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Role of Parasitoid Species and Insecticides in Controlling Populations of Beet Moth in Sugar Beet Fields

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ABSTRACT

During 2020/2021 and 2021/2022 seasons, sugar beet leaves and infested necks with the beet moth, *Scrobipalpa ocellatella* Boyd. (Lepidoptera: Gelechiidae) were collected from untreated fields with insecticides at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate. Four hymenopterous parasitoids were recorded from larval–pupal stages of this insect in Egypt. These were *Agathis* sp. (Braconidae); *Alysia* sp. (Braconidae); *Diadegma oranginator* Aub. (Ichneumonidae); and for the first time, *Eurytoma* sp. (Eurytomidae). Parasitism (%) by these parasitoid species was 12.29 ± 0.10, 12.39 ± 0.30, 27.54 ± 2.11 and 24.30 ± 2.01 in the first season and were 11.04 ± 0.22, 9.79 ± 0.31, 21.92 ± 3.21 and 14.31 ± 2.22 in the second season, respectively. Regardless of species, parasitism ranged between 51.78 to 93.38% in the first season and from 56.36 to 84.96% during the second season. In another field, the overall mean of reductions in *S. ocellatella* larvae populations by three insecticides [Protecto® and Biovar® (biocides) and Robek extra® (conventional)] were 71.39, 76.84 and 85.14% in the first season and were 71.39, 75.99 and 82.53% in the second season. Further, these pesticides reduced parasitoid populations by 33.39, 30.29 and 97.72% in the first season and by 43.22, 41.27 and 97.70% in the second season. Biocides were less harmful to parasitoids than the conventional ones. Finally, the parasitoids' complex of *S. ocellatella* in addition to biocides seems to be promising tools in the biological control of *S. ocellatella* in Egypt.

INTRODUCTION

The beet moth, *Scrobipalpa ocellatella* Boyd. (Lepidoptera: Gelechiidae) is one of the most important pests infesting sugar beet plants (*Beta vulgaris* L.: Chenopodiaceae). The first record of this insect pest in Egyptian sugar beet fields was by Willcocks (1922). Its larvae attack the succulent heart leaves causing puncture holes, longitudinal slits and short tunnels. These leaves where appeared crinkled, wilt and attached together with a silken web, whereas leaf mid-ribs infested by the last instars become soft, black and breakable (El- Sufty *et al.*, 1987). The severe infestation by this pest led to higher weight reductions in roots (38 %) and sugar content (52%) than those caused by the beet fly, *Pegomyia mixta* Vill. or *Cassida vittata* L. (Abo-Saied, 1987). In such concern, Ahmadi *et al*. (2017) in Iran, stated that *S. ocellatella* is one of the most important pests of sugar beet that causes quantitative and quantitative yield loss in sugar roots and sugar content. Pest damage occurs in the central

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buds and the root of the sugar beet plant. Shalaby (2001) indicated that the average larval populations in sugar beet plantations were 11.83, 16.50 and 33.60 larvae/ 5 plants in September, October and November plantations, respectively. Usually, the highest damage to sugar beet plants by the invasion of this insect pest was at harvest time. Further, Talha (2001) found that the infestation by *S. ocellatella* was the highest in sugar beet plants that were sown in mid-November. In contrast, Abou- El Kassem (2010) found that the lowest numbers of *S. Ocellatella* (1.8 larvae/ 5 plants) were during September plantation and the highest numbers (2.5 larvae/ 5 plants) during November plantation with two peaks of abundance on 22nd December and 26th March. Mohisen (2012) observed that the activity of *S. ocellatella* on sugar beet plants increased from November to the harvest time. As well, Abdel- Rahman (2018) found that the infestation by *S. ocellatella* larvae increased from November (4 larvae/ 80 plants) to May (115 larvae/ 80 plants). In other countries, Camprag *et al*. (2004) in Serbia, recorded *S. ocellatella* in all inspected sugar beet fields and infesting 93.3% of the plants with 4.6 larvae per plant. In Slovenia, Valic *et al*. (2005) estimated the economic damage threshold by *S. ocellatella* to be 4 - 5 larvae on 70% of plants.

The sugar beet fields have several parasitoids that should be conserved to keep the natural balance in these fields (Talha, 2001 and Hendawy, 2009). Parasitoids are vital biological agents that are used widely in agriculture for controlling various insect pest species (Sampaio *et al*., 2010; Kalyanasundaram and Kamala, 2016; Cruz *et al*., 2017). The relationship between *S. ocellatella* larvae and its parasitoid, *Agathis* sp. was significantly positive (Bazazo, 2010). El-Samahy and Shalaby (2011) found that the highest population density of *Agathis* sp. was recorded during the third sugar beet plantation in June. Khalifa (2018) indicated that parasitism by *Diadegma* sp. on *S. ocellatella* was the highest in late October plantation and exhibited the highest peak (22.92 %) in May. In addition, Bazazo and Ibrahim (2019) estimated the parasitism rates by *Diadegma oranginator* Aub to be 55.17, 60.46 and 68.91% for three cultivations, respectively. Further, mean parasitism by *Diadegma aegyptiator* Shaumer on *S. ocellatella* larvae ranged from 24.52 to 31.03% in the first and second seasons, respectively (Bazazo and Hassan, 2021).

Biocides are increasingly being considered as environmentally friendly alternatives to conventional insecticides. The pathogens that have been used successfully are bacterial and fungal agents (Ramanujam and Yandigeri, 2014). Biocides are not harmful to human health, the environment and parasitoids (Bhattarai *et al*. 2016).

Accordingly, the current study aims to cover the following objectives:

1- Surveying and monitoring the parasitoids' complex of *S. ocellatella* in third cultivations during the two seasons.
2- Evaluating the effect of certain biocides on *S. ocellatella* larvae and their parasitoids compared to conventional insecticides.

MATERIALS AND METHODS

Parasitoids' Complex of *S. ocellatella*:

This experiment was done at the experimental farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during 2020/2021 and 2021/2022 seasons. The experimental area was about half feddan divided into 3 replicates and cultivated with Sahar variety on 16th October and 17th October during the two seasons, respectively. Recommended agricultural methods were followed without insecticide applications. The samples were taken from 30 plants (10 plants/ replicate) in each replicate.

In each sample, infested necks of leaves with *S. ocellatella* larvae were gathered with scissors, then put into paper bags in the field. After that, these samples were transferred to the laboratory, kept in Petri dishes (9 cm) containing filter papers at 25 ± 2˚C and 60 –

70% R.H., and monitored till the pupae stage. The pupae were collected and kept in another 9.0 cm Petri dish. The individuals of parasitoid species were identified, counted, and the percentages of parasitism were estimated according to the following formula:

$$\text{Parasitism}(\%) = \frac{\text{No. parasitoids}}{\text{No. pupa}} \times 100$$

The species of parasitoids were identified at Insect Identification Unit (Plant Protection Research Institute), Cairo, Egypt.

Efficacy of Biocide and Conventional Compounds against *S. ocellatella* larvae:

Another experiment was selected to evaluate these compounds and divided into 16 plots (replicates), each plot measured 42 m^2. Three compounds were applied, each replicated four times (3×4 = 12 plots), in addition to four plots were used as a check. A knap sac sprayer (20 L. volume) was used for spraying these insecticides. The date of spraying was 1st March and 2nd March during the two seasons respectively. A completely randomized block design was applied (CRBD).

The selected insecticides were:

1- Protecto® (bacteria) 400g/ fed.
2- Biovar® (fungi) 300g/ fed.
3- Robek extra® (50% wp) (Acetamiprid 22.7% + Bifenthrin 27.3%) 50g/ fed.

Numbers of insect larvae and their parasitoids were counted in each plot before spraying (10 plants/plot), and after 1, 7 and 10 days for conventional insecticide, whereas it was after 3, 7 and 10 days for biocides. Individuals of parasitoids were taken by sweep net (50 double strikes for each date) and the catch was put into glass jars containing 70% ethyl alcohol for preservation till identification by a stereoscope (4.8 - 56.0 × magnifications). Species of parasitoids were identified by Insect Identification Unit (Plant Protection Research Institute), Cairo, Egypt. Whereas, individuals of *S. ocellatella* larvae were counted by visual record on the selected plants in the field. Reductions in *S. ocellatella* larvae and their parasitoids were determined by using a formula of Henderson and Tilton (1955).

Henderson and Tilton formula:

$$\text{Reduction } (\%) = \left(1 - \frac{\text{No. in check before}}{\text{No. in check after}} \times \frac{\text{No. in treated after}}{\text{No. in treated before}}\right) \times 100$$

In addition, differences between compounds in their reductions were analyzed using one-way ANOVA and mean separated using Duncan test (1955) at 0.05 probability level.

RESULTS AND DISCUSSION

Seasonal Abundance of Parasitism Percentages on *S. ocellatella* larvae:

During the two seasons, data in Tables (1 and 2) and Figures (1,2,3,4,5 & 6) show that *Agathis* sp., *Alysia* sp., *Eurytoma* sp. and *Diadegma oranginator* are the dominant parasitoids on larval – pupal of *S. ocellatella*. In 2020/ 2021, seasonal abundance of parasitism percentages regardless of species were 93.33, 86.04, 51.78, 59.49, 75.26 and 93.38% on 15 Jan., 30 Jan, 15 Feb., 28 Feb., 15 Mar. and 30 Mar., respectively. The highest percentage was recorded on 30 Mar., the lowest percentage was noticed on 15 Feb. Mean of emerged parasitoids were 2.941 ± 0.10, 2.886 ± 0.20, 6.553 ± 1.30 and 5.606 ± 1.42 to *Agathis* sp.; *Alysia* sp.; *Eurytoma* sp. and *D. oranginator*, respectively. Moreover, overall parasitism (%) to each species was 12.29 ± 0.10, 12.39 ± 0.30, 27.54 ± 2.11 and 24.30 ± 2.01, respectively. The highest mean of parasitism was recorded for *Eurytoma* sp., while the lowest mean of parasitism was monitored for *Agathis* sp.

In 2021/ 2022 season, seasonal abundance of parasitism percentages regardless of species were 50.00, 61.53, 56.36, 57.83, 81.81 and 84.96 on 16 Jan., 31 Jan., 13 Feb., 27

Feb., 13 Mar., and 28 Mar, respectively. The highest percentage was recorded on 28 Mar., while the lowest on 13 Feb. Mean of emerged parasitoids were 3.218 ± 0.21, 2.830 ± 0.20, 7.051 ± 1.10 and 5.051 ± 1.02 for the previous parasitoids, respectively. In addition, overall parasitism (%) for each species of these parasitoids was 11.04 ± 0.22, 9.79 ± 0.31, 21.92 ± 3.21 and 14.31 ± 2.22, respectively.

The highest parasitism was recorded by *Eurytoma* sp., whereas, the lowest was by *Alysia* sp. In general, a good relationship between *S. ocellatella* larvae and their parasitoids in sugar beet fields. Also, these parasitoids are able to reduce *S. ocellatella* populations greatly. Bazazo (2010) and El- Samahy and Shalaby (2011) noticed a positive significant correlation between *S. ocellatella* and *Agathis* sp. Moreover, Khalifa (2018) found that the parasitism percentages on *S. ocellatella* by *Diadegma* sp. Ranged between (11.11 to 22.92%). In another study, Bazazo and Ibrahim (2019) calculated the mean of parasitism of *D. oranginator* on *S. Ocellatella* was 55.17, 60.46 and 68.91% for the three cultivations, respectively. In addition, Bazazo and Hassan (2021) monitored the overall parasitism to *D. aegyptiator* on *S. Ocellatella* larvae with 24.52 and 31.03% during the two seasons, respectively. these findings demonstrated that these parasitoids complex of *S. ocellatella* are able to manage this dangerous insect pest.

Table 1: Overall mean of parasitism on *S. ocellatella* larvae during 2020/ 2021.

Date	Mean of pupae	*Agathis* sp.		*Alysia* sp.		*Eurytoma* sp.		*Diadegma oranginator*		Parasitism regardless of species
		Mean emerged parasitoids	Parasitism %	Mean emerged parasitoids	Parasitism %	Mean emerged parasitoids	Parasitism %	Mean emerged parasitoids	Parasitism %	
15 Jan.	10.00	1.66	16.66	2.00	20.00	3.00	30.00	2.66	26.66	93.33
30 Jan.	14.33	2.33	16.27	2.33	16.27	4.00	27.90	3.66	25.58	86.04
15 Feb.	18.66	0.00	0.00	0.00	0.00	5.33	28.57	4.33	23.21	51.78
28 Feb.	26.33	3.00	11.39	2.00	7.59	3.33	12.65	7.33	27.84	59.49
15 Mar.	31.00	4.00	12.90	4.33	13.97	10.00	32.25	5.00	16.12	75.26
30 Mar.	40.33	6.66	16.52	6.66	16.52	13.66	33.88	10.66	26.44	93.38
Overall mean of emerged parasitoids		2.941±0.10 c	-	2.886±0.20 c	-	6.553±1.30 a	-	5.606±1.42 b	-	-
Overall mean of % parasitism		-	12.29±0.10 c	-	12.39±0.30 c	-	27.54±2.11 a	-	24.30±2.01 b	-

*Means followed by different letters are significantly different at 0.05 probability level.

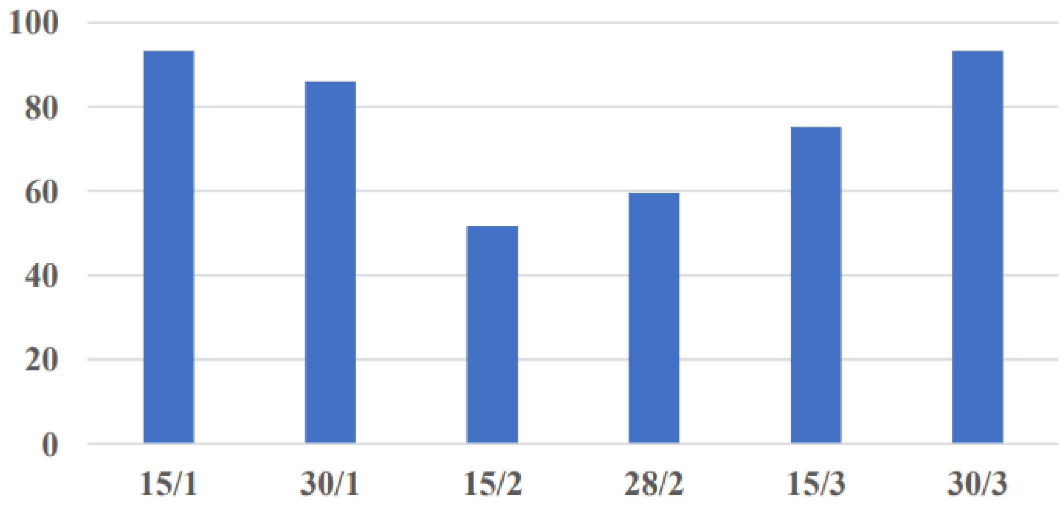

Fig. 1: Seasonal abundance of parasitism percentage, 2020/ 2021.

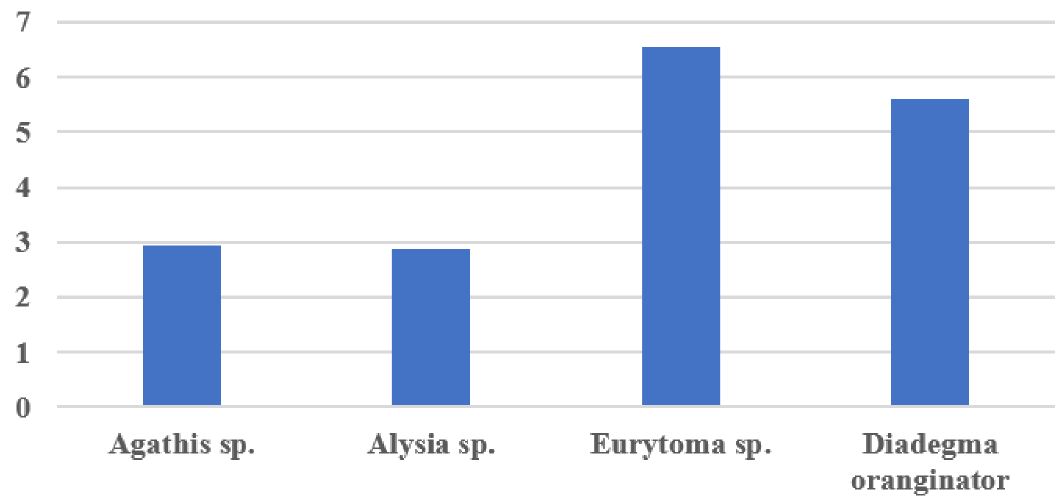

Fig. 2: Overall mean of emerged parasitoids for each species, 2020/ 2021.

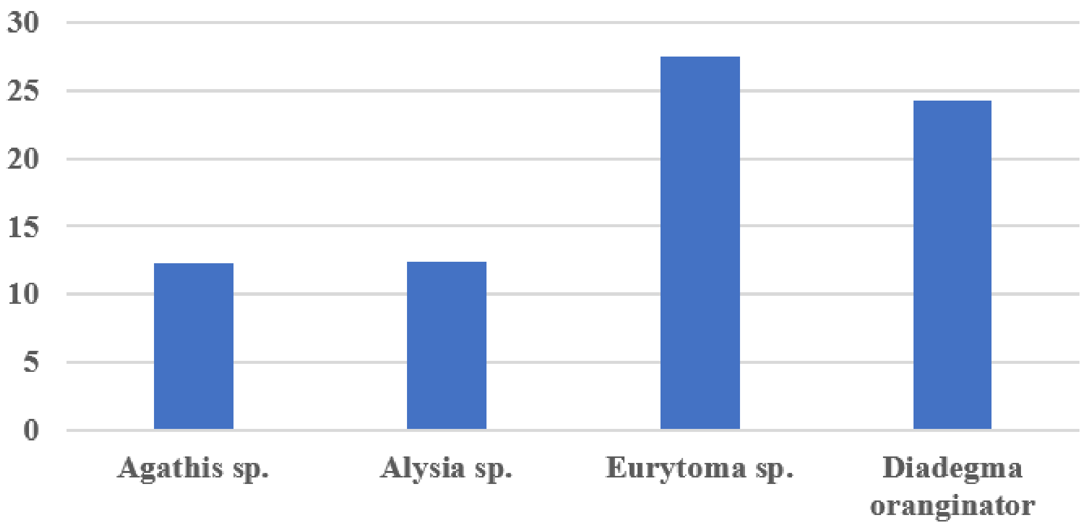

Fig 3: Overall parasitism % for each species, 2020/ 2021.

Table 2: seasonal abundance of parasitism percentage, 2021/ 2022.

Date	Mean of pupae	*Agathis* sp.		*Alysia* sp.		*Eurytoma* sp.		*Diadegma oranginator*		Parasitism regardless of species
		Mean emerged parasitoids	Parasitism %	Mean emerged parasitoids	Parasitism %	Mean emerged parasitoids	Parasitism %	Mean emerged parasitoids	Parasitism %	
16 Jan.	8.66	0.00	0.00	0.00	0.00	0.00	0.00	4.33	50.00	50.00
31 Jan.	17.33	2.66	15.38	2.00	11.53	3.33	19.23	2.66	15.38	61.53
13 Feb.	18.33	1.66	9.09	1.66	9.09	3.66	20.00	3.33	18.18	56.36
27 Feb.	27.66	4.00	14.45	4.33	15.66	4.66	16.86	3.00	10.84	57.83
13 Mar.	36.66	5.33	14.54	4.66	12.72	13.33	36.36	6.66	18.18	81.81
28 Mar.	44.33	5.66	12.78	4.33	9.77	17.33	39.09	10.33	23.30	84.96
Overall mean of emerged parasitoids		3.218±0.21 c	-	2.830±0.20 c	-	7.051±1.10 a	-	5.051±1.02 b	-	-
Overall mean of % parasitism		-	11.04±0.22 c	-	9.79±0.31 d	-	21.92±3.21 a	-	14.31±2.22 b	-

*Means followed by different letters are significantly different at 0.05 probability level.

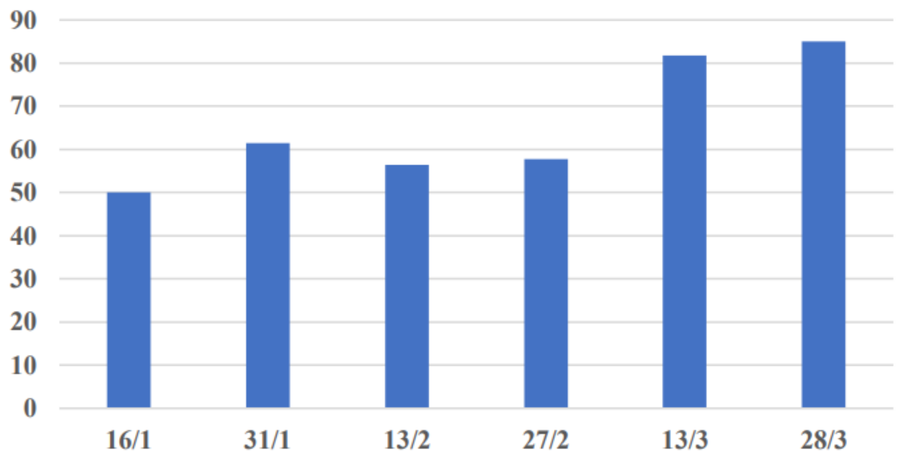

Fig. 4: Seasonal abundance of parasitism percentage, 2021/ 2022

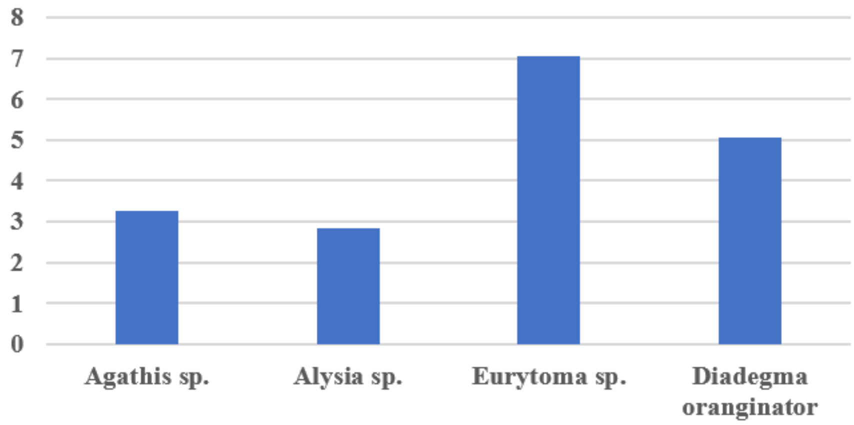

Fig. 5: Overall mean of emerged parasitoids for each species, 2021/ 2022.

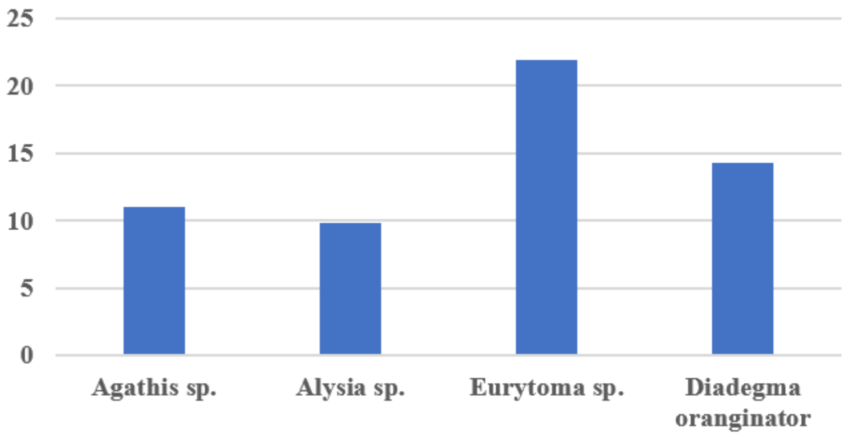

Fig 6: Overall parasitism % for each species, 2021/ 2022.

Comparing Biocides With Conventional Insecticides In Reducing *S. ocellatella* Larvae Numbers, and Their Side Effects On Associated Parasitoids:

Regarding the reduction in larvae populations of *S. ocellatella*, Table (3) and Fig. (7), indicated that the overall mean of reduction was 71.39, 76.84 and 85.14% for the three selected insecticides (Protecto®, Biovar® and Robek extra®), respectively in 2020/ 2021 season. While, the corresponding values were 71.93, 75.99 and 82.53% for the three previous insecticides throughout 2021/ 2022. Statistical analysis proved that significant differences between the three treatments.

Table 3: Reduction in *S. ocellatella* larvae populations by biocide and conventional compounds during 2020/ 2021 (A) and 2021/ 2022 (B) growing seasons.

Insecticides	Before spraying	After spraying								Overall of mean reductions
		1		3		7		10		
	M.	M.	Red.	M.	Red.	M.	Red.	M.	Red.	
A										
Protecto®	29.75	0.00	0.00	15.25	54.72	10.25	72.75	5.75	86.71	71.39 c
Biovar®	29.50	0.00	0.00	12.50	62.57	8.25	77.88	4.25	90.09	76.84 b
Robek extra®	30.00	10.00	67.98	0.00	0.00	3.25	91.43	1.75	95.98	85.14 a
Check	30.25	31.50	-	34.25	-	38.25	-	44.0	-	-
B										
Protecto®	29.25	0.00	0.00	15.00	57.26	10.75	73.41	6.50	85.14	71.93 c
Biovar®	29.25	0.00	0.00	13.00	62.96	9.75	75.89	4.75	89.14	75.99 b
Robek extra®	29.00	10.75	65.89	0.00	0.00	5.25	86.90	2.25	94.81	82.53 a
Check	28.75	31.25	-	34.50	-	39.75	-	43.00	-	-

*Means followed by different letters are significantly different at 0.05 probability level.

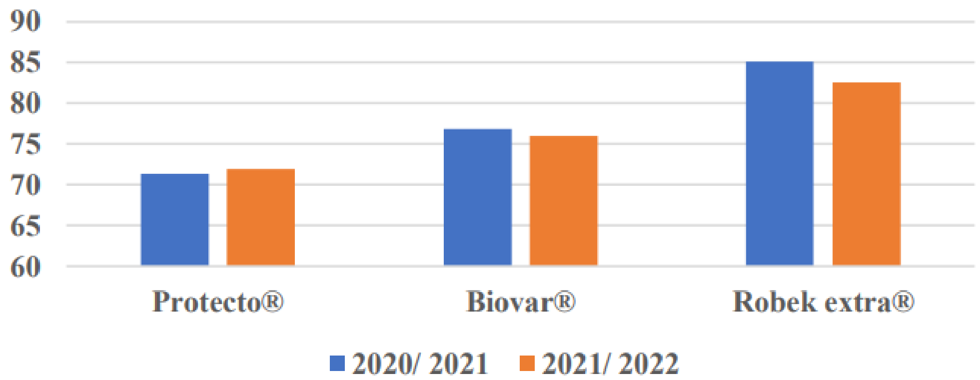

Fig. 7: Overall mean of reductions in *S. ocellatella* larvae populations by the three tested compounds during 2020/ 2021 and 2021/ 2022 growing seasons.

In connection with the reduction in parasitoids complex associated with *S. ocellatella*, Table (4) and Figure (8) clarify that the overall mean of reduction was 33.39, 30.29 and 97.72% for the three insecticides, respectively during 2020/ 2021 season. As, in the second season 2021/ 2022 the values were 43.22, 41.27 and 97.70% for the three insecticides, respectively.

Awad *et al*. (2014) reported that intensive use of conventional insecticides led to numerous important drastic problems; i.e. environmental pollution, destruction of parasitoids, and incidence of insect resistance to these insecticides. Biocides are promising insecticides with efficacy against different insects, at the same time, low- toxic to parasitoids compared to conventional ones. In such concern, Bhattarai *et al*. (2016) showed that biocides are not harmful to parasitoids.

This experiment proved that biocides (protecto® and Biovar®) are very efficacious in reducing the densities of *S. ocellatella* larvae populations in sugar beet fields. In addition, these biocides products did not decrease the densities of parasitoids, thereby maintaining biological control of *S. ocellatellain* in comparison with conventional ones.

Table 4: reduction in parasitoids complex numbers associated with *S. ocellatella* due to spraying some insecticides throughout 2020/ 2021 and 2021/ 2022 seasons.

Insecticides	Before spraying	After spraying								Overall of mean reductions
		1		3		7		10		
	M.	M.	Red.	M.	Red.	M.	Red.	M.	Red.	
2020/ 2021season										
Protecto®	8.00	0.00	0.00	6.25	33.59	6.50	34.22	7.00	32.38	33.39 b
Biovar®	7.75	0.00	0.00	6.50	28.70	6.75	29.49	6.75	32.69	30.29 c
Robek extra®	8.50	0.00	100	0.00	0.00	0.00	100	0.75	93.18	97.72 a
Check	8.50	8.75	-	10.00	-	10.50	-	11.00	-	-
2021/ 2022 season										
Protecto®	6.25	0.00	0.00	5.00	33.33	5.25	47.50	5.50	48.83	43.22 b
Biovar®	6.25	0.00	0.00	5.25	30.00	5.50	45.00	5.50	48.83	41.27 c
Robek extra®	6.50	0.00	100	0.00	0.00	0.25	97.59	0.50	95.52	97.70 a
Check	6.25	6.50	-	7.50	-	10.00	-	10.75	-	-

*Means followed by different letters are significantly different at 0.05 probability level.

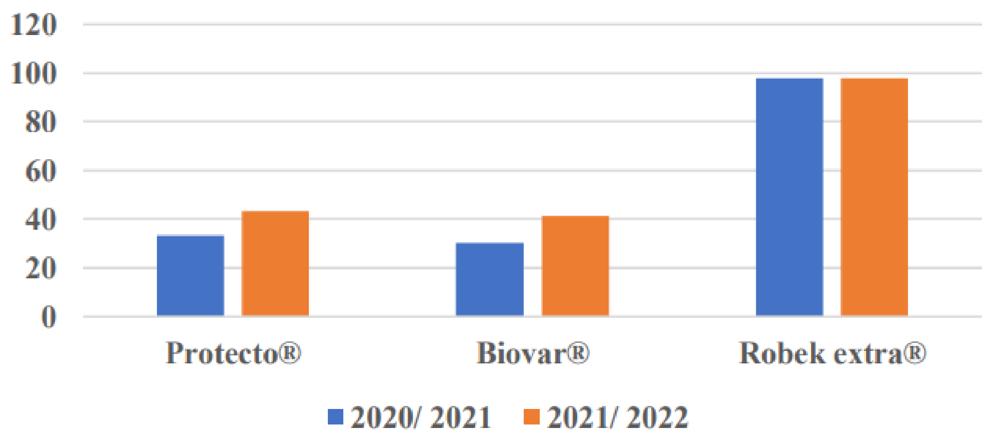

Fig. 8: Overall mean of reductions for the three tested insecticides in parasitoid complex numbers associated with *S. ocellatella* during the two seasons 2020/ 2021 and 2021/ 2022.

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