EFFICACY OF TWO BIORATIONAL INSECTICIDES, EMAMECTIN BENZOATE AND SPINOSAD, AGAINST THE IMMATURE STAGES OF THE COTTON LEAFWORM, *SPODOPTERA LITTORALIS* (BOISD.) (LEPIDOPTERA: NOCTUIDAE)

Mohamed A. El-Aw

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ABSTRACT

The toxicity of two biorational insecticides, Emamectin benzoate (Proclaim 5% SG) and Spinosad (Tracer 24% SG), was evaluated against the immature stages of a laboratory susceptible strain of the cotton leafworm, S. littoralis. Among the egg stage, plant leaves containing egg masses, 24 hrs-old, were dipped in different concentrations of each insecticide diluted in 1% detergent (Nastabon)-water solution or in water only. When insecticides diluted in 1% detergent-water solution (DWS), ovicidal activity of both compounds was significantly increased by about 36-51% than those diluted in water only. A concentration-dependent response was observed for eggs treated with both insecticides.

The toxicity of Proclaim and Spinosad was evaluated against the newly hatched larvae of S. littoralis, at 24, 48, and 72 hrs posttreatment. Results demonstrated that the LC_{50} values of both insecticides were decreased, in general, by increasing the posttreatment period of times. On the bases of LC_{50} values, Proclaim was more toxic on the newly hatched larvae of S. littoralis than Spinosad. The LC_{50} values of Proclaim and Spinosad diluted in water only were 0.0321 and 5.902 ppm, 24 hrs posttreatment, respectively. When both insecticides diluted in 1% DWS, the LC_{50} values of both insecticides slightly decreased to 0.0294 and 5.153 ppm, respectively.

The toxic action of Proclaim and Spinosad against male and female pupae of S. littoralis, 48 hrs-old, was also investigated. Both insecticides diluted in 1% DWS caused no pupal mortality after 24, 48, and 72 hrs of treatment, but significantly increased percentages of deformed adults. Present results indicated that the two tested bio-insecticides are potentially potent for control of S. littoralis and using a detergent-water solution for insecticide application may be useful in this respect.

INTRODUCTION

The Egyptian cotton leafworm, *S. littoralis*, is one of the most important polyphagous pests, widely distributed in the Mediterranean region, North and East Africa, Asia and Europe (Horowitz *et al.*, 1994; Smagghe and Degheele, 1997; and Quero *et al.*, 2002).

The insecticide market has been dominated by the organophosphate, carbamate, and pyrethroid classes of insecticides (Argentine *et al.*, 2002). There is a continuing need for new, safe, effective and economical insecticides for crop protection and public health (Casida and Quistad, 2005). The searsh for new insecticides is an ongoing process dependent on many factors including the ability of insect to develop resistance to conventional materials (Cochran, 1990). High level of resistance to the synthetic insecticides had increased due to the intensive application of such insecticides for controlling *S. littoralis* larvae (Ishaaya and Klein, 1990 and El-Aw *et al.*, 2002). If this trend continues, new compounds will be required to replace these insecticides. Recently, a number of new insecticide classes have been discovered and commercialized (Argentine *et al.*, 2002).

Avermectins, a group of chemicals produced by soil-inhibiting streptomycete bacteria, have demonstrated high toxicities to a number of insects, mites and nematode pests (Putter *et al.*, 1981). Abamectin is a fermentation product composed of two avermectins derived from the soil bacterium *Streptomyces avermitilis*. Emamectin benzoate (Proclaim®) is an analog of abamectin, produced by the same fermentation system as abamectin. The active ingredient in Proclaim is avermectin B1 (Ware and Whitacre, 2004).

Spinosyns are among the newest classes of insecticides, represented by spinosad (Success®, Tracer Naturalyte®). Spinosad is a fermentation metabolite of the actinomycete *Saccharopolyspora spinosa*, a soil-inhibiting microorganism. It has both contact and stomach activity against lepidopteran larvae, leaf miners, thrips, and termites, with long residual activity. (Thompson *et al.*, 1999; Dow AgroSciences Co., 2001).

The purpose of this investigation is to study the ovicidal activity of two bio- insecticides, Proclaim and Spinosad, against the egg stage and to evaluate their toxicity to the newly hatched larvae as well as male and female pupae of *S. littoralis* under the laboratory conditions by improving their application methods.

MATERIAL AND METHODS

1. Experimental insects:

The stock culture of the Egyptian cotton leafworm *S. littoralis* was maintained for several years under the laboratory conditions of 25 ± 2.0 °C, 75.0 ± 5.0% R.H., and LD 16:8 (lightness from 8 a.m., to 12 p.m. and darkness from 12 p.m. to 8 a.m., daily). Larvae were fed on castor leaves and adults were fed on 10 % sucrose solution. Adults of both sexes were placed in a wooden cage provided with a small branches of Nerium plant (*Nertum oleander*) as an oviposition site.

2. Bioassay tests:

Bioassay tests of the selected insecticides against laboratory susceptible strain of *S. littoralis*

Pest Control and Environmental Protection Department, Faculty of Agriculture (Damanhour), Alexandria University

were carried out using egg masses (24 hrs-old), newly hatched larvae, and male and female pupae (48 hrs-old).

a) Tested bio-insecticides:

Proclaim 5% SG (Emamectin benzoate) which is, like abamectin, supplied by Syngenta Co., with a recommended rate of 60 gm/ 400 L. water and Tracer 24% SG (the commercial formulation of spinosad) is produced by AgroSciences Co., with a recommended rate of 120 gm/ 400 L. water. The detergent Nastabon (ingredients: anionic surfactants 5-15 % preservative) used in the experiments with a rate of 1% in water (v:v) is produced by the Egyptian Co. for Starch, Yeast and Detergents, Alex., Egypt.

b) Procedure:

For the determination of the ovicidal activity of Proclaim and Spinosad, Nerium plant leaves containing egg masses of *S. littoralis* were dipped in different concentrations of each insecticide. Series of concentrations were prepared by dissolving the appropriate amount of the insecticide according to the recommended rate of each insecticide in 1000 ml of 1% DWS or in tap water only, in two parallel experiments. Ten egg masses of *S. littoralis*, 24 hrs-old, were dipped for 15 second in each insecticide concentration, and kept in a clean plastic cup covered with muslin. Control egg masses were dipped for 15 second in tap water and kept in a clean plastic cup covered with muslin. The treated egg masses were examined daily and number of hatched and unhatched eggs were counted and recorded. Percentages of hatched and unhatched eggs in each treatment and control were calculated.

For the determination of the base line (LC-p-line) of Proclaim and Spinosad, castor leaves were dipped for 15 second in each insecticide concentration dissolved either in 1% DWS or in tap water only and dried in open air. Ten newly hatched larvae of *S. littoralis* were fed for 24 hrs on the treated leaves for each concentration. Each concentration was replicated four times. After 24 hrs posttreatment the treated leaves were replaced by untreated ones. Control larvae were fed for 24 hrs on castor leaves dipped for 15 second either in 1% DWS or in tap water and kept in a clean plastic cup covered with muslin. Mortality counts were observed and recorded at 24, 48, and 72 hrs posttreatment. Percentages mortality were corrected, if needed, according to abbott formula (Abbott, 1925). The concentration required to kill 50 % of the newly hatched larvae (LC_{50}) in ppm was then determined, at 24, 48, and 72 hrs posttreatment, for each tested insecticide according to the method of Finney (1971).

Experiments were conducted also to determine the pupicidal activity of Proclaim and Spinosad on 48-old male and female pupae of *S. littoralis*. Ten pupae, 48 hrs-old, for each replicate were dipped for 15 second in each tested insecticide concentration dissolved either in 1% DWS or in water only, in two parallel experiments, and kept in a clean plastic cup covered with muslin. Control pupae of *S. littoralis*, 48 hrs-old, were dipped for 15 second either in 1% DWS or in tap water and kept in a clean plastic cup covered with muslin. Four replicates were prepared for each tested insecticide concentration. The treated male or female pupae were examined daily until adult emergence and number of died pupae were recorded 24, 48, and 72 hrs posttreatment. Number of male and female adults emerged from the treated pupae were recorded.

The above-mentioned data were statistically analyzed to obtain the the analysis of variance (ANOVA) and least significant differences (L.S.Ds) by the method of Steel and Torrie(1984) according to which the data were transformed, when desired, using square root and angular transformation.

RESULTS AND DISCUSSION

Ovicidal activity:

Among the egg stage, plant leaves containing egg masses were dipped in different concentrations of each insecticide diluted either in water or in 1% DWS.

Data in Tables (1 and 2) show the ovicidal activity of the bio-insecticide, Proclaim, dissolved in water only (Table 1) or in 1% DWS (Table 2), against 24 hrs-old eggs of *S. littoralis*. When the insecticide diluted with water only, the compound at a concentration of 7.5 ppm exhibited ovicidal activity as percentage of unhatched eggs reached to 42.35 % which increased to 90.15 % when diluted with 1% DWS. Increasing the percentage of unhatched eggs from 23.11 % to 59.26 % was obtained with 1.0 ppm of Proclaim diluted with water only, or with 1% DWS, respectively. However, significant differences in the percentages of unhatched eggs were found between all tested concentrations of Proclaim and control eggs.

Data in Tables (3 and 4) show the ovicidal activity of the bio-insecticide, Spinosad, dissolved in water only (Table 3) or in 1% DWS (Table 4), against 24 hrs-old eggs of *S. littoralis*. When insecticide diluted with water only, the compound at a concentration of 72 ppm exhibited ovicidal activity reached to 51.28 % which increased to 93.39 % when diluted with 1% DWS. Inhibition of egg-hatch of 81.64 and 31.85 % were obtained with 9.0 ppm of Spinosad diluted in 1% DWS or in water, respectively. However, significant differences in the percentages of unhatched eggs were found between all of the tested concentrations and control eggs. The report of (Dow AgroSciences (2001) revealed that Spinosad has been found to be highly active on most Lepidoptera. It has contact activity on all stages of a pest (egg, larvae, and adult). Eggs must be sprayed directly but larvae and adults can be effectively dosed through contact with treated surfaces. Spinosad is most effective when

ingested. However, Results of Raslan (2002) support our results. The author used Spinosad 24 % SC for the control of egg masses of the cotton leafworm, *S. littoralis*, and concluded that this product could replace the manual hand picking of egg masses.

Data in Table (5) show the ovicidal activity of the detergent, Nastabon, dissolved in water, on 24 hrs-old eggs of *S. littoralis*. The concentrations of the detergent ranging from 0.125-2 % in water (v:v). It is observed that 2.0, 1.5 and 1 % detergent diluted in water caused 19.7, 15.5, and 16.7 % unhatched eggs, respectively. No significant differences in the percentages of unhatched eggs were found between the above-mentioned three tested concentrations of the detergent. The percentages of unhatched eggs were significantly decreased to be 11.02, 8.4, and 7.1 % when the tested concentrations of the detergent decreased to 0.5, 0.25, and 0.125 %, respectively. The percentages of unhatched eggs for all tested concentrations of the detergent were significantly different from that of control eggs.

The present results demonstrated that inhibition of egg-hatch of *S. littoralis* of 42.25 and 51.28 % was obtained with the high concentrations 7.5 and 72 ppm of Proclaim and Spinosad, diluted in water, respectively. However, the relatively high concentrations of DPX-MP062 [methyl 7-chloro-2,3,4a,5-tetrahydro-2-] [methoxycarbonyl(4-trifluoromethoxyphenyl) carbamoyl] indeno [1,2-][1,3,4] oxadiazine-4a-carboxylate], diluted in water, for suppression of egg-hatch of *S. littoralis* are due to the compound not being able to penetrate the eggshell (Pluschkell *et al.*, 1998). Present results show that when insecticides diluted in 1% DWS, the ovicidal activity of both compounds was increased by about 45-60% more than those diluted in water only. A concentration-dependent response was observed for eggs treated with both insecticides. Significant differences in the percentages of unhatched egges were observed between the tested concentrations of either Proclaim or Spinosad and the eggs treated only with 1% DWS as control. Pineda *et al* (2004) found that no ovicidal activity was recorded when insecticides, Spinosad and Methoxyfenozide, were diluted in water. In contrast when insecticides were diluted in acetone, both egg age classes, young (less than 24 h old) and old (24-48 h old), generally showed a concentration-dependent response for both compounds. However, the authors used the solvent, acetone, for dissolving the insecticides to evaluate their toxicities against *S. littoralis* eggs in the laboratory. This process is very expensive and difficult specially in case of field application. The present results demonstrated that adding a cheap detergent material like Nastabon to the insecticide-water dilutions significantly increased the toxicity of the two tested insecticides against the egg stage of *S. littoralis*.

Effects on newly hatched larvae:

The toxicity of Proclaim and Spinosad diluted either in 1% DWS or in water only was evaluated against the newly hatched larvae of *S. littoralis*. Table (6) shows the LC_{50} values for both tested bioinsecticides, Proclaim and Spinosad, as calculated from the resulted LC-p-lines, at 24, 48, and 72 hrs posttreatment.

Present results demonstrated that the LC_{50} values of both insecticides were decreased, in general, by increasing the posttreatment period of times. The LC_{50} values of Proclaim, diluted either in water only or in 1% DWS for the newly hatched larvae of *S. littoralis* were 0.0321 and 0.0294 ppm, 24 hrs posttreatment, respectively. Such values decreased to 0.0216 and 0.017 ppm, 72 hrs posttreatment, respectively. It means that mortality of newly hatched larvae of *S. littoralis* were increased even after replacing treated leaves with untreated ones. However, in support to our results, El-Aw (2003) found that the 2nd instar larvae were more susceptible to Proclaim than the 4th instar larvae of *S. littoralis*. According to the present results, the newly hatched larvae of *S. littoralis* were more susceptible to Proclaim, diluted in water only, than the 2nd and 4th instar larvae, respectively.

The LC_{50} value of Spinosad on the newly hatched larvae of *S. littoralis* were 5.902 and 5.153 ppm when the compound diluted either with water and with 1% DWS, 24 hrs posttreatment, respectively. Such values decreased to 3.331 and 2.296 ppm, 72 hrs posttreatment, respectively. On the other hand, newly hatched larvae of *S. littoralis*, in the present work, were more susceptible to the compound than the 2nd and 4th instar larvae, respectively, as found by El-Aw (2003). Results of Pineda *et al.* (2004) revealed that mortality of newly hatched larvae of *S. littoralis* was significantly increased, compared with control larvae at all concentrations of the two insecticides, Spinosad and Methoxyfenozide, when diluted in water or acetone alike and the prevalence of mortality was similar with each insecticide. However, because of size of an insect is a factor in the response to an insecticidal material (Dulmage, 1971), early instars might be controlled by lesser amount of toxin (Barker, 1998). Pluschkell *et al.*, (1998) found that first instar larvae of *S. littoralis* was the most susceptible to DPX-MPO62 compared with 3rd and 5th ones.

On the bases of LC_{50} values, Proclaim was more toxic to the newly hatched larvae of *S. littoralis* than Spinosad. High mortality rates in the newly hatched larvae of *S. littoralis* were found with much lower concentrations of Proclaim than Spinosad. Present results demonstrated that the LC_{50} values of Proclaim and Spinosad, diluted in water only, were 0.0321 and 5.902 ppm, 24 hrs posttreatment, respectively. In other words, comparable levels of population mortality,

though, for the newly hatched larvae will require a much higher concentration of Spinosad than Proclaim, to achieve a comparable mortality rate. According to the recommended field concentrations of both insecticides, the 24 hrs posttreatment LC_{50} value for Spinosad, diluted in 1% DWS, was about 175-fold higher than those for Proclaim (Table 6).

Pupicidal activity:

The toxic action of Proclaim and Spinosad against male and female pupae of *S. littoralis* was also investigated. Dipping of male and female pupae in both insecticides diluted in 1% DWS caused no pupal mortality after 24, 48, and 72 hrs posttreatment, but increased percentages of deformed adults (Tables 7 and 8).

Data in Table (7) show that treatment of 48-old male and female pupae of *S. littoralis* with different concentrations of Proclaim dissolved in water caused no significant differences in the percentages of pupal mortality or deformed adults (5.0-7.5%) compared with untreated pupae. When Proclaim dissolved in 1% DWS, the percentages of pupal mortality or deformed adults significantly increased by about 35-40 % for male pupae, and by about 17.5-27.5 % for female pupae, respectively, compared with untreated pupae. It was observed from the present results that Proclaim was more toxic to male pupae than female ones.

Emamectin benzoate (Proclaim®) is a second generation avermectin with superior activity against lepidopterans compared with abamectin (Dybas *et al.*, 1989; and Jansson and Dybas, 1997). Present results demonstrated that Proclaim was toxic not only against eggs and newly hatched larvae but also against the pupal stage of *S. littoralis*. However, the toxicity of four classes of insecticides including Emamectin benzoate (Proclaim®) were compared against several species of Lepidoptera by Argentine *et al.* (2002). They found that emamectin benzoate was consistently the most toxic insecticide. Also, Eckel *et al.* (1996) found that emamectin benzoate provided greater insecticidal effect against beet armyworm, *Spodoptera exigua*, in celery fields, than methomyl or *Bacillus thuringiensis* subsp. *Azawai*. The use of petroleum oil provided substantial extension of residual activity of abamectin versus abamectin applied alone in controlling citrus rust mite (Childers *et al.*, 2001). Also, adding mineral oil (1L/feddan) enhancing Spinosad performance to combat cotton bollworms and was significantly better than Spinosad alone(Emara *et al.*, 2002). On the other hand, no phytotoxicity has been demonstrated with Spinosad on any crop (Vergoulas and Jousseaume, 2002).

Table (8) shows that the mortality percentages of male and female pupae of *S. littoralis* treated with different concentrations of Spinosad, dissolved in water only, ranging from 0 to 5%. When Spinosad, with the same concentrations, dissolved in 1% DWS, the percentages of pupal mortality or deformed adults significantly increased to be ranging from 27.5 to 45 % for male pupae. Whereas the corresponding percentages of pupal mortality or deformed adults of female pupae were 25 to 35 % more than those of untreated pupae. Generally, the percentages of pupal mortality or deformed adults of both sexes were slightly higher for pupae treated with Spinosad than those treated with Proclaim. Pineda *et al* (2004) examined the toxic effects of Spinosad and Methoxyfenozide on the mortality of pupae, adult emergence, and the prevalence of deformed adults after topical application on young pupae of *S. littoralis*. In contrary to our results, they found that only Methoxyfenozide caused pupal mortality and deformed adults.

Present results demonstrated that dissolving Spinosad in 1% DWS increased the toxic action of the compound against the immature stages of *S. littoralis*. However, according to Thompson *et al.*, (1999), results from initial field trials showed that Spinosad would provide suppression of codling moth, but never in the range that would provide commercially acceptable control. Recent trials have shown that combining Spinosad with 1% oil v:v significantly increases the observed efficacy. It is believed that this tank mix utilizes two modes of action, oil suppressing egg hatch and Spinosad killing hatching larvae. If retreatment intervals are frequent enough (10-14 days), Spinosad plus oil can provide effective codling moth control. In general, Spinosad provides effective control of pests in the insect orders Lepidoptera, Diptera, and Thysanoptera. It is also effective for some species Coleoptera and Orthoptera that consume large amounts of foliage (Thompson *et al.*, 1999). Results of Kristensen and Jespersen (2004) indicated that there was no substantial cross-resistance to Spinosad in house fly strains resistant to conventional insecticides. However, a unique mode of action coupled with a high degree of activity on targeted pests and low toxicity to non-target organisms (including many beneficial arthropods) make Spinosad an effective new tool for management of insect pests (Thompson *et al.*, 1999). Present results verify direct lethal effects of the two tested bio-insecticides, Proclaim and Spinosad, against the immature stages of *S. littoralis*, and as previously reported (El-Aw, 2003), demonstrate indirect sublethal effects on some biological aspects of pupal and adult stages of the insect.

It is concluded from the present results that the two tested bio-insecticides are potentially potent for control of *S. littoralis* and using a detergent in the preparation of the tested dilutions of the insecticides increased their effects. However, with new compounds, such as Proclaim and Spinosad, as alternatives to the recommended OP and carbamate insecticides currently in use, *S. littoralis* could be successfully included in the management programs.

Table (1): Ovicidal activity of the bio-insecticide, Proclaim, dissolved in water, to 48 hrs-old eggs of the cotton leafworm, *S. littoralis*.

Egg batch (Replicates)	Number of eggs (H and UH)													
	Water (Control)		Proclaim concentration (ppm) in water only											
			1.0		1.25		2.5		3.75		5.0		7.5	
	H*	UH**	H	UH	H	UH	H	UH	H	UH	H	UH	H	UH
1	323	16	143	59	59	26	193	106	85	34	62	35	58	83
2	168	08	197	88	123	56	88	43	21	16	39	31	43	11
3	232	10	104	39	157	67	211	123	111	48	82	74	39	33
4	166	11	82	23	233	102	216	162	117	71	109	58	106	108
5	212	15	129	28	119	46	111	44	104	37	37	26	122	119
6	218	13	153	44	77	31	68	43	213	109	114	97	213	186
7	196	05	206	68	146	78	129	87	126	89	76	57	104	69
8	213	04	134	35	178	99	167	83	98	77	93	48	71	38
9	269	03	168	57	216	98	86	42	67	51	161	89	129	88
10	390	08	96	31	46	43	134	81	153	83	87	69	83	48
Total No. of tested eggs	2470		1884		2055		2217		1710		1444		1751	
Mean No. of eggs/batch	247.0±68.61		188.4±60.014		205.5±84.65		221.7±92.86		171.00±77.3		144.4±58.61		175.1±100.3	
Mean No. of hatched eggs	238.7±70.61		1.2±41.2		140.4±57.14		140.30±53.9		109.5±50.92		86.00±36.95		96.8±51.54	
Mean No. of unhatched eggs	8.3±5.17		47.2±20.48		64.6±28.65		81.4±40.51		61.5±28.92		58.4±24.13		78.3±51.06	
% of unhatched eggs	3.32±2.0^{d}		23.11±5.1^{c}		31.15±2.4^{b}		35.89±4.3^{ab}		36.37±6.6^{ab}		40.65±5.1^{a}		42.35±10.4^{a}	
L.S.D.$_{0.05}$	3.226													

*H; Hatched eggs
** UH; Unhatched eggs
Means followed by the same letter (s) are not significantly different according to L. S. D. $_{0.05}$.

Table (2): Ovicidal activity of the bio-insecticide, Proclaim, dissolved in 1% detergent in water, to 48 hrs-old eggs of the cotton leafworm, *S. littoralis*.

Egg batch (Replicates)	Number of eggs (H and UH)													
	1% detergent (Control)		Proclaim concentration (ppm) in 1% detergent in water											
			1.0		1.25		2.5		3.75		5.0		7.5	
	H*	UH**	H	UH	H	UH	H	H	H	UH	H	UH	H	UH
1	240	41	130	157	14	138	32	96	18	226	28	288	39	569
2	135	12	53	96	07	86	12	84	42	263	31	252	17	643
3	126	16	112	187	46	147	83	334	06	51	86	239	67	712
4	299	33	38	55	28	283	21	78	03	62	14	103	15	124
5	119	36	177	169	65	118	13	89	18	426	17	457	42	637
6	116	20	149	95	72	426	17	110	43	189	05	566	22	196
7	52	09	86	127	38	84	46	87	12	87	41	498	39	183
8	181	48	30	68	49	108	78	567	48	288	71	534	61	922
9	123	22	48	143	33	76	73	249	22	156	25	287	49	127
10	83	24	71	108	107	156	03	112	36	424	31	116	17	738
Total No. of tested eggs	1735		2098		2081		2183		2420		3689		5219	
Mean No. of eggs/batch	173.5±82.39		209.8±84.9		208.1±122.4		218.3±185.5		242.0±145.8		368.9±171.5		521.9±304.2	
Mean No. of hatched eggs	26.1±12.91		89.4±50.49		45.9±29.57		37.8±30.20		24.8±16.27		34.9±25.34		36.6±18.74	
Mean No. of unhatched eggs	147.4±75.74		120.5±43.6		162.2±110.2		180.6±160.3		217.2±136.1		334.0±168.9		485.1±297.2	
% of unhatched eggs	15.54±5.2^{e}		59.26±10.2^{d}		76.71±12.3^{c}		82.74±8.9^{bc}		87.75±5.3^{ab}		88.89±7.6^{ab}		90.15±7.7^{a}	
L.S.D.$_{0.05}$	5.99													

*H; Hatched eggs

** UH; Unhatched eggs

Means followed by the same letter (s) are not significantly different according to L. S. D. $_{0.05}$.

Table (3): Ovicidal activity of the bio-insecticide, Spinosad, dissolved in water, to 48 hrs-old eggs of the cotton leafworm, *S. littoralis*.

Egg batch (Replicates)	Number of eggs (H and UH)													
	Water (Control)		Spinosad concentration (ppm) in water only											
			9.0		18		24		36		48		72	
	H*	UH**	H	UH	H	UH	H	UH	H	UH	H	UH	H	UH
1	205	11	493	276	216	136	183	67	223	146	51	64	164	181
2	99	03	349	123	103	54	325	233	174	115	127	173	116	87
3	236	15	388	166	206	86	135	63	158	132	29	138	51	108
4	76	07	136	93	202	111	327	171	113	86	121	71	86	63
5	126	03	129	36	448	244	339	213	232	143	81	53	78	83
6	316	19	144	79	317	118	276	141	118	69	208	173	127	111
7	83	02	226	117	189	79	125	69	181	152	143	116	169	158
8	124	09	178	78	274	133	159	112	241	167	263	186	106	142
9	91	03	133	68	166	87	163	93	335	208	118	97	98	77
10	476	34	129	56	193	116	219	168	119	77	85	88	88	129
Total No. of tested eggs	1938		3396		3478		3581		3189		2488		2222	
Mean No. of eggs/batch	193.8±139.1		339.6±198.4		347.8±144.2		358.1±142.9		318.9±111.9		248.8±106.5		222.2±68.88	
Mean No. of hatched eggs	183.2±129.3		230.5±132.1		231.4±95.36		225.1±84.39		189.4±69.91		115.8±49.00		108.30±37.2	
Mean No. of unhatched eggs	10.6±10.00		109.2±69.4		116.4±51.70		133.00±61.9		129.5±43.53		132.9±62.26		113.9±38.21	
% of unhatched eggs	4.88±2.20^{d}		31.85±4.34^{c}		33.44±3.73^{c}		36.38±5.08^{bc}		40.73±3.73^{b}		46.85±6.85^{a}		51.28±8.28^{a}	
L.S.D.$_{0.05}$	2.954													

*H; Hatched eggs
** UH; Unhatched eggs
Means followed by the same letter (s) are not significantly different according to L. S. D. $_{0.05}$.

Table (4): Ovicidal activity of the bio-insecticide, Spinosad, dissolved in 1% detergent in water, to 48 hrs-old eggs of the cotton leafworm, *S. littoralis*.

Egg batch (Replicates)	Number of eggs (H and UH)													
	1% detergent (Control)		Spinosad concentration (ppm) in 1% detergent in water											
			9.0		18		24		36		48		72	
	H*	UH**	H	UH	H	UH	H	UH	H	UH	H	UH	H	UH
1	123	34	59	168	72	289	49	298	06	138	36	196	58	483
2	168	29	74	129	88	410	74	171	94	556	21	294	16	227
3	216	23	196	353	43	167	88	304	87	369	08	313	11	246
4	197	26	47	119	32	141	08	91	10	211	41	293	02	115
5	311	37	88	246	42	216	09	62	08	268	33	176	10	141
6	209	43	64	148	21	95	19	74	46	403	12	349	21	217
7	118	21	57	131	117	331	17	294	17	117	30	174	23	233
8	98	19	61	141	11	54	30	126	05	63	12	236	35	314
9	176	18	106	316	65	154	21	223	31	389	16	147	18	347
10	135	16	39	85	67	172	26	148	31	167	26	384	05	139
Total No. of tested eggs	2017		2627		2577		2132		3011		2797		2661	
Mean No. of eggs/batch	201.7±67.93		262.7±132.4		257.7±139.4		213.2±112.53		301.1±184.6		279.7±79.66		266.1±126.5	
Mean No. of hatched eggs	175.1±62.76		79.1±45.44		55.8±32.12		4.1±27.50		33.5±32.89		23.5±11.39		19.9±16.43	
Mean No. of unhatched eggs	16.6±8.98		183.6±90.12		201.9±118.5		179.1±95.01		267.6±156.8		256.2±81.72		246.2±111.6	
% of unhatched eggs	13.66±4.00^{e}		69.99±3.84^{d}		78.72±4.85^{c}		84.43±7.63^{b}		89.15±4.96^{ab}		90.75±5.14^{a}		93.39±3.01^{a}	
L.S.D.$_{0.05}$	4.04													

*H; Hatched eggs

** UH; Unhatched eggs

Means followed by the same letter (s) are not significantly different according to L. S. D. $_{0.05}$.

Table (5): Ovicidal activity of the detergent , Nastabon, dissolved in water, to 48 hrs-old eggs of the cotton leafworm, *S. littoralis*

Egg batch (Replicates)	Number of eggs (H and UH)													
	Water (Control)		detergent concentration in water (%)											
			0.125		0.25		0.5		1.0		1.5		2.0	
	H*	UH**	H	UH	H	UH	H	UH	H	UH	H	UH	H	UH
1	163	06	231	25	258	16	44	03	146	21	240	41	234	67
2	326	13	68	06	327	31	333	54	164	24	135	12	176	51
3	213	14	317	19	167	13	615	66	26	08	126	16	317	76
4	137	05	159	12	192	27	308	45	51	09	299	33	168	49
5	93	00	91	07	418	36	189	21	49	12	119	36	124	23
6	271	07	143	08	138	14	212	23	177	30	116	20	93	22
7	119	10	128	07	249	24	141	18	154	31	52	9	112	26
8	108	05	176	19	615	56	126	19	272	46	181	48	742	139
9	69	00	313	21	384	29	99	13	235	44	123	22	118	31
10	123	09	238	18	119	11	176	23	94	26	83	24	45	11
Total No. of tested eggs	1691		2006		3124		2529		1619		1735		2644	
Mean No. of eggs/batch	169.1±84.80		200.6±92.2		312.4±166.4		252.9±182.3		161.9±94.21		173.5±82.39		264.4±239.5	
Mean No. of hatched eggs	162.2±82.80		14.2±6.97		25.7±13.65		28.5±19.82		136.8±81.54		26.1±12.91		212.9±201.2	
Mean No. of unhatched eggs	6.9±4.77		186.4±86.3		286.7±153.4		224.3±163.3		25.1±13.31		147.4±73.74		51.5±39.83	
% of unhatched eggs	4.04±2.59^{d}		7.13±1.66^{c}		8.38±1.71^{bc}		11.02±2.17^{b}		16.68±3.77^{a}		15.54±5.19^{a}		19.65±2.51^{a}	
L.S.D.$_{0.05}$	2.971													

*H; Hatched eggs

** UH; Unhatched eggs

Means followed by the same letter (s) are not significantly different according to L. S. D. $_{0.05}$.

Table (6): Toxicity of Proclaim and Spinosad, dissolved in 1% detergent-water solution or in water only, against the newly hatched larvae of *S. littoralis*.

Insecticide		Time posttreatment (hrs)	LC_{50} (ppm)	Fiducial limits		Slope
				Upper	Lower	
Proclaim	Water only	24	0.0321	0.766	0.535	1.181
		48	0.024	0.623	0.370	1.379
		72	0.0216	0.526	0.350	1.020
	1% DWS*	24	0.0294	0.697	0.495	1.264
		48	0.0196	0.454	0.340	0.890
		72	0.017	0.407	0.283	1.205
Spinosad	Water only	24	5.902	33.720	25.813	1.502
		48	4.100	23.703	17.723	1.496
		72	3.331	19.277	14.370	1.459
	1% DWS*	24	5.153	29.204	22.726	1.769
		48	3.761	23.662	14.921	1.506
		72	2.296	13.420	9.811	1.394

Y = probit kill, X = Log concentration

LC50 = Concentration calculated (ppm) to give 50 percent mortality.

* DWS: detergent-water solution

Table (7): Pupicidal activity of the bio-insecticide, Proclaim, dissolved in 1% detergent in water or in water only, to 48 hrs-old male and female pupae of the cotton leafworm, *S. littoralis*.

Time posttreatment (hrs)	% Accumulative mortality of male pupae												
	Control (water only)	Proclaim concentration (ppm) in water only						Control (1% detergent in water)	Proclaim concentration (ppm) in 1% detergent in water				
		1.0	1.25	2.5	3.75	5.0	7.5		1.0	1.25	2.5	3.75	5.0	7.5
24	0.0	2.5	2.5	0.0	2.5	2.5	0.0	0.0	2.5	2.5	2.5	2.5	2.5	0.0
48	0.0	2.5	2.5	0.0	2.5	2.5	2.5	0.0	2.5	2.5	2.5	2.5	2.5	5.0
72	0.0	2.5	2.5	2.5	2.5	2.5	2.5	0.0	2.5	2.5	2.5	2.5	2.5	5.0
% died pupae	0.0	2.5	2.5	2.5	2.5	2.5	5.0	0.0	32.5	35.0	35.0	35.0	37.5	35.0
% emerged adult	100	95.0	95.0	95.0	95.0	95.0	92.5	100	65.0	62.5	62.5	62.5	60.0	60.0
% nonemerged adult	0.0[a]	5.0± 5.77[a]	5.0± 5.77[a]	5.0± 5.77[a]	5.0± 5.77[a]	5.0± 5.77[a]	7.5± 5.00[a]	0.0[b]	35.0± 5.00[a]	37.5± 9.57[a]	37.5± 9.57[a]	37.5± 9.57[a]	40.0± 8.17[a]	40.0± 8.17[a]
L.S.D.	14.509							7.404						
Time posttreatment (hrs)	% Accumulative mortality of female pupae												
	Control (water only)	Proclaim concentration (ppm) in water only						Control (1% detergent in water)	Proclaim concentration (ppm) in 1% detergent in water				
		1.0	1.25	2.5	3.75	5.0	7.5		1.0	1.25	2.5	3.75	5.0	7.5
24	0.0	0.0	2.5	0.0	2.5	2.5	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0
48	0.0	0.0	2.5	0.0	2.5	2.5	2.5	0.0	0.0	2.5	2.5	0.0	2.5	5.0
72	0.0	2.5	2.5	2.5	2.5	2.5	2.5	0.0	0.0	5.0	5.0	2.5	2.5	7.5
% died pupae	0.0	2.5	2.5	2.5	2.5	2.5	2.5	0.0	17.5	12.5	15.0	17.5	25.0	20.0
% emerged adult	100	95.0	95.0	95.0	95.5	95.0	95.0	100	82.5	82.5	80.0	80.0	72.5	72.5
% nonemerged adult	0.0[a]	5.0± 5.77[a]	5.0± 5.77[a]	5.0± 5.77[a]	5.0± 5.77[a]	5.0± 5.77[a]	5.0± 5.77[a]	0.0[b]	17.5± 5.00[a]	17.5± 9.57[a]	20.0± 8.17[a]	20.0± 8.17[a]	27.5± 14.14[a]	27.5± 9.57[a]
L.S.D.	15.011							8.55						

Table (8): Pupicidal activity of the bio-insecticide, Spinosad, dissolved in 1% detergent in water or in water only, to 48 hrs-old male and female pupae of the cotton leafworm, *S. littoralis*.

Time posttreatment (hrs)	% Accumulative mortality of male pupae													
	Control (water only)	Spinosad concentration (ppm) in water only						Control (1% detergent in water)	Spinosad concentration (ppm) in 1% detergent in water					
		9.0	18	24	36	48	72		9.0	18	24	36	48	72
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
48	0.0	0.0	0.0	0.0	2.5	2.5	2.5	0.0	2.5	2.5	0.0	2.5	0.0	2.5
72	0.0	0.0	0.0	0.0	2.5	2.5	2.5	0.0	2.5	2.5	2.5	5.0	2.5	5.0
% died pupae	0.0	0.0	2.5	2.5	2.5	2.5	2.5	0.0	35.0	40.0	42.5	37.5	40.0	40.0
% emerged adult	100	100	97.5	97.5	95.0	95.0	95.0	100	62.5	57.5	55.0	57.5	57.5	55.0
% nonemerged adult	0.0[a]	0.0[a]	2.5± 5.77[a]	2.5± 5.77[a]	5.0± 5.77[a]	5.0± 5.77[a]	5.0± 5.77[a]	0.0[b]	37.5± 9.6[a]	42.5± 9.6[a]	45.0± 8.2[a]	42.5± 14.1[a]	42.5± 17.1[a]	45.0± 12.9[a]
L.S.D.	11.291							10.215						
Time posttreatment (hrs)	% Accumulative mortality of female pupae													
	Control (water only)	Spinosad concentration (ppm) in water only						Control (1% detergent in water)	Spinosad concentration (ppm) in 1% detergent in water					
		9.0	18	24	36	48	72		9.0	18	24	36	48	72
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	2.5	0.0
72	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	2.5	5.0	2.5	2.5	2.5	2.5
% died pupae	0.0	0.0	0.0	2.5	2.5	0.0	2.5	0.0	25.0	20.0	25.0	27.5	30.0	32.5
% emerged adult	100	100	100	97.5	97.5	97.5	97.5	100	72.5	75.0	72.5	70.0	67.5	65.0
% nonemerged adult	0.0[a]	0.0[a]	0.0[a]	2.5± 5.0[a]	2.5± 5.0[a]	2.5± 5.0[a]	2.5± 5.0[a]	0.0[c]	27.5± 9.57[b]	25.0± 5.8[ab]	27.5± 5.0[ab]	30.0± 8.17[a]	32.5± 5.00[a]	35.0± 5.77[a]
L.S.D.	11.159							6.385						

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الملخص العربي

كفاءة اثنين من المركبات الحشرية الحيوية، بروكلام و سبينوساد، ضد الأطوار غير الكاملة لحشره دودة ورق القطن المصرية *Spodoptera littoralis*.

محمد عبد القادر العو

قسم مكافحة الآفات وحماية البيئة – كلية الزراعة – دمنهور – جامعة الإسكندرية

تم تقييم سميه اثنين من المركبات الحشرية الحيوية، بروكلام وسبينوساد، ضد الأطوار غير الكاملة لحشره دودة ورق القطن *Spodoptera littoralis*.

تم معاملة كتل البيض بعد ٢٤ ساعة من وضعة بسلسلة من تركيزات أي من المبيدين المذكورين والتى تم تحضيرها إما فى محلول ١% منظف (ناستابون) مع الماء أو فى ماء فقط. أظهرت نتائج المعاملة فى طور البيضة، أنة عند معاملة البيض بالمبيد المخفف فى محلول المنظف مع الماء، فقد ذادت معنويا النسب المئوية للبيض غير الفاقس بحوالى ٣٦ – ٥١ % عنة عند معاملة البيض بالمبيد المخفف فى الماء فقط، وذلك لكلا المبيدين المختبرين بروكلام أو سبينوساد.

كما تم تقييم سميه المبيدين، بروكلام و سبينوساد، على اليرقات حديثة الفقس لحشره دودة ورق القطن الكبرى *S. littoralis* وذلك بعد ٢٤ و ٤٨ و ٧٢ ساعة بعد المعاملة. أظهرت النتائج أن قيم التركيز القاتل لـ ٥٠ % من اليرقات حديثة الفقس من البيض (LC_{50}) لكلا المركبين انخفضت عموما بزيادة الوقت المنقضى بعد المعاملة. أظهرت قيم الـ LC_{50} أن مبيد بروكلام كان اكثر سمية على اليرقات حديثة الفقس عن مبيد سبينوساد. كانت قيم الـ (LC_{50}) ٠,٠٣٢١ و ٥,٩٠٢ جزء فى المليون (ppm) لكل من مبيد بروكلام وسبينوساد، المخفف فى الماء، وذلك بعد ٢٤ ساعة من المعاملة بالمبيد، على الترتيب. انخفضت قليلا قيم الـ LC_{50} لتصبح ٠,٠٢٩٤ و ٥,١٥٣ جزء فى المليون (ppm) لكل من مبيد بروكلام وسبينوساد، المخفف فى محلول المنظف مع الماء ، وذلك بعد ٢٤ ساعة من المعاملة بالمبيد، على الترتيب.

تم أيضا تقييم الفعل السمي لكلا المبيدين، بروكلام و سبينوساد، والتى تم تحضيرها إما فى محلول ١% منظف (ناستابون) مع الماء أو فى ماء فقط ،على طور العذراء من الجنسين الذكور والإناث. أظهرت النتائج أنة بعد ٢٤ و٤٨ و٧٢ ساعة من المعاملة بأى من المبيدين المختبرين لم يلاحظ وجود فروق معنوية فى النسب المئوية للموت فى العذارى من كلا الجنسين، ولكن ذادت معنويا النسب المئوية للموت فى العذارى عند انبثاق الفراشات. كان الفعل السمي لكلا المبيدين أقوي على الذكور عن الإناث، وكان مركب سبينوساد أقوى تأثيرا عن مبيد بروكلام.

وتشير هذه النتائج إلى أن هناك تأثير سمى قوى لكلا المبيدين المختبرين، بروكلام و سبينوساد، ضد الأطوار غير الكاملة لحشرة دودة ورق القطن وخصوصا عند تطبيق المبيد فى محلول ١% منظف مع الماء.