Field Evaluation of a Commercial Biopesticide in Comparison with a Conventional Insecticide Against *Spodoptera littoralis* (Boisduval) and *Scrobipalpa ocellatella* (Boyd) Sugar Beet Insect Pests and Their Effect on the Associated Predators

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Abstract

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In this study, the insecticidal activities of one commercially available biopesticide, Biotect of *B. thuringeinsis* var. kurstaki, (9.4% WP, 32000 I.U./mg), and the conventional insecticide, Andros 5.7% WDG (Emamectin benzoate), against *Spodoptera littoralis* (Boisd.) and *Scrobipalba ocellatella* (Boyd) larvae and three natural enemies; *Chrysoperla carnea* (Steph.), *Coccinella undecimpunctata* L. and *Scymnus interruptus* (Goeze) were evaluated during 2020 and 2021 seasons in sugar beet fields at Kafr El-Sheikh Governorate, Egypt. Andros was the most effective against *S. littoralis* and *S. ocellatella* populations with reduction of 83.3% and 91% in 2020 and 82.60% and 88.96% in 2021, respectively. Whereas, Biotect had the least effect with 67.2% and 60% reduction in 2020, and 70.12% and 56.4% reduction in 2021 for *S. littoralis* and *S. ocellatella*, respectively. On the other hand, treatments had a mediocre effect during the two seasons on the predators. Andros showed the highest effect on *S. interruptus* larvae with a reduction of (91.0% and 98.5% reduction), on *C. undecimpunctata* (81.66% and 83.22% reduction) and on *C. carnea* (78.12% and 86.19% reduction) in 2020 and 2021 growing seasons, respectively. Andros induced the highest decline in insect numbers. From this study, it can be proposed that Biotect is a promising *B. thuringeinsis* product for the biocontrol of cotton leaf worm and beet moth under field conditions.

Keywords: Sugar Beet, *Spodotera littoralis*, *Scrobipalba ocellatella*, Biopesticides, Predators, Field evaluation.

Introduction

Sugar beet, *Beta vulgaris* L., is cultivated for sugar production in temperate areas (Rashid, 1999). Lepidopteran pests reduce yield significantly in most sugar beet growing parts of the world (Jafari *et al.*, 2009). The cotton leafworm, *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae) is cited as a key pest of a range of crops in Asia, Africa, and Europe (Horowitz *et al.*, 2020; Smagghe & Degheele, 1997). Cotton leaf worm, *Spodoptera littoralis*, and beet moth, *Scrobipalba ocellatella*, (Boyd) (Lepidoptera: Gelechiidae) are destructive insects that cause significant economic losses to Egypt's sugar beet crop. Sugar beet root weight and sugar content were reduced by 38.20 and 52.40%, respectively, after severe infestation with *S. ocellatella* larvae (Abo-Saied, 1987).

Biopesticides caused lower mortality rate than chemical pesticides in case of initial kill, but 1-10 days after treatment they caused higher mortality rate than the organophosphorus insecticides. *Spodoptera littoralis* second larval instar demonstrated more sensitive reaction than the fourth larval instar to all examined insecticides (Fetoh *et al.*, 2015). El Kenawy *et al.* (2021) evaluated the insecticidal activity of Quinoa-derived extracts on *C. carnea*. The use of 66.2 ppm concentration resulted in significant reduction compared to the control group or the 20.0 ppm group, but 48 hours after treatment with 66.2 ppm, a significant effect on the natural enemy *C. carnea* was observed compared to the control or 20.0 ppm treatments.

On the other hand, the differences among 40.0, 33.2 and 20.0 ppm treatments were not significant compared to the control treatment. In direct spray assay, the maximum mortality *of C. carnea* larva was obtained with the higher dose (66.2 ppm) 24 and 48 h after treatment which reached 9.1±0.7 and 13.6±1.2%, respectively. However, four days after spray, there was no evidence of dead insects in response to all concentrations used.

According to Bassyouny *et al.* (1991), *B. thuringiensis* has is one of the most widely used products since the development of microbial bio-pesticides to control insect pests in agriculture. It is regarded as a promising alternative to the traditional insecticides due to its positive effect on the environment (Abd El-Salam *et al.*, 2011). Commercial BT-bio pesticides are considered one of the most popular, safe, and effective methods in the management of early *S. littorallis* infestations in Egyptian sugar beet fields (El-Fergani, 2019).

The objective of this study was to examine the effect of commercially available biopesticides on *S. littoralis* and *S. ocellatella* larval attack of sugar beet and also their effects on natural enemies.

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Materials and Methods

Experimental site and design

This study was conducted during the 2020 and 2021 growing seasons to evaluate the efficacy of two bio-pesticides, and one insecticide against cotton leafworm, *S. littoralis*, and beet moth, *S. ocellatella*. Field experiments were conducted in Shanu village around 6 km southeast of Kafr El-Sheikh city. Crops grown in the study area were maize, faba bean and clover. The experimental field was divided into 16 plots, 42 m^2 (7x6 m) each, and included four treatments with four replications in a completely randomized block (CRB) design. The four treatments included two bio-pesticides, an insecticide and a non-treated control.

Cultivated variety

Farida sugar beet cultivar, provided by the sugar crops research department, Sakha Agricultural Research Station, was sown on 12 September 2020. All agricultural practices were followed, except for the pesticide treatment.

Tested pesticides and their application

The pesticides used were: (1) Biotect *(B. thuringeinsis* var. kurstaki), (9.4% WP, 32000 I.U./mg) applied at the rate of 300 gm/feddan. The commercial biopesticides were obtained from the Bio-insecticide Production Unit, Plant Protection Research Institute, Agriculture Research Centre, Giza, Egypt, and (2) Andros (emamectin benzoate) (5.7% WG) applied at the rate of 80 gm/feddan. It is an insecticide from the avermectin group containing the active substance emamectin benzoate in the form of granules dispersible in water. One-kilogram commercial product contains 57 g of the active substance. Both pesticides were applied twice. The first time was one month after sowing for the control of the cotton leafworm, and the second time was three months after sowing to control the beet moth.

Data collection

The experimental plots were separated from each other by untreated belts to avoid spray drift. Each sample consisted of 10 plants/plot (40 plants/ treatment). The primary examination was done before treatment to count live larvae. Knapsack sprayer (20 L volume) was used in applying the treatments. Number of *S. littoralis* and *S. ocellatella* larvae was simultaneously counted early and late during the growing season. The visual examination was carried out 3, 7 and 10 days after treatments. In addition, arthropod fauna predators were sampled using visual examination and sweeping net. In each replicate, 5 double strokes were made at diagonal directions (Kandil *et al*., 1991).

Data analysis

Analysis of variance (ANOVA) using the Holmes-Sidak method was followed to refuse the null hypnosis and confirm the presence of significant variance between different treatments. The analysis was made by using SigmaPlot V12.5 and MiniTab V18.1 software. Two-way cluster (Heat map) was constructed using Euclidean (Pythagorean) distance measure with Ward's group linkage method, and the analysis was made by using Pc-Ord V5.0 software. Principal components analysis (PCA) was made by using a correlation cross-products matrix. Whereas the score of the ratios was calculated using a distance-based biplot in Pc-Ord V5.0 software. Spearman correlations was made available using Minitab V18.1 software.

The Reduction rate (%) in the *S. littoralis* and *S. ocellatella* larvae and associated arthropod predators number were calculated by Henderson & Tilton (1955) equation as follows:

$$\text{Reduction rate (\%)} = 100 \times \left(1 - \frac{\text{Number in the control after spraying} \times \text{Number in the treatment before spraying}}{\text{Number in the control before spraying} \times \text{Number in the treatment after spraying}}\right)$$

Differences between mean numbers of the *S. littoralis* and *S. ocellatella* and predator larvae on the tenth day after treatment were analyzed using the Duncan test (1955).

Results

The field recommended rates of Biotect 9.4% bt., and Andros 5.7% were sprayed on sugar beet foliage under field conditions to study the field efficacy of these biopesticides on *S. littoralis* and *S. ocellatella* and on the present natural enemies. Each pesticide had a nearly identical strong effect on *S. littoralis* and *S. ocellatella* (Figure 1). On the other hand, different pesticides had a mediocre effect on natural enemies during the two seasons. Data obtained (Figure 2) showed that the insect pests and biological control agents exposed to Biotect and Andros treatments during the 2020 and 2021 seasons showed that different insect species gathered in one cluster and the biological control species in another cluster due to the variable effect of different pesticides and the strong effect on insect species and the mediocre effect on the natural enemies.

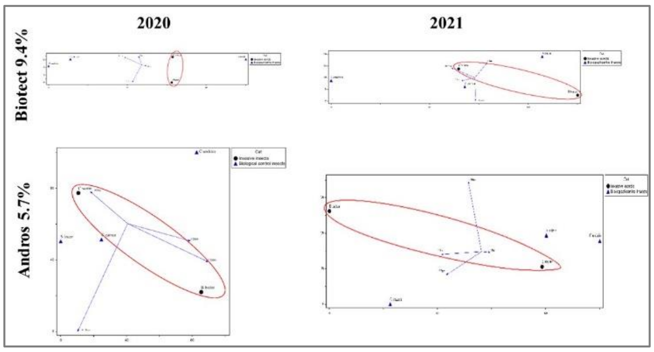

Figure 1. 2D ordination for insect pests and biological control agents subjected to Biotect 9.4% WP, Andros 5.7% WDG for 2020 and 2021 seasons.

Efficacy against *S. littoralis* and *S. ocellatella*

Two pesticides were evaluated for their efficacy against sugar beet insect pests, the cotton leaf worm, *S. littoralis,* and beet moth, *S. ocellatella*) as compared to the control. The performance of the pesticides on the infestation reduction is presented in Table 1. All the treatments significantly reduced pest population in 2020 but with no significant differences in 2021. However, all the treatments produced a lower pest population density than the untreated control, and the insecticide Andros caused the highest decline in insect pest numbers.

Cotton leafworm, *S. littoralis*

A highly correlation was obtained ed relationship between 2020 and 2021 seasons revealing r^2 value of 0.999 and 0.978 for Biotect and Andros treatments, respectively. Results (Table 1) showed that Andros product was the most effective in reducing the population density of *S. littoralis* larvae with reductions from 14.5±0.7 larvae/plant at 0 days to 2±0.5 larvae/plant 10 days after application in 2020 season (t=21.93, p<0.001) (83.3% reduction), and from 22.5±2.58 larvae/plant at 0 days to 1±0.5 larvae/plant at 10 days after application in 2021 season (t= 74.95, p<0.001) (91% reduction). Likewise, Biotect product significantly reduced the *S. littoralis* population in 2020 (t=18.303, p<0.001) from 15.5±0.6 larvae/plant at 0 days to 3±0.5 larvae/plant at 10 days after application (67% reduction), however, in 2021 (t=49.635, p<0.001) it reduced the pest population from 22.5±2.06 larvae/plant at 0 day to 9±0.82 larvae/plant at 10 days after application (60% reduction). All treatments were significantly different (P< 0.001) from the control treatment, and Andro's product was significantly different from Biotect product (t=5.950, P<0.001) during the 2020 growing season. Similarly, during the 2021 season, all investigated treatments were significantly different (t=25.316, P<0.001).

Sugar-beet moth, *S. ocellatella*

Data analysis showed a high correlation between the 2020 and 2021 seasons with r^2 values of 0.98 and 0.97, respectively. The maximum reduction rate of *S. ocellatella* population (82.60%) was obtained by spraying Andro's product (t=21.9, p<0.001), followed by 70.12% reduction by applying Biotect product (t=18.303, p<0.001) during the 2020 growing season. Likewise, during the 2021 growing season, the maximum reduction rate (88.96%) of S. *ocellatella* population was obtained by spraying Andro's product (t=37.05, p<0.001), followed by Biotect product (56.43%) (t=22.910, p<0.001) (Table 1).

Efficacy against natural enemies:

The efficacy of Biotect and Andros products were evaluated against the natural enemies *Chrysoperla carnea*, *Coccinella undecimpunctata* and *Scymnus interruptus* collected from the field. Biotect had a mediocre effect on the biological control agents, whereas Andros produced the highest decline in the number of insects (Table 2). There was a high correlation between the effect of Biotect (r^2 = 0.870) and Andros (r^2 = 0.94) on the numbers of *C. carnea* between the 2020 and 2021 growing seasons.

There was a high correlation (r^2 = 0.91) between the effect of Andros product on *C. undecipunctata* between the 2020 and 2021 growing seasons, however, there was no correlation between the two seasons when Biotect product was used. As for the natural enemy *S. interruptus*, there was a high correlation (r^2 = 0.962) between the effect of Andros product in the 2020 and 2021 growing seasons, but with no correlation for Biotect product use between the two seasons.

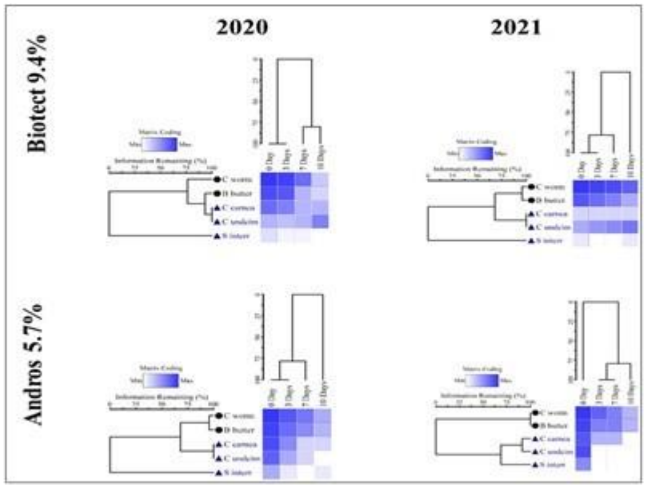

Figure 2: Heat map for pests and biological control agents subjected to Biotect 9.4%, Andros 5.7% during 2020 and 2021 seasons.

Green Lacewing, *Chrysoperla carnea* (Neuroptera: Chrysopidae)

The treatments were significantly different (P< 0.001) when compared with the control during the 2020 season. The mortality rate of adults was 33.96% and 78.12% with Biotect and Andros treatments, respectively. Whereas during the 2021 season, the mortality rate was 48.61% and 86.19% for the same two products, respectively.

Eleven-spotted ladybird, *Coccinella undecimpunctata* Linnaeus (Coleoptera: Coccinellidae)

The results obtained revealed that during the 2020 and 2021 seasons, the population density of *C. undecimpunctata* decreased in the treated plots compared to the untreated plots.

Results obtained also showed that there was more toxic effect for the Andros product on *C. undecimpunctata* compared to the untreated plots. The mortality rate due to the different treatments can be arranged in a descending order as follows: Andros product (81.66%) and Biotect (38.16%) during the 2020 season. During the 2021 sugar beet season, data obtained showed a higher mortality rate due to Andros product treatment (83.32%) and Biotect product treatment (67.15%) (Table 2).

Red-Flanked Ladybird Beetle, *Scymnus interruptus* Goeze (Coleoptera: Coccinellidae)

Data obtained during the 2020 season showed significant differences (P<0.001) between the control treatment and Andro's treatment, with no significant differences (P>0.001) between other treatments. During the 2021 season, all three treatments were significantly different (Table 2).

The mortality rate caused by the different treatments during the 2020 season can be arranged in descending order as follows: Andro's product (91.05%), Biotect product (43.12%). However, during the 2021 season lower mortality rate was obtained for the Biotect spray (31.4%) and a higher mortality rate due to Andro's spray (98.58%) (Table 2).

Table 1. Mean mortality rate of biological and conventional pesticides against *Spodoptera littoralis* and *Scrobipalpa ocellatella* on sugar beet compared with the untreated control after different time periods.

	2020			2021		
Days	**Control**	**Biotect 9.4%**	**Andros 5.7%**	**Control**	**Biotect 9.4%**	**Andros 5.7%**
Spodoptera littoralis						
0	15.0±1.30	15.5±0.60 a	14.5±0.70 a	23.0±0.82	22.5±2.06 a	22.5±0.58 a
3	17.5±0.65	10.0±0.63 b	5.5±0.48 b	30.5±0.96	16.5±0.96 b	2.5±0.58 b
7	21.0±0.63	5.50±0.48 c	3.0±0.25 c	33.0±0.50	12.0±0.50 c	2.0±0.50 c
10	25.5±0.48	3.00±0.50 d	2.0±0.50 d	35.5±0.58	9.0±0.82 d	1.0±0.50 d
Reduction %		67.20	83.30		60.00	91.00
t		18.303	21.932		49.635	74.951
Scrobipalpa ocellatella						
0	7.5±0.50 a	9.0±0.90 a	9.0±0.40 a	10.0±0.25 a	10.5±0.30 a	10.5±0.40 a
3	10.0±0.30 b	6.0±0.80 b	4.0±0.60 b	11.0±0.25 b	8.0±0.30 b	2.0±0.25 b
7	15.5±0.30 c	4.5±0.30 c	2.5±0.50 c	13.0±0.25 c	5.0±0.40 c	2.0±0.25 c
10	17.0±0.80 d	2.5±0.30 d	1.5±0.40 d	14.0±0.25 d	3.5±0.30 d	1.0±0.25 d
Reduction %		70.12	82.60		56.43	88.96
t		18.303	21.932		22.910	37.052

P Value for both insects was <0.001.

Table 2. Mean mortality rate of biological and conventional pesticides against *Chrysoperla carnea*, *Coccinella undecimpunctata* and *Scymnus interruptus* on sugar beet as compared to the untreated control after different time periods.

	2020			2021		
Days	**Control**	**Biotect 9.4%**	**Andros 5.7%**	**Control**	**Biotect 9.4%**	**Andros 5.7%**
Chrysoperla carnea						
0	5.5±0.28	5.5±1.19	6.0±0.60	3.0±0.70	4.5±0.25	8.0±0.25
3	6.0±0.40	5.0±0.25	2.5±0.20	3.0±0.60	3.0±0.00	3.0±0.25
7	8.0±0.60	4.5±0.48	1.0±0.20	3.5±0.50	3.0±0.25	3.0±0.25
10	9.0±0.25	4.5±0.29	1.0±0.00	3.0±0.00	1.0±0.00	0.0±0.00
Reduction %		33.96	78.12		48.61	86.19
t		7.071	12.728		8.820	17.105
P Value				<0.001		
Coccinella undecimpunctata						
0	4.5±0.65	4.5±0.71	4.5±0.29	3.5±0.29	4.0±0.41	4.0±0.25
3	5.0±0.41	4.0±0.50	2.0±0.25	4.0±0.00	3.5±0.48	0.0±0.00
7	7.5±0.29	4.5±0.48	1.0±0.25	4.5±0.29	3.5±0.29	0.0±0.00
10	9.0±0.41	5.0±0.63	0.0±0.00	5.5±0.29	3.5±0.25	0.0±0.00
Reduction %		38.16	81.66		67.15	83.32
t		14.607	5.527		2.923	14.613
P Value		<0.001		0.011	0.016	<0.001
Scymnus interruptus						
0	1.5±0.85	2.0±0.41	2.0±0.58	1.0±0.25	1.5±0.29	1.5±0.48
3	1.5±0.94	1.5±0.64	0.5±0.28	2.0±0.25	1.0±0.25	0.0±0.00
7	2.5±0.29	1.5±0.48	0.0±0.00	3.0±0.25	1.0±0.25	0.0±0.00
10	3.0±0.91	1.0±0.75	0.5±0.29	4.5±0.29	1.5±0.29	0.0±0.00
Reduction %		43.12	91.05		31.40	98.58
t		1.549	4.028		7.967	13.164
P Value		0.337	0.001		<0.001	

Discussion

Both *S. littoralis* and *S. ocelletetella* are considered important dangerous sugar beet pests. These two pests not only cause direct damage to sugar beet by feeding on the leaves and roots, but also sugar production can be significantly reduced (Abbas, 2018; Rashed, 2017; Shalaby *et al.*, 2011). Recently, effective, and non-hazardous control methods for *S. littoralis* control in Egypt has been published (Hazaa *et al.*, 2019). Bioinsecticides represent a promising tool for the biocontrol of insect pests with no toxic pollution to the environment (Evans, 1999). In this study, *B. thuringiensis* illustrated a high insect mortality rate following larvae treatment of two sugar beet insect pests. Thus, *B. thuringiensis* is one of the excellent alternatives to the traditional pesticides used in the control of insect pests because it is environmentally safe with no effect on natural enemies (Abd El- Salam *et al.*, 2011; El-Fergani, 2019). A similar residual effect of *B. thuringeinsis* against *S. littoralis* was evaluated by Said *et al.* (2012) who showed that Protecto caused a 77% reduction in the cotton leaf worm population. Also, the impact of the residual effect of *B. thuringiensis* on *S. littoralis* was reported by El-Zoghbey (2003) who observed that the conventional insecticide reduced the populations of the beet moth *(S. ocelletella)* and cotton leaf worm (*S. littoralis)* larvae, but also reduced the number of predators associated with both insects. This agreement with the findings of Ibrahim (2020) who showed that conventional insecticides had a markedly antifeedant effect against larvae of *S. littoralis* and *S. ocelletella* and their predators.

Based on the results obtained in this study, it can be concluded that the bacteria *B. thuringeinsis* at the recommended rate is an effective agent against *S. littoralis* and *S. ocelletella*, *and* Poretecto and Biotect can be considered as promising *B. thuringeinsis* commercial products to be used in the biocontrol program of both insects.

الملخص

فرج، عبد السلام، أحمد القناوي والسيد رفاعي. 2023. التقييم الحقلي للمبيدات الحيوية التجارية مقارنة بالمبيدات الحشرية التقليدية ضدّ حشرات (Boisduval) *Spodoptera littoralis* و (Boyd) *Scrobipalpa ocellatella* التي تصيب الشوندر/بنجر السكر وتأثيرهما على المفترسات المرافقة. مجلة وقاية النبات العربية، 41(3): 266–271. https://doi.org/10.22268/AJPP-041.3.266271

في هذه الدراسة، تمّ تقييم اثنين من المبيدات المتاحة تجارياً، المبيد الحيوي (*B. thuringeinsis* var. kurstaki) Biotect والمبيد الكيميائي الحشري التقليدي Andros (Emamectin benzoate)، ضدّ يرقات: (.Spodoptera littoralis* (Boisd* و *Scrobipalba ocellatella* (Boyd)؛ وثلاثة مفترسات: *Coccinella undecimpunctata* L.، *Chrysoperla carnea* (Steph.) و *Scymnus interruptus* (Goeze) خلال موسمي 2020 و 2021 في حقول الشوندر/بنجر السكر بمحافظة كفر الشيخ، مصر. كان المبيد الكيميائي Andros أشدّ تأثيراً على يرقات *S.littoralis* و *S. ocellatella* مسبباً انخفاضاً في أعداد الحشرات حتى 83.3% و 91% في موسم 2020، 82.60% و 88.96% في موسم 2021، على التوالي. بينما كان للمبيد الحيوي Biotect أقلّ تأثيراً حيث بلغت نسبة انخفاض أعداد نوعي الحشرات 67.2% و 60% في موسم 2020، 70.12% و 56.4% في موسم 2021، على التوالي. من ناحية أخرى، كان للمبيد الحيوي تأثير متواضع على المفترسات الحشرية خلال الموسمين، بينما أظهر المبيد الكيميائي Andros أعلى تأثير على يرقات الأعداء الطبيعية المرافقة. بناءً للنتائج التي حصلنا عليها في هذه الدراسة، يمكن اقتراح استخدام البكتيريا *B. thuringeinsis* في برامج المكافحة الحيوية لدودة أوراق القطن وفراشة البنجر/الشوندر تحت الظروف الحقلية.

كلمات مفتاحية: الشوندر/بنجر السكر، *Spodotera littoralis*، *Scrobipalba ocellatella*، المبيدات الحيوية، المفترسات، التقييم الحقلي.

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