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Bioefficacy of Emamectin Benzoate against American Bollworm, *Helicoverpa armigera* Under Field Conditions.

Cross Mark

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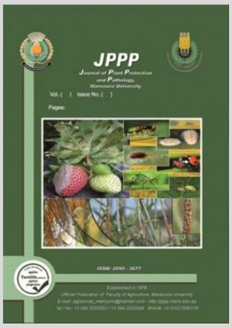

ABSTRACT

American bollworm, *Helicoverpa armigera* is the foremost insect that negatively affected cotton crops around the world. A field experiment was conducted at the Sedi-Salem area, Kafr El-Sheikh Governorate,Egypt to assess the bioefficacy of emamectin benzoate 5 SG(EB)on cotton against *H. armigera*.The tested pesticides were used as a foliar application under field conditions at the2019-2020season.The experiment was designed in plots of 5 m × 5 m size using a randomized block design (RBD) with seven different treatments.A pneumatic knapsack sprayer was used for foliar application of tested pesticides. Three doses of EB @ 7, 11, and 15 g a.i./ha were evaluated against the pest under study. Furthermore, endosulfan 35 EC, Proclaim®, Spinosad 45 SC, and an untreated blank were also included in the field experiment. The findings concluded that 11 g a.i./ha of EB was the active dose for controlling the larval population of *H. armigera*.This dose caused a 64.75% reduction of boll damage over an untreated check at the end of observation in the field experiment.The yield ranged from 16.00 to 19.66 q/ha in all treatments.EB at 15 g a.i./ha was a very effective dose which was on par with the final results of 11 g a.i./ha.Entirely EB treatments augmented seed cotton yield under field conditions as compared to the control plot. The study demonstrates the potentiality of EB as an eco-friendly bioinsecticide against the American bollworm.The effective doses of EB @ 11and 15 g a.i./ha should be used in the cotton field to manage the infestation of *H. armigera.*

Keywords*:* Eco-friendy, Emamectin Benzoate, *Helicoverpa armigera*, Cotton.

INTRODUCTION

Cotton (*Gossypium spp*.) provides the most versatile fiber which accounts for about 50% of the total fiber consumption in the world. The loss in cotton yield reached 87% owing to agricultural insect pests (Abid *et al.*, 2020a). The bollworm complex consists of three bollworms *viz*., American (*Helicoverpa armigera*, Hubner), spotted *(Earias* spp.), and pink (*Pectinophora gossypiella).* American bollworm, *Helicoverpa armigera* (Lepidoptera: Noctuidae) is a dangerous pest of numerous plant families producing losses of several billion dollars annually (Abid *et al.,* 2020a). American bollworm has extensive hosts including most commercially grown crops. This could be one of the reasons for the evolution of resistance in this pest against different insecticides (Wang and Qin, 2007). Chemical control is a rapid and consistent manner for pest management, but there is an urgent need to substitute older conventional insecticides with new ones to protect the environment. Consequently, finding alternative methods and compounds are recommended for the sustainable management of *H. armigera* without causing damage to the non-target organisms and the environment (Abid *et al.*, 2020b). Emamectin benzoate 5 SG (EB) is one of the bioinsecticides confirmed to be greatly active against lepidopteran insects (Moustafa *et al.,* 2018; Temiz, 2020; Liu, 2021). EB belongs to the avermectin family of 16-membered macrocyclic lactones generated by the soil-dwelling microorganism, Streptomyces avermitilis (Lopez *et al*., 2010; Abid *et al.*, 2020a). It is a promising bioinsecticide for lepidopteran insect management. Furthermore, this pesticide can manage several species of lepidopteran such as; *Heliothis virescens, Plutella xylostella, Pseudoplusia includes, Spodoptera frugiperda, Trichoplusia ni, Spodoptera littoralis, Spodoptera exigua,* and *Mamestra Brassicae* (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 (Abid *et al.*, 2020a).

EB has mainly consisted of avermectin B1a (90%) and avermectin B1b (10%) as mentioned by Mushtaq *et al.* (1997). It is promoted in various formulations, but there is a lack of data establishing the relative efficacy of these formulations against lepidopteran insects (Abid *et al.*, 2020b). At the same time, to overcome the previously mentioned problems, identification of effective doses with higher insecticidal property and lower mammalian toxicity that fits well in the integrated pest management concept is important currently. One such new molecule, EB was identified in 1984 and is a semi-synthetic derivative of avermectin produced as fermentation metabolites of soil actinomycetes *Streptomyces avermitilis* Burg., (Abid *et al.*, 2020a). It has both stomach and contact actions against the tested pest. The HaNPV is mixed with spinetoram and EB at lower doses of HaNPV for controlling *H. armigera* (Abid *et al.*, 2020b).

Keeping the above interpretations in mind, the present research work was carried out to assess the bioefficacy of emamectin benzoate 5 SG against American bollworms, *Helicoverpa armigera* in the cotton ecosystem under field conditions at the Sedi-Salem area, Kafr El-Sheikh Governorate, Egypt.

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MATERIALS AND METHODS

Study site and experiment layout

A field experiment was carried out to evaluate the bioefficacy of emamectin benzoate 5 SG (EB) as a foliar application against American bollworm, *Helicoverpa armigera* on cotton plants. The trial was carried out under field conditions of the semiarid region during the 2019-2020 season. The field experiment was conducted at Sedi-Salem city, Kafr El-Sheikh Governorate, Egypt (Fig. 1). The cotton field comprised of 355-270 m^2 (9.5 hectares) was selected and divided into similar blocks with seven treatments (Fig. 1). A randomized block design was used in the field experiment during the cotton-summer season to evaluate the bioefficacy of EB against American bollworm, *Helicoverpa armigera* on cotton (Fig. 1). The experiment area was divided into equal plots with seven treatments replicated thrice using a randomized block design (RBD). A pneumatic knapsack sprayer was used for spraying the studied pesticides using 1000 liters of spray fluid per hectare at 10 days intervals commencing from the 60^{th} day after sowing. The field was leveled before seedbed preparation. The soil was well prepared to be suitable for germination process. Irrigation for germination was made after every 5 days and after that at every 7-10 days break based on the soil characteristics and climate conditions.

The materials adopted for the present study are outlined below.

Properties of emamectin

Chemical name : Emamectin benzoate

Empirical formula : $C_{56}H_{81}NO_{15}$ (emamectin B_{1a} benzoate) + $C_{55}H_{79}NO_{15}$ (emamectin B_{1b} benzoate)

Formulation : 5 SG

Molecular weight : B1 a: 1008.3***;*** B 1b: 994.2

Colour/appearance : Light yellow granules

Melting point : 141 to 146ºC

Content : More than 90%

Structural formula of emamectin benzoate

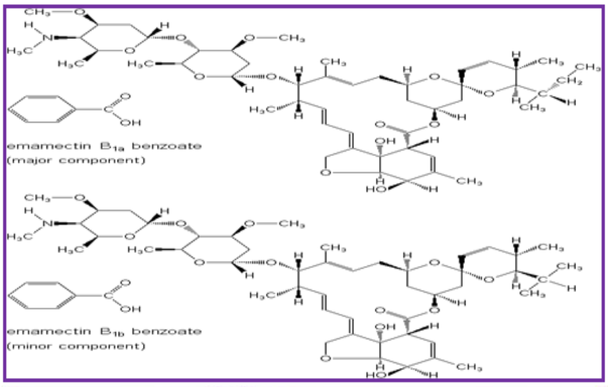

Fig. 1. Field view at Sedi-Salem area, Kafr El-Sheikh Governorate, Egypt for evaluation of bioefficacy of emamectin benzoate 5 SG against American bollworm, *Helicoverpa armigera.*

Treatments details

The tested insecticidal materials and their dosages were as follows:

No	Treatment	Dose (Gram active ingredient per hectare, g a.i./ha)	Given abbrevaition
1	Emamectin benzoate 5 SG	7	EB1
2	Emamectin benzoate 5 SG	11	EB2
3	Emamectin benzoate 5 SG	15	EB3
4	Endosulfan 35 EC	350	ES
5	Proclaim® 5 SG	11	Proclaim®
6	Spinosad 45 SC	75	SS
7	Untreated check	-	UC

Method of assessment

The field observations on the larval population of *H. armigera* were made. The infestation of bollworm in green fruiting bodies (squares, flowers, and green bolls) before each spray application and on 1, 3, 5, 7, and 10 days after treatment (DAT) from five randomly tagged plants per plot were done. Entirely interpretations on open boll damage and locule caused by *H. armigera* were also worked out at the time of harvest.

Yield and data analysis

The yield of cotton per plot was documented during each picking and pooled to arrive at the total yield. Furthermore, it was calculated to quintal per hectare and exposed to statistical analysis. The reduction data percentage of the *H. armigera* population in studied treatments was exposed to randomized block design (RBD) analysis of variance (ANOVA) and the mean values were separated by Tukey's HSD test. The values of results were statistically analyzed using SPSS software, and completed based on the procedures given by Analytical Software (2005).

RESULTS AND DISCUSSION

Results

Larval population

The findings of the tested treatments during the field study are furnished in Table 1. The plots treated with EB2 (11 g a.i./ha) and EB3 (15 g a.i./ha) recorded a significant decrease in the larval population of *H. armigera*. The larval population of tested pest before imposing treatments ranged from 1.96 to 2.25 larvae per plant and crossed the economic threshold level (ETL) of *H. armigera*. There was a major decrease in the larval population after three days of treating with EB at different doses, the lowest larval population was recorded in plots sprayed with EB2 and EB3 (1.48 and 1.32 larvae/plant, respectively) affecting > 50% reduction, followed by standard insecticide (Proclaim®) (1.41 larvae/plant), SS (75 g a.i./ha of spinosad 45 SC) (1.54 larvae/plant) and the highest larval population (1.80 larvae/plant) was identified in the plots treated with ES (endosulfan 35 EC at 350 g a.i./ha) whereas, UC plots (untreated check) recorded 3.00 larvae per plant. The minimum larval population (1.15 larvae/plant) was recorded in plots sprayed with EB3 affecting 69.12% of reduction, followed by Proclaim® and SS that showed on par effect at 5 DAT**.** At 10 DAT, EB3 and EB2 registered 77.40 and 70.80% of reduction in larval population, respectively, when compared to the non-treated one (UC).

Table 1. Number of Larva of *H. armigera* per cotton plant under different treatments of selected pesticides after the first application.

Treatment	Dose (g a.i./ha)	Number of larva per plant*										
		PTC	1 DAT	ROC (%)	3 DAT	ROC (%)	5 DAT	ROC (%)	7 DAT	ROC (%)	10 DAT	ROC (%)
EB1	7	2.15	1.48 (1.40)^{ab}	40.65	1.60 (1.44)^{c}	46.66	1.46 (1.40)^{bc}	60.10	1.54 (1.42)^{c}	67.18	1.54 (1.42)^{bc}	69.40
EB2	11	2.01	1.32 (1.35)^{a}	45.93	1.48 (1.40)^{ab}	51.33	1.27 (1.32)^{ab}	65.57	1.15 (1.27)^{ab}	75.75	1.48 (1.40)^{b}	70.80
EB3	15	1.96	1.32 (1.35)^{a}	45.93	1.32 (1.35)^{a}	55.66	1.15 (1.27)^{a}	69.12	0.92 (1.19)^{a}	80.04	1.15 (1.27)^{a}	77.40
ES	350	2.00	1.73 (1.49)^{bc}	29.67	1.80 (1.51)^{bc}	40.00	1.86 (1.53)^{c}	49.18	1.87 (1.54)^{d}	59.87	2.47 (1.72)^{d}	50.60
Proclaim®	11	2.25	1.32 (1.35)^{a}	45.93	1.41 (1.37)^{a}	53.33	1.28 (1.32)^{ab}	65.02	1.20 (1.30)^{b}	74.24	1.54 (1.42)^{ab}	69.40
SS	75	1.96	1.60 (1.44)^{b}	34.95	1.54 (1.42)^{b}	49.00	1.32 (1.35)^{ab}	63.66	1.26 (1.32)^{b}	72.96	1.86 (1.53)^{d}	62.80
UC	-	2.06	2.46 (1.72)^{d}	-	3.00 (1.90)^{d}	-	3.66 (2.03)^{d}	-	4.66 (2.27)^{e}	-	5.00 (2.33)^{e}	-

EB1: (Emamectin benzoate 5 SG), EB2: (Emamectin benzoate 5 SG), EB3: (Emamectin benzoate 5 SG), ES:(Endosulfan 35 EC), SS: (Spinosad 45 SC), UC: (Untreated control, PTC: (Pre-treatment count); DAT: (Days after treatments), ROC: (Reduction over control), * Mean of three replications; Values in parentheses are $\sqrt{x+0.5}$ transformed values; In a column means followed by a common letter(s) are not significantly different by DMRT (P=0.05)

After the second round of application, the plots treated with EB3 registered 0.87 larvae/ plant at 3 DAT followed by EB2 (1.06 larvae/ plant) and EB1(1.30 larvae/plant) which were in line with the plots treated with SP. At 7 DAT, the treatment with EB3 was found to be more operative registering 0.55 larva/plant whereas, untreated control recorded the highest population of 5.45 larvae per plant. At 10 DAT, the cotton plants sprayed with EB2 and EB3 reduced 90.31% and 93.96% over the untreated check, respectively (Table 2).

Table 2. Number of Larva of *H. armigera* per cotton plant under different treated pesticides after the second application.

Treatments	Dose (g a.i./ha)	Number of larva per plant*										
		PTC	1 DAT	ROC (%)	3 DAT	ROC (%)	5 DAT	ROC (%)	7 DAT	ROC (%)	10 DAT	ROC (%)
EB1	7	1.87	1.32 (1.35)^{a}	73.92	1.30 (1.31)^{cd}	75.60	1.27 (1.32)^{b}	76.66	0.93 (1.19)^{bc}	82.93	0.66 (1.07)^{bc}	87.93
EB2	11	2.00	1.30 (1.32)^{a}	74.50	1.06 (1.25)^{b}	80.11	0.93 (1.19)^{a}	82.77	0.73 (1.10)^{a}	86.60	0.36 (0.96)^{a}	90.31
EB3	15	2.07	1.29 (1.31)^{a}	74.70	0.87 (1.16)^{a}	83.36	0.73 (1.10)^{a}	86.48	0.55 (1.01)^{a}	90.27	0.33 (0.91)^{a}	93.96
ES	350	2.60	2.59 (1.71)^{c}	49.21.	2.30 (1.67)^{d}	56.84	2.22 (1.56)^{d}	58.88	1.80 (1.45)^{d}	66.97	1.70 (1.35)^{e}	68.92
Proclaim®	11	2.07	1.54 (1.42)^{b}	70.00	1.15 (1.27)^{bc}	78.79	1.06 (1.25)^{b}	80.37	0.87 (1.16)^{b}	84.22	0.73 (1.10)^{cd}	86.65
SS	75	2.13	1.60 (1.44)^{b}	68.62	1.32 (1.35)^{cd}	75.46	1.20 (1.30)^{cd}	77.77	1.00 (1.22)^{c}	81.65	0.87 (1.16)^{d}	84.27
UC	-	5.00	5.10 (2.43)^{d}	-	5.33 (2.53)^{e}	-	5.40 (2.57)^{e}	-	5.45 (2.63)^{e}	-	5.47 (2.67)^{f}	-

PTC: (Pre-treatment count); DAT: (Days after treatments), ROC: (Reduction over control), *:(Mean of three replications); Values in parentheses are $\sqrt{x+0.5}$ transformed values; The values followed by a common letter(s) are not significantly different by DMRT (P=0.05)

Damage to green fruiting bodies

The damage percentage due to *H. armigera* before striking treatments varied from 15.30 to 17.44% per plant (Table 3). On 3 DAT, there was a significant reduction in damage after the first round of application. The lowest damage was verified in EB3 (9.85%) followed by Proclaim® which was consistent with EB2. Among the insecticidal treatments, the highest boll damage (17.36%) was notified in plots treated with ES. After the first round of application, the highest reduction (72.09%) was documented in plots treated with EB3, followed by EB2 (64.90%). After the second round of application, the treatment with EB3 showed a mean reduction of 66.97% of damage over untreated check followed by EB2 (64.75%), Proclaim® (63.26%), EB1 (60.39%), and SS (61.60%) (Table 4).

Loss at the harvest time

After first picking, the lowest boll damage (4.43%) was detected in treatments sprayed with EB3, followed by EB2 (5.88%), Proclaim® (10.33%), and SS (10.53%) (Table 5). Among the insecticidal treatments, the highest damage (14.43%) was discovered in plots treated with ES. After four pickings, the mean reduction in boll damage was high (83.21%) in plots treated with EB3, followed by EB2 (80.60%). Regarding the locule damage, the plants treated with EB1, EB2, and EB3 registered 68.82%, 83.51%, and 84.78% of reduction, respectively (Table 5) while Proclaim® and SS documented 67.31% and 68.29% of reduction, respectively. But the highest mean value (14.31%) of locule damage was identified in plots treated with ES, followed by treated plots with EB1 (10.51%).

Table 3. Percentage damage per cotton plant caused by the studied pest on green fruiting bodies of cotton after the first application.

Treatments	Dose (g a.i./ha)	Damage per plant (%)*						
		PTC	3 DAT	5 DAT	7 DAT	10 DAT	MEAN	ROC (%)
EB1	7	17.16	14.44 (22.33)^{c}	12.22 (20.45)^{b}	11.48 (19.80)^{b}	15.70 (23.30)^{b}	13.46	58.12
EB2	11	17.44	12.16 (20.40)^{b}	9.95 (18.39)^{ab}	10.80 (19.18)^{b}	12.22 (20.45)^{a}	11.28	64.90
EB3	15	16.47	9.85 (18.22)^{a}	8.10 (16.52)^{a}	8.10 (16.52)^{a}	9.85 (18.22)^{a}	8.97	72.09
ES	350	17.25	17.36 (24.62)^{d}	16.35 (23.84)^{c}	17.21 (24.51)^{c}	18.30 (25.35)^{c}	17.31	46.14
Proclaim®	11	15.30	12.08 (20.29)^{b}	10.73 (19.10)^{b}	11.33 (19.65)^{b}	14.30 (22.21)^{ab}	12.11	62.32
SS	75	16.73	11.45 (19.77)^{ab}	10.44 (18.88)^{b}	11.23 (19.57)^{b}	14.30 (22.21)^{ab}	11.85	63.13
UC	-	16.49	29.77 (33.02)^{e}	31.80 (33.78)^{d}	33.00 (34.78)^{d}	34.00 (35.78)^{d}	32.14	-

PTC: (Pretreatment count); DAT: (Days after treatments); ROC: (Reduction over control), * :(Mean of three replications); Mean values followed by a common letter(s) are not significantly different by DMRT (P=0.05).

Table 4. Influence of emamectin benzoate treatments against *H. armigera* on green fruiting bodies of cotton after the second application

Treatments	Dose (g a.i.ha^{-1})	Per cent damage per plant*						
		PTC	3 DAT	5 DAT	7 DAT	10 DAT	MEAN	ROC (%)
EB1	7	19.50	15.51 (23.18)^{c}	14.06 (22.02)^{c}	10.83 (19.21)^{bc}	9.33 (17.78)^{bc}	12.43	60.39
EB2	11	18.50	14.26 (22.19)^{b}	13.10 (21.21)^{b}	10.10 (18.52)^{b}	7.50 (15.96)^{a}	11.24	64.75
EB3	15	17.02	13.16 (21.27)^{a}	12.01 (20.28)^{a}	9.16 (17.61)^{a}	7.16 (15.52)^{a}	10.37	66.97
ES	350	20.20	17.00 (24.34)^{d}	14.83 (22.65)^{d}	12.16 (20.41)^{d}	10.66 (19.06)^{e}	13.66	56.51
Proclaim®	11	18.80	13.66 (21.69)^{a}	13.36 (21.44)^{b}	10.83 (19.21)^{bc}	9.16 (17.62)^{bc}	11.57	63.26
SS	75	19.27	14.44 (22.30)^{b}	13.66 (21.69)^{bc}	11.23 (19.58)^{c}	9.66 (18.11)^{d}	12.24	61.60
UC	-	26.30	29.16 (32.68)^{e}	30.48 (33.48)^{e}	32.00 (33.78)^{e}	34.00 (34.78)^{f}	31.41	-

PTC: Pretreatment count; DAT: Days after treatments; ROC: Reduction over control, * Mean of three replications; In a column, means followed by a common letter(s) are not significantly different by DMRT(P=0.05).

Table 5. Effect of emamectin benzoate 5 SG on damage caused by *H. armigera* to bolls and locules at the time of harvest .

Treatment	Pickings; Damage (%)											
	Boll						Locule					
	I	II	III	IV	Mean	ROC (%)	I	II	III	IV	Mean	ROC (%)
EB1	12.44 (20.66)^{d}	12.55 (20.75)^{d}	12.95 (21.10)^{c}	14.57 (22.44)^{c}	13.12	60.96	9.43 (17.89)^{c}	9.58 (18.03)^{c}	10.48 (18.89)^{c}	12.58 (20.77)^{c}	10.51	68.82
EB2	5.88 (14.02)^{ab}	5.07 (13.01)^{ab}	6.60 (14.88)^{a}	8.57 (17.02)^{a}	6.52	80.60	4.50 (12.20)^{a}	5.57 (13.65)^{a}	4.44 (12.16)^{a}	5.77 (13.89)^{a}	5.07	83.51
EB3	4.43 (12.16)^{a}	4.23 (11.87)^{a}	6.43 (14.69)^{a}	7.47 (15.86)^{a}	5.64	83.21	4.37 (12.06)^{a}	5.07 (13.01)^{a}	4.23 (11.87)^{a}	5.07 (13.01)^{a}	4.68	84.78
ES	14.43 (22.33)^{e}	14.23 (22.16)^{e}	18.43 (25.43)^{d}	15.67 (23.32)^{d}	15.69	53.31	12.43 (20.65)^{d}	11.58 (19.89)^{d}	15.48 (23.16)^{d}	17.78 (24.94)^{d}	14.31	53.46
Proclaim®	10.33 (18.75)^{c}	11.23 (19.58)^{c}	11.73 (20.03)^{b}	11.97 (20.24)^{b}	11.31	66.34	8.73 (17.19)^{b}	9.54 (17.99)^{b}	10.28 (18.70)^{b}	11.68 (19.98)^{b}	10.05	67.31
SS	10.53 (18.94)^{c}	11.03 (19.40)^{c}	11.43 (19.76)^{b}	11.57 (19.88)^{b}	11.14	66.85	8.37 (16.81)^{b}	9.18 (17.63)^{b}	10.08 (18.51)^{b}	11.38 (19.71)^{b}	9.75	68.29
UC	30.93 (33.79)^{f}	32.53 (34.78)^{f}	33.43 (35.33)^{e}	37.57 (37.80)^{e}	33.61	-	25.63 (30.42)^{e}	33.45 (35.35)^{e}	30.94 (33.80)^{e}	31.48 (34.13)^{e}	30.75	-

ROC: (Reduction over control), Arc sine transformed values are in parentheses; The values followed by a common letter are not significantly different by DMRT (P=0.05)

Effect of emamectin benzoate 5 SG on cotton yield

The cotton yield was dramatically higher in entirely the treated insecticides than the untreated ones (UC). The highest yield of 19.66 q./ha was obtained in the plots treated with EB3 which was in agreement with EB2 (19.35 q./ha) followed by the standard Proclaim® (18. 54 q./ha) and SS (17.69 q./ha). In the untreated control, the seed cotton yield was 12.00 q./ha (Table 6).

Table 6. Effect of the treated pesticides on the yield of cotton

Treatment	Dose (g a.i./ha)	Kapas Yield (Kg /plot)*	Kapas Yield (q./ha)	Increase in yield over the untreated check (%)
EB1	7	4.65	16.00[d]	33.33
EB2	11	4.83	19.35[a]	60.83
EB3	15	4.90	19.66[a]	63.33
ES	350	3.80	15.20[e]	26.66
Proclaim®	11	4.63	18.54[b]	54.33
SS	75	4.40	17.69[c]	46.66
UC	-	3.00	12.00[f]	-

*** :(Mean of three plots; the mean values tailed by a common letter(s) are not significantly different by DMRT (P=0.05)**

Discussion

Unselective use of insecticides has opened a new era of eco-friendly insecticides having novel modes of action with higher bioefficacy against target insects. One such insecticide is emamectin benzoate that belongs to the avermectin group. This novel group showed increased efficacy against lepidopteran caterpillars. Henceforth, detailed field studies on cotton were conducted during the 2019-2020 season. The results on the bioefficacy assessment of emamectin benzoate 5 SG (EB) against *H. armigera* in cotton are discussed hereunder.

Bioefficacy of emamectin benzoate 5SG against cotton bollworms

The findings of the studied field experiment on cotton revealed that EB affected a marked reduction in the damage caused by *H. armigera*. The treatment with EB3 recorded a 93.96% of reduction of bollworms. This dose (15 g a.i./ha) was in agreement with EB2 (11 g a.i./ha). The higher dose was topmost to all other treatments. EB2 reduced 70.80% of *Helicoverpa armigera* larvae at the end of the first spray, and 90.31% at the end of the second spray. This may be due to the initial activity of the active ingredient for the selected pesticides on the target pest and its residual activity (Mulrooney and Elmore, 2000). These results are in line with those reported by Prakash and Tomar (2009). Brevault *et al.* (2009) stated that EB 5 EC @ 10 g a.i/ha was effective causing 85.40% of mortality against fifth instar larvae of *H. armigera* in cotton. According to Achallke *et al.* (2009), EB 5 SG @ 12 g a.i/ha was effective in suppressing larval population and boll damage caused by *H. armigera* on cotton. Parallel findings were concluded by Gupta *et al*. (2005), Sontakke *et al.* (2007), Srinivasan *et al.* (2007), Kulkarni and Adsule (2007), and Raghuraman *et al.* (2008). Likewise, the lower dose of EB1 caused an 87.93% of reduction of *H. armigera* larvae after the second spray in the experiment. Similar findings were reported for foliar application at the lower dose of EB 5 SG @ 6.75 g a.i/ha which was effective in controlling the *H. armigera* on cotton (Gaikwad *et al.,* 2009). This shows that EB is effective even at lower doses. Singh and Chander (2009) found that the plots treated with EB 5 SG @ 9.8 g a.i/ha reduced the bollworm damage and increased the seed cotton yield.

In EB treated plots, the mean reduction in damage to bolls by *H. armigera* at each picking varied from 60.96 to 83.21% in the field experiment. Likewise, it was in the range of 68.82 and 84.78% in the experiment. Similar outputs were also described by Gaikwad *et al.* (2009) with foliar application of EB 5 SG @ 6.75 g a.i/ha which was effective in controlling the bollworms and reducing shed material, locule infestation, and bad kappas. Raghuraman *et al.* (2008) found that the plots treated with EB 5 EC @11g a.i/ha were effective in reducing the boll damage. According to Udikeri *et al*. (2004) EB 5 SG at 11 g a.i./ha verified significantly less damage to fruiting bodies (4.17%). Ishaaya *et al*. (2002) found that EB 5 SG at 25 mg a.i./l registered 90% suppression of *H. armigera* larvae up to 28 days after treatment (DAT) on cotton.

In the studied field experiment, the standard check SS reduced the incidence of *H. armigera* population by 84.27% in the field experiment. Aghav *et al.* (2009) stated that foliar application of spinosad 45 SC @ 168 g a.i./ha was found to be effective in suppressing the larval population of *H. armigera*. The foliar application of SS pesticide reduced the *H. armigera* infestation up to 61.60%. Bheemanna *et al.* (2008) also reported that spinosad 45 SC @ 75g a.i./ha decreased the bollworm damage. Singh and Chander (2009) and Gaikwad *et al.* (2009) found that plots treated with spinosad 45 SC @ 75g a.i./ha had reduced bollworm damage. Sheeba Jasmine (2005) reported a 71.0 - 71.8% reduction of cotton bollworms in spinosad treatments. Dandale *et al*. (2001) demonstrated that spinosad 45 SC at 75 g a.i./ha registered minimum infestation (3.62%) of bollworm complex on 14 DAT, as against 14.8% in untreated check. These results were also in agreement with those reported by Kharboutli *et al.* (1999), Agi *et al*. (2000), Brickle *et al*. (2000), Johnson *et al*. (2000), and Vadodaria *et al.* (2001). Several workers studied the efficacy of spinosad against *H. armigera* in crops like black gram (Patil *et al.* 2008), dolichos bean (Rekha and Mallapur, 2007), chickpea (Sidde Gowda *et al.,* 2006; Raghvani and Poshiya, 2006), chilies (Shobanadevi, 2003) and tomatoes (Suganyakanna *et al.,* 2005).

Efficacy of Proclaim® against *H. armigera* agreed with EB1 treatment recording 86.65% reduction of *H. armigera* larval population in the field experiment. This conforms with the findings of Duraimurugan *et al.* (2007) who stated that spraying of Proclaim® at 11 and 9.5 g a.i./ha listed the highest reduction (84.60%) of the *H. armigera* larval population. Proclaim® 5 SG at 7.5 g a.i./ha was found more effective against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee (Stanley *et al.*, 2007). Proclaim® @ 200 g a.i./ha (Balikai and Patil, 2007) and 11g a.i./ha (Kulkarni and Adsule, 2007) were found to be effective against grapevine thrips. Prasad Kumar and Devappa (2006) reported that Proclaim 5 SG at 200 g a.i/ha was effective against cabbage diamondback moth and brinjal shoot and fruit borer.

Effect of emamectin benzoate 5 SG on yield of cotton

Seed cotton yield was increased in all plots treated with EB1, EB2, and EB3 and the yield ranged from 16.00 to 19.66 q./ha in the experiment. This indicates the effectiveness of EB in controlling the *H. armigera* of cotton which results in higher yield. Similar results with foliar application of EB on cotton at 11 g a.i./ha recording higher yield (24.74 q./ha) were reported by Gupta *et al.* (2005), Prakash and Tomar (2009) (15.65 - 16.42 q.ha), Singh and Chander (2009) (21.53 q./ha), and Srinivasan *et al.* (2007) (19.54 q./ha). The standard check of spinosad 5

SC at 75 g a.i./ha recognized a 17.69 q./ha in the experiment. Similar findings were achieved by Prakash and Tomar (2009) who found that spinosad 5 SC at 75 g a.i./ha treated plots recorded 1612 kg/ha in cotton. Sheeba Jasmine (2005) recorded 16.5 to 19.5 q./ha in abamectin treated plots against cotton bollworms. Udikeri *et al*. (2004) reported that EB 5 SG recorded a yield of 15.93 q./ha.

CONCLUSION

Bioefficacy of emamectin benzoate 5 SG (EB) was evaluated on the cotton crop at certain doses (7, 11, and 15 g a.i./ha) against *Helicoverpa armigera*. Moreover, the field experiment included the following treatments: endosulfan EC @ 350 g a.i./ha, Spinosad SC @ 75 g a.i. ha^{-1}, Proclaim® @ 11 g a.i. ha^{-1}, and untreated control. The treated dose (11 g a.i. ha^{-1}) of EB was very operative in checking the damage caused by *H. armigera*. This dose reduced boll damage (64.75%) at the end of observation in the field experiment. The yield of cotton ranged from 16.00 to 19.66 q./ha in whole treatments of EB. Specifically, EB @ 15 g a.i./ha was a very operative dose which was on par with EB @ 11 g a.i./ha. The obtained findings in the current paper indicate that EB is an eco-friendly potent compound for controlling *H. armigera*. This compound is a promising material that may be used as substitute components instead of the harmful conventional insecticides in the integrated pest management programs. In conclusion, the present results suggest that the recommended doses of EB (EB2 and EB3) could be applied for the destruction of the tested larvae under field conditions.

REFERENCES

Abid, A.D., Saeed, S., Zaka, S. M., Shahzad, S., Ali, M., Iqbal, M., Iqbal, N., Jamal, Z.A., (2020a). Field evaluation of nucleopolyhedrosis virus and some biorational insecticides against Helicoverpa armigera Hubner (Noctuidae: Lepidoptera), Saudi Journal of Biological Sciences, 27: 2106–2110.

Abid, A.D., Saeed, S., Zaka, S.M, Ali, M, Shahzad, M.S., Iqbal, M., Shahzad, U., Iqbal, N., Alghanem, S.M., (2020b). Interaction of HaNPVs with two novel insecticides against Helicoverpa armigera Hubner (Noctuidae: Lepidoptera). Saudi Journal of Biological Sciences, 27: 2124–2128.

Achallke, J., Vassayre, M., and Prevault, T., (2009). Evaluation of pyrethroid alternatives for the management of cotton bollworms and resistance in Cameroon. Ex. Pl Agriculture, 45: 35 - 46.

Agi, A.L., Boykin, L.S., Anderson, D.H., Hendrix W.H, Benson, and M.A., (2000). Economics of a karate Z/ Tracer conventional cotton program vs. Bt cotton: two-year results. In: Proc. Beltwide Cotton Conf., P. Dugger and D. Richter (eds.), San Antonio, USA, 4-8 January, Vol.2. 2000, pp 1090-1093.

Analytical software, (2005). Statistix 8.1 for Windows. Analytical Software, Tallahassee.

Argentine, J.A., Jansson, R.K., Halliday, W.R., Rugg, D., and Jany, C.S., (2002). Potency, spectrum, and residual activity of four new insecticides under glasshouse conditions. Florida Entomology, 85: 552–562.

Balikai, R.A., and Patil, D.R., (2007). Bioefficacy of emamectin benzoate 5 SG (Proclaim®) against grapevine pests and its effect on natural enemies and plants. Pestology, 31(5):13-20.

Bengochea, P., Sánchez-Ramos, I., Saelices, R., Amor, F., del Estal P., Viñuela, E., Adán, Á., López, A., Budia, F., and Medina, P., (2014). Is emamectin benzoate effective against the different stages of Spodoptera exigua (Hübner) (Lepidoptera, Noctuidae)?. Irish Journal of Agricultural and Food Research, 53: 37–49.

Bheemanna, M., Hosamani, A. C., Basppa, S., and Patil. B.V., (2008). Bioefficacy of newer insecticides chlorothraniprole (E2Y45 20 SC) against bollworms in cotton ecosystem Pestology, 32 (10): 37-40.

Brevault, T., Oumarou, Y., Achallke, J., Vaissayre, M., and Bouche, S.N., (2009). Initial activity and persistence of insecticides for the control of bollworms (Lepidoptera: Noctuidae) in cotton crops. Crop Protection, 28: 401-406.

Brickle, D.S., Turnipseed, S.G., and Sullivan, M.J., (2000). Efficacy of insecticides of different chemistries against Helicoverpa zea (Lepidoptera: Noctuidae) in transgenic Bacillus thuringiensis and conventional cotton. J. Econ. Entomol., 94(1): 86-92.

Dandale, H.G., Rao, N.G.V., Tikar, S.N., and Nimbalkar, S.A., (2001). Efficacy of spinosad against cotton bollworms in comparison with some synthetic pyrethroids. Pestology, 25(3): 24-28.

Duraimurugan, P., Suganya Kanna, S., Chandrasekaran, S., and Regupathy, A., (2007). Field evaluation of emamectin benzoate 5 SG against cotton bollworm *Helicoverpa armigera* (Hubner). Pestic. Res. J., 19(2):186-189.

El-Sheikh, E.A., (2015). Comparative toxicity and sublethal effects of emamectin benzoate, lufenuron, and spinosad on Spodoptera littoralis Boisd. (Lepidoptera: Noctuidae). Crop Protection, 67: 228–234.

Firake, D.M., and Pande R., (2009). Relative toxicity of Proclaim 5% SG (Emamectin benzoate) and Dipel 8L (Bacillus thuringiensis var. kurstaki) against Spodoptera litura (Fab.) by leaf roll method. Current Biotechnology, 3: 445–449.

Gaikwad, R.S., Waghmare, U.M., Khan, F.S., and Bhute. N.K., (2009). Bioefficacy of certain newer insecticides against bollworm complex of cotton. Pestology, 33(2):18-20.

Gupta, G.P., Raghuraman, M., Birah, A., and Singh, B., (2005). Field efficacy of newer insecticides against cotton bollworms in cotton. Pestology, 67(1): 16-20.

Ishaaya, I., Kontsedalov, S., and Horowitz, A.R., (2002). Emamectin, a novel insecticide for controlling field crop pests. Pest Manag. Sci., 58: 1091-1095.

Johnson, D.W., Lorenz, G.M., Hopkins J.D., and Page, L.M., (2000). Summary of Tracer performance for bollworm *(Helicoverpa zea)* and tobacco budworm *(Heliothis virescens)* control in Arkansas cotton, 1998-99. In: Proc. Cotton Res. Mgmt, AAES Special Report, 198: 240-244.

Kharboutli, M.S., Allen, C.T., Capps, C., Earnest, L., and Oosterhuis, D.M., (1999). Bollworm and tobacco budworm control studies. In: Proc. Cotton Research meeting. Special Report Arkansas Agric. Exp. Sta., 1999, No. 193, pp 209-213.

Kulkarni, N.S. and Adsule, P.G., (2007). Bioefficacy of Proclaim® 5 SG (Emamectin benzoate) for management of thrips in grapes. Pestology, 31(9): 30-32.

Liu, Y., Zhu, F., Shen, Z., Moural, T.W., Liu, L., Li, Z., Liu, X., Xu. H., (2021). Glutaredoxins and thioredoxin peroxidase involved in defense of emamectin benzoate induced oxidative stress in *Grapholita molesta*. Pesticide Biochemistry and Physiology, 176: 104881.

Lopez, J.D., Latheef, M.A., and Hoffmann, W.C., (2010). Effect of emamectin benzoate on mortality, proboscis extension, gustation, and reproduction of the corn earworm, *Helicoverpa zea.* Journal of Insect Science, 10: 1–16.

Moustafa M.A.M., Kákai, A., Awad M., and Fónagy A., (2016). Sublethal effects of spinosad and emamectin benzoate on larval development and reproductive activities of the cabbage moth, Mamestra brassicae L. (Lepidoptera: Noctuidae). Crop Protection, 90: 197–204.

Moustafa, M.A.M., Awad, M., Abdel-Mobdy, Y. E., and Eweis E. A., (2018). Latent Effects Of Emamectin Benzoate Formulations On Spodoptera Littoralis Boisd. (Lepidoptera: Noctuidae). Alex. J. Agric. Sci. Vol. 63, No.1, pp. 53-61.

Mulrooney, J.E. and C.D. Elmore, (2000). Rainfastening of bifenthrin to cotton leaves with selected adjuvants. J. Environ. Qual., 29:1863–1866.

Mushtaq, M., Allen, L.R.S., Crouch, L.S., and Wislocki, P.G., (1997). Fate of 3H and b14C-labeled emamectin benzoate in lactating goats. Journal of Agricultural and Food Chemistry, 45: 253– 259.

Patil, S.K., Pngle, M.B., and Janadagm, B.M., (2008). Bioefficacy and economics of insecticides for the management of *Helicoverpa armigera* (Hubner) in chickpea. Ann. Pl. Prot. Sci., 15: 307-311.

Prakash, S. and Tomar S., (2009). Field evaluation of insecticides against bollworms in cotton. Ann. Pl. Protec. Sci., 17(1): 66-69.

Prasad Kumar, V, and Devappa, V., (2006). Bioefficacy of emamectin benzoate 5 SG (Proclaim) against diamondback moth in cabbage. Pestology, 30(2): 23-25.

Raghuraman, M., Birah, A., Singh, B., and Gupta, G.P., (2008). Bioefficacy of newer insecticide of emamectin benzoate 5 EC against cotton bollworm. Indian J. Ent., 70(3): 264-268.

Raghvani, B. R. and Poshiya, V.K., (2006). Field efficacy of newer molecule of insecticides against pod borer (*Helicoverpa armigera* Hub.) in chickpea. Pestology, 30(4): 18-20.

Rekha, S. and Mallapur, C.P., (2007). Efficacy of indigenous materials and new molecules against pod borer complex in dolichus bean. Karnataka J. Agrl. Sci., 20(2): 414-416.

Sheeba Jasmine, R., (2005). Bioefficacy of abamectin 1.9 EC (Abasin) against cotton bollworms, Cabbage diamondback moth, and rose two-spotted spidermite and determination of residues on cotton and cabbage. Ph.D. Thesis. TamilNadu Agric. Univ., Coimbatore, India, 200 p.

Shobanadevi, R., (2003). Bioefficacy and selective toxicity of emamectin 5 SG (Proclaim®) against *Helicoverpa armigera* (Hubner) on bhendi and chillies. M.Sc. Thesis, Tamil Nadu Agricultural University, Coimbatore -3, India, 89p.

Sidde Gowda, D.K., Suhas, Y., Patil B.V., and Gopal, J.B., (2006). Field evaluation of newer insecticides against gram pod borer, *Helicoverpa armigera* (Hubner). Pestology, 30(4): 27-29.

Singh, V., and Chander, R., (2009). Comparative study of new insecticides against cotton bollworm complex Pestology, 33(3):24-26.

Sontakke, B.E., Das, N., and Swain, L.K., (2007). Bioefficacy of emamectin benzoate against bollworm complex in cotton. Ann. Pl. Prot. Sci., 15: 1-3.

Srinivasan, T., Kumaran, N., Vinoth Kumar, B., and Kuttalam, S., (2007). Bioefficacy of emamectin benzoate 1.9 EC against the bollworm complex of cotton. Pestology, 31(10): 56-58.

Stanley, J., Chandrasekaran, S., and Regupathy, A., (2007). Evaluation of emamectin benzoate against brinjal fruit borer *Leucinodes orbonalis* (Guen.). Pestic. Res. J., 19(1): 34-36.

Suganyakanna, S., Chandrasekaran, S., Regupathy, A., and Stanley, J., (2005). Field efficacy of emamectin 5 SG against tomato fruit borer *Helicoverpa armigera* (Hubner). Pestology, 29(4): 21-24.

Temiz, O., 2020. Biopesticide emamectin benzoate in the liver of make male: evaluation of oxidative toxicity with stress protein, DNA oxidation, and apoptosis biomarkers. Environ. Sci. Pollut. Res., 27: 23199–23205.

Udikeri, S.S., Patil, S.B., Rachappa, V., and Khadi B.M., (2004). Emamectin benzoate 5 SG, a safe and promising bio rational against cotton bollworms. Pestology, 28(6): 78-81.

Vadodaria, M.P., Patel, V.G., Maisuria, J.M., Patel, C.J., and Patel, R.B. (2001). Bioefficacy of new insecticide spinosad against bollworms of cotton. Pestology, 25(9): 24-28.

Wang, C.Z., and Qin, J.D., (2007). Insect-plant co-evolution: multitrophic interactions concerning Helicoverpa species. Chinese Bull. Entomol. 44 (3): 311-319.

الفعالية الحيوية لمبيد إيمامكتين بنزوات ضد دودة اللوز الأمريكية بمحصول القطن تحت الظروف الحقلية

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أُجريت الدرسة الحقلية بمنطقة سيدي سالم، محافظة كفر الشيخ، جمهورية مصر العربية لتقييم الفعالية الحيوية لمادة إيمامكتين بنزوات Emamectin benzoate 5 SG (EB) ضد دودة اللوز الأمريكية *Helicoverpa armigera* على محصول القطن. ولتحقيق الهدف من الدراسة؛ تم إختبار بعض مبيدات الآفات تحت الدراسة (Emamectin benzoate 5 SG ، Endosulfan 35 EC، Proclaim®، Spinosad 45 SC) رشاً على الأوراق تحت الظروف الحقلية بموسم 2020/2019 م. صُممت التجربة بنظام القطاعات العشوائية (RBD) 5 م × 5م بسبع معاملات أساسية وهي كالتالي: (أ) بنزوات إيمامكتين 5SG بالجرعات 7 ، 11 و 15 جم مادة فعالة/ هكتار ، (ب) إندوسلفان Endosulfan 35 EC بواقع 350جم مادة فعالة/هكتار ، (ج) بروكليم (Proclaim®) بواقع 11 جرام مادة فعالة/هكتار، وأخيراً (د) سبينوساد 45 SC بالجرعة 75جم مادة فعالة /هكتار ، بالإضافة إلى تجربة المقارنة (غير المعاملة) ، وذلك بواقع ثلاثة مكررات لكل معاملة لمدة 10 أيام تبدأ من اليوم رقم 60 بعد الزراعة .أوضحت النتائج أن إستخدام الجرعة بمعدل 11 جم مادة فعالة/ هكتار من مبيد بنزوات إيمامكتين (EB) كانت فعالة جداً ضد يرقات دودة اللوز الامريكية، والتي أدت إلى تقليل الإصابة بمعدل يصل إلى 64,75% من الضرر للوزعند مقارنتها بالنباتات غير المعاملة بأي من المبيدات (تجربة المقارنة). كما تم ملاحظة زيادة الإنتاجية المحصولية في جميع معاملات بنزوات الايمامكتين، حيث تراوح محصول القطن ما بين 16,00 إلى 19,66 قنطار/هكتار. كما سجلت المعاملة بـ EB عند معدل 15 جم مادة فعالة/ هكتار مؤشرات إيجابية ضد يرقات الحشرة تحت الدراسة والتي تشابهت نتائجها بصورة متوازية مع نتائج المعاملة بـ EB عند معدل 11 جم مادة فعالة/هكتار. كما أدت جميع معاملات EB إلى زيادة بذور القطن تحت الظروف الحقلية. أوصت أهم نتائج البحث والتي أجريت تحت الظروف الحقلية تحقيقاً للواقعية لإختبار عدد من المبيدات بمدى فعالية مبيد بنزوات إيمامكتين عند الجرعات 11 و 15 جم مادة فعالة/ هكتار ضد دودة اللوز الأمريكية والتي يمكن إستخدامه كمبيد صديق للبيئة وبصورة آمنة على كلاً من التربة والنبات والحيوان؛ وبالتالي الحفاظ على الموارد البيئية وكذلك على صحة الإنسان.