{50} of all emamectin benzoate formulations compared with the control.

DISCUSSION

Emamectin benzoate was shown to reduce the development rate of larvae. In addition, following exposure increased the pupal stage duration, decreased pupal weight of both males and females, and a reduction in the percentage of pupae that successfully eclosed was recorded. Similarly, the LC_{90} values of emamectin benzoate against the 3rd and 5th instar larvae of *S. littoralis* were reported as being 0.31 and 0.64 µg/ml respectively, (El-Shiek, 2015) suggesting that the formulations tested in this study displayed greater insecticidal activity. Therefore, Jansson *et al*., (1997) and Jansson and Dybas, (1998) reported that the LC_{90} values for emamectin benzoate against thirteen lepidopterans pests such as; *H. virescens, T. ni, H. zea, S. exigua, Ostrinia nubilalis*, *Agrotis ipsilon, etc.* were ranged between 0.002 - 0.89 µg/ml, a slightly larger range to that found for the activity of different formulations against *S. littoralis* in the current experiments. Argentine *et al*., (2002) found that the LC_{90} values for emamectin benzoate ranged from 0.005 to 0.021 µg/ml for six species of Lepidoptera. In contrast, the LC_{90} for emamectin benzoate against *H. armigera* was 13.08 µg a.i./ml (Parsaeyan *et al*., 2013).

Table 1: Lethal and sublethal effects of emamectin benzoate formulations after 4 days post-treatment on 2nd instar larvae of *S. littoralis*.

Emamectin benzoate formulations	LC_{10} (µg/ml) 95% confidence limits	LC_{50} (µg/ml) 95% confidence limits	LC_{90} (µg/ml) 95% confidence limits	Slope ± SE
Absoluota 5% ME	0.001 (0.001-0.001)	0.015 (0.012-0.021)	0.230 (0.122-0.592)	1.08 ± 0.11
Emi-Mainar 5.7% WG	0.001 (0.000-0.001)	0.007 (0.006-0.009)	0.084 (0.054-0.157)	1.21 ± 0.11
Camaro 5% EC	0.002 (0.001-0.005)	0.013 (0.008-0.026)	0.080 (0.035-0.575)	1.61 ± 0.26
Proclaim 5% SG	0.004 (0.001-0.006)	0.019 (0.013-0.040)	0.100 (0.046-0.652)	1.79 ± 0.28

Results of the current study are consistent with those of Moustafa *et al*., (2016) who found that emamectin benzoate prolonged larval and pupal period when 2nd instar larvae of *M. brassicae* were treated with 0.005 µg/ml of emamectin benzoate. The LC_{25}, LC_{30}, and LC_{50} concentrations of emamectin benzoate also increased the larval and pupal developmental periods of *H. armigera* (Parsaeyan *et al*., 2013; Kandil *et al*., 2014). The emamectin benzoate in Emi-Mainar 5.7% WG resulted in lower female and male pupal weight and percentage emergence when compared with other formulations in the present study. This reduction in pupal weight reflected a similar reduction found in *H. armigera*, and *M. brassicae* (Lixia *et al*., 2011; Parsaeyan *et al*., 2013; Moustafa *et al*., 2016) after larvae were treated with sublethal concentrations of emamectin benzoate. Therefore, in another study the larval weight of *S. littoralis* was significantly decreased after 3rd instar larvae were treated with 0.20 µg/ml of emamectin benzoate for a period of four days (El-Shiekh, 2015).

The percentage of eggs that hatched and in some cases the fecundity of adults from the treated the 2nd instar larvae with LC_{10} and LC_{50} values of the all formulations of emamectin benzoate was reduced. These results are in agreement with results obtained in a previous study when 3rd instar larvae of *H. armigera* were treated with a sublethal concentration (LC_{30} (0.77 µg/ml) of emamectin benzoate (Parsaeyan *et al*., 2013). Similarly, a significant reduction in fecundity and fertility was observed after *H.* zea adults were treated with emamectin benzoate (Lopez *et al*., 2010). Finally, fecundity was also significantly decreased in *S. exigue* after female adults were treated with 0.5 and 1.0 µg/ml of emamectin benzoate (Bengochea *et al*., 2014). It has been suggested that the repression of movement in the muscles used in egg laying could contribute to the reduction in fecundity in insects following treatment with emamectin benzoate (White *et al.,* 1997).

Asignificant increase in the activity of antioxidant enzymes, such as SOD and CAT are a sign of oxidative stress since these four defensive enzymes function cooperatively to holder the relatively by high amounts of ROS inside the cell (Foyer *et al*., 1994). The current results showed that the treated larvae with emamectin benzoate as an active ingredient induce significantly the activity of SOD enzyme, while there was no significant effect on CAT enzyme activity contrast to untreated larvae. The SOD is reduces of superoxide radicals in the cells by the stimulation of extracellular factors such as pesticide treatment. The damage that can be caused by superoxide radicals, could be defense by SODs. Consistent with this, the increased oxidative stress leads to an up-regulation of antioxidant enzymes, insects may restrict oxidative radicals and other oxidants from reaching metabolically active tissues. Previous studies reported a strong correlation between CAT gene expression and longevity in *Drosophila melanogaster* (Orr and Sohal 1994); decreased CAT activity or interruption of the CAT gene expression could lead to death after adult emergence (Griswold *et al.*, 1993; Orr and Sohal 1994).

CONCLUSION

Understanding the biological or mechanistic effects of any pesticide is important if treatment thresholds for pesticides are to be reduced without the associated risk of control failure. This study aimed to enhance our knowledge of insecticidal efficiency and the latent effects of different forms of emamectin benzoate formulations against *S. littoralis*. The significance of our results on the effects of the different emamectin benzoate formulations are varied significantly and evidence is reported that indicates that Emi-Mainar 5.7% WG may have the largest impact on pest populations, followed by Camaro 5% EC and Proclaim 5% SG.

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Table 2: Effects of emamectin benzoate formulations on development of *S.littoralis* from 2nd instar larvae to adult emergence.

Treatments		[a]Larval duration (day)	Pupation%	[b]Pupal duration (day)	Pupal weight (mg)		Sex ratio		Emergence %
					Female	Male	Female	Male	
Control		16.70^{b}±0.05	97.03^{a}±1.37	8.43^{a}±0.04	0.296^{a}±0.004	0.274^{a}±0.003	47.20^{a}±2.67	52.80^{a}±2.67	96.15^{a}±1.46
Absolutoin	LC_{10}	17.51^{g}±0.04	100.0^{d}±0.00	9.59^{b}±0.07	0.349^{b}±0.005	0.331^{b}±0.004	49.76^{a}±8.14	50.24^{a}±8.14	99.30^{b}±0.69
5%ME	LC_{50}	18.16^{f}±0.10	100.0^{d}±0.00	9.65^{b}±0.08	0.370^{c}±0.009	0.331^{b}±0.004	35.24^{a}±3.13	64.76^{a}±3.13	97.77^{b}±1.11
Emi-Mainar	LC_{10}	19.91^{c}±0.12	97.03^{a}±1.96	10.04^{b}±0.03	0.268^{d}±0.008	0.262^{d}±0.006	50.36^{a}±5.23	49.64^{a}±5.23	94.60^{ab}±1.58
5.7% WG	LC_{50}	20.59^{b}±0.09	98.51^{a}±0.74	10.75^{a}±0.07	0.291^{c}±0.006	0.294^{bc}±0.007	48.88^{a}±8.48	51.12^{a}±8.48	90.19^{b}±2.04
Camaro 5% EC	LC_{10}	19.61^{d}±0.08	99.24^{a}±0.76	9.93^{b}±0.12	0.333^{bc}±0.005	0.313^{b}±0.005	50.36^{a}±6.68	49.64^{a}±6.68	98.48^{a}±0.76
	LC_{50}	20.30^{b}±0.12	96.28^{a}±1.96	10.68^{a}±0.14	0.334^{bc}±0.005	0.309^{bc}±0.005	55.85^{a}±11.7	44.15^{a}±11.7	96.22^{a}±1.97
Proclaim 5% SG	LC_{10}	18.15^{e}±0.04	98.51^{a}±1.48	9.94^{b}±0.10	0.309^{cd}±0.006	0.291^{c}±0.004	46.84^{a}±3.64	53.16^{a}±3.64	94.67^{ab}±2.09
	LC_{50}	18.66^{e}±0.09	97.03^{a}±1.96	10.81^{a}±0.10	0.325^{bc}±0.005	0.310^{bc}±0.007	50.44^{a}±4.57	49.56^{a}±4.57	94.30^{ab}±2.84

Values marked with the same letters are not significantly different (P> 0.05: Duncan's multiple range test).

a = number of days from 2nd instar larvae till pupation.

b= number of days from the pupation till the emergence.

Table 3: Mean Fecundity and percentage eggs that hatched (±SE) of *S. littoralis* female after exposure of 2nd instar larvae to LC_{10} and LC_{50} Values of emamectin benzoate formulations.

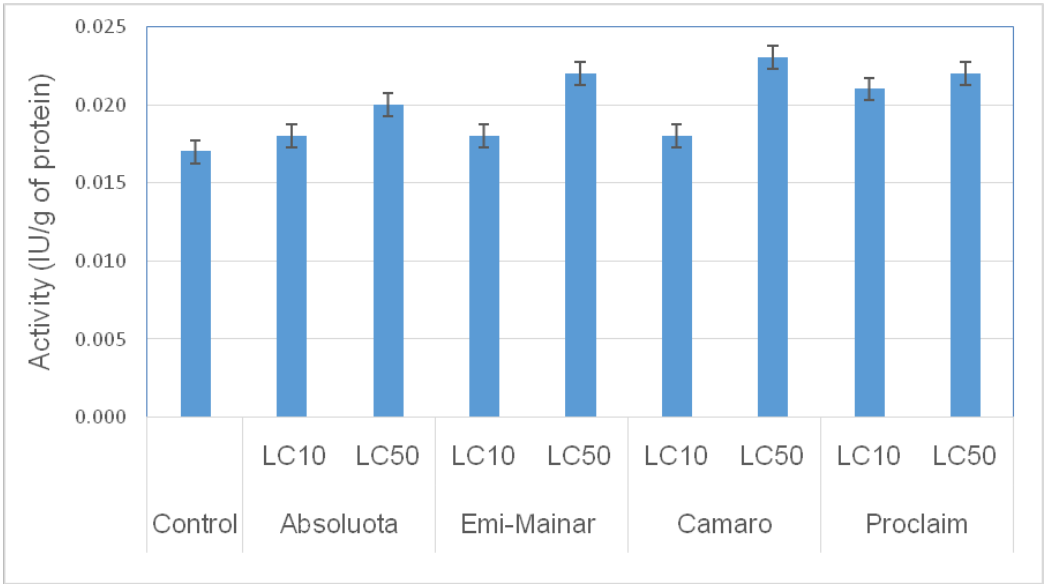
Treatments		[a]Fecundity	[b]Hatchability %
Control		573.73[a]±28.92	92.95[a]±2.17
Absoluota 5% ME	LC_{10}	417.15[cd]±31.25	83.14[a]±8.87
	LC_{50}	317.78[d]±16.06	66.88[b]±2.45
Emi-Mainar 5.7% WG	LC_{10}	423.86[cdb]±49.32	55.56[bc]±1.07
	LC_{50}	384.51[cd]±18.78	49.67[c]±5.37
Camaro 5% EC	LC_{10}	551.80[ab]±19.14	53.01[c]±2.18
	LC_{50}	433.31[cdb]±91.88	48.61[c]±5.00
Proclaim 5%SG	LC_{10}	458.93[cab]±17.10	51.05[c]±2.69
	LC_{50}	421.89[cdb]±28.62	48.26[c]±1.58

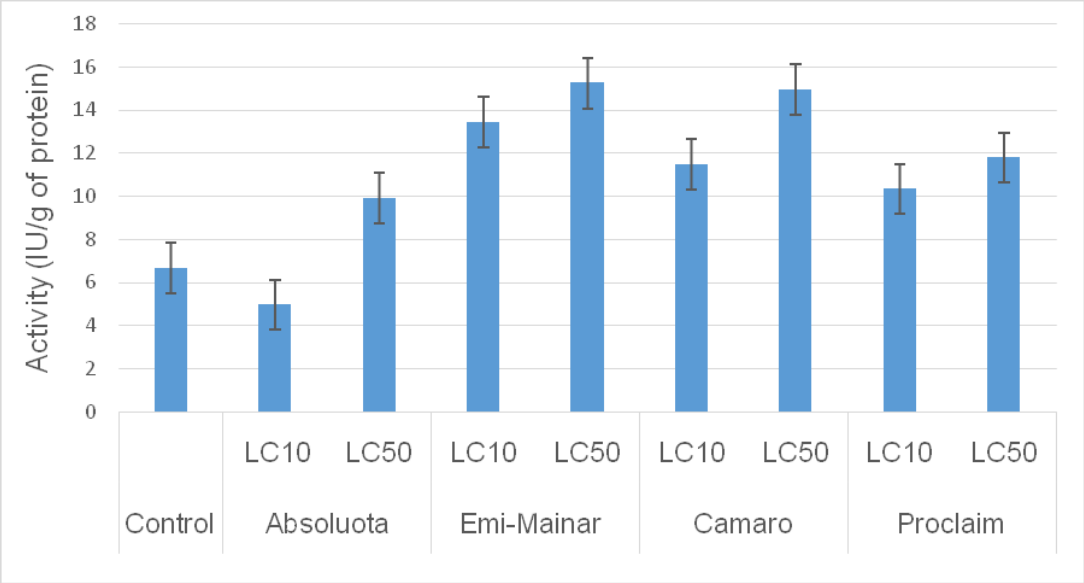
Values marked with the same letters are not significantly different (P > 0.05: Duncan's multiple range test)

[a]Fecundity was estimated by counting the eggs from the first day till the sixth day (total number of eggs laid by one female).

[b]Hatchability% is calculated by counting of the percent of emerged larvae from the collected eggs batches.

Figure 1: CAT (A) and SOD (B) activities of *S. littoralis* after exposure of 2nd instar larvae to LC_{10} and LC_{50} values of different formulations of emamectin benzoate.





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الملخص العربي

التأثيرات المتأخرة لمستحضرات مبيد إيمامكتين بنزوات على دودة ورق القطن

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تستخدم المكافحة الكيميائية كطريقة سريعة في مكافحة الحشرات ولكن هناك حاجة مستمرة لاستبدال المبيدات الحشرية التقليدية القديمة بمبيدات كيميائية جديدة للحفاظ على الفعالية وحماية البيئة. ويعتبر مبيد إيمامكتين بنزوات من المبيدات الحشرية التابعة لمجموعة المبيدات الحيوية والتي تستخدم على نطاق واسع في مكافحة حشرات حرشفية الأجنحة. حيث تم دراسة ومقارنة التأثيرات المتأخرة لأربعة مستحضرات مختلفة من مبيد إيمامكتين بنزوات وهم: أبسولوتا (ME 5%)، إيمي ماينر (WG 5.7%)، كامارو (EC 5%)، وبروكليم (SG 5%) على تطور و النشاط التناسلي وكذلك نشاط انزيمات الإجهاد التأكسدي ليرقات الطور الثاني من دودة ورق القطن بعد معاملتها بالتركيزات LC_{10} ، LC_{50}. وقد أظهرت النتائج أن مستحضري ايمي ماينر و كامارو كانا أكثر سمية من الأخرين بقيم LC_{50} مقدارها ٠,٠٠٧ و ٠,٠١٣ ميكروجرام / مل في حين كانت قيمة LC_{50} لكلا من أبسولوتا و البروكليم ٠,٠١٩ و ٠,٠١٥ ميكروجرام / مل . وكذلك كان نشاط أنزيم SOD عاليا عند معاملة يرقات العمر الثانى بتركيز LC_{50} لكلا من مستحضري إيمي ماينر و كامارو ، مع انخفاضه معنوياً بعد المعاملة بقيم LC_{50} من تركيزات أبسولوتا و البروكليم و LC_{10} من مستحضرات إيمي ماينر و كامارو و كذلك أبسولوتا. في حين أدت المستحضرات المختبرة عند تركيزي LC_{10} ، LC_{50} إلي زيادة فترات تطور الطور اليرقي والعذارى مع أنخفاض معدل وضع البيض ونسبة الفقس نتيجة معاملة يرقات الطور الثاني من دودة ورق القطن. وتشير النتائج إلي إمكانية أستخدام مستحضر WG من إيمي ماينر والذي أظهر فعالية عالية في مكافحة دودة ورق القطن مع إمكانية أدراجه في برامج المكافحة المتكاملة لهذة الأفة.