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Effect of the Utilization of The Bioinsecticide Spinosad on Certain Piercing Sucking Insect Pests Attacking Okra Plants and Effect on *Aphidius colemani* Viereck, in Sohag Governorate

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ABSTRACT

Okra, *Abelmoschus esculentus* L. (Malvaceae) is one of the most important vegetable and cash crop in Egypt. The present study was conducted to determine the effect of Spinosad on the population trends of *Aphis gossypii*, *Bemisia tabaci* and *Empoasca discipiens* infesting okra in relation to some weather factors during 2022 and 2023 seasons at Sohag Governorate. Data indicated that Spinosad treatment reduced the number of the three studied pests and affected on their fluctuation trends in both seasons. Spinosad reduced *A. gossypii*, *B. tabaci* and *E. discipiens* by 67.53%, 62.80% and 50.37%, respectively, in 2022 season, and 64.66%, 66.99% and 51.31%, respectively, in 2023 season. For the parasitism of *A. gossypii* by *Aphidius colemani*, it is clear that the parasitism percentage decreased from 12.35% and 8.87% in control to 9.56% and 7.01% in Spinosad with reduction percentage of 22.64% and 21.00% in the two seasons, respectively. In case of weather factors, results showed that the temperature and relative humidity varied in their effect depending on factor, insect and season. However, it is clear that parasitoid showed highly positive significant effect on *A. gossypii* activity in both treated and untreated okra in the two seasons.

INTRODUCTION

Okra, *Abelmoschus esculentus* L. (Malvaceae) is one of the most important vegetable and cash crop in Egypt. Okra is subjected to be attacked by many destructive piercings and sucking insect pests, amongst these pests, cotton aphid (*Aphis gossypii* Glover), whitefly (*Bemisia tabaci* Gennadius) and leafhopper (*Empoasca discipiens* (Paoli)) (Abou Hatab and Elgendy, 2013; Akbar and Khan, 2015 and El-Fakharany *et al.*, 2017). These insect pests were recorded as the most responsible for loss in yield and quality (Mohamed and El-Solimany, 2019). Chemical control measures have been used since long time to reduce these injurious pests and crop losses. But due to indiscriminate use of pesticides, the pest has developed resistance, besides the hazardous to human health and other non-target organisms like parasitoid (Abdel-Galil *et al.*, 2019). Bio-insecticides having good potential as insect control agent, in addition to their safety on human and environment. Spinosad (Tracer 24%) compound is being sought to replace the synthetic insecticides (Bacci *et al.*, 2016 and Bahy El-Din, 2020). Therefore, the present study was conducted to

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determine the effect of Spinosad on the population trend of *A.gossypii*, *B.tabaci* and *E.discipiens* infesting okra. Also,its effect on aphid parasitoid *Aphidiu scolemani* and some weather factors were included.

MATERIALS AND METHODS

1. Experimental Design:

The present study was occurred during 2022 and 2023 seasons at Experimental Shandweel Agricultural Research Station, (JMM3+F2F 1698224) Sohag Governorate, Egypt. Okra seeds were sown on April 9^{th} in both seasons with Balady green cultivar. Each experimental unit was 1/400 Fadden (10.5 m^2) including 5 rows, each row 50 plants each of 3.5 m length and 70 cm width. Sowing was done by sowing three seeds per hill at 35 cm intervals, and then growing plants were thinned into one plant/ hill. Conventional agricultural practices were performed and chemical insecticidal treatments were completely prevented. Randomized complete block design with three replicates was adopt. Three separated areas were used to the three pests.

2. Spinosad Treatment:

The natural components Spinosad (Tracer 24%SC) was chosen to be utilized against the three previous pests. The date of spraying Spinosad was the 3^{rd}, 1^{st}, and 2^{nd}weeks of May in case of aphid, whitefly and leafhopper, respectively, this depending on the sufficient number of each pest to estimate the effect of bio-insecticide compound. The spraying was made by using the recommended concentration of the Ministry of Agricultural. Use a single experiment with different dates of the same site at 3 replicates

3. Sampling Methods:

Sampling was started after emergence of plants and continued until harvesting time. Each sample consisted of 10 leaves which picked up randomly from top, middle and lower canopy of okra plants per plot at weekly intervals. The samples were kept into paper bags and transferred to laboratory for examination using a stereomicroscope, the numbers of aphid and whitefly nymphs were counted and recorded. Whitefly adults and leafhopper (adults and nymphs) numbers were estimated on 10 randomly chosen leaves in the field. Population trends and peaks of each pest were determined.

The number of aphid mummies was recorded and the parasitism percentage was calculated according to the following formula:

$$\textbf{Parasitism\%} = \textbf{100} \times \left(\frac{\textbf{Number of mummies}}{\textbf{Total number of aphid}}\right)$$

The reduction percentages on aphid, whitefly and leafhopper were calculated according to the following formula:

$$\textbf{Reduction\%} = \textbf{100} - \left(\textbf{100} \times \frac{\textbf{Total number in spinosad}}{\textbf{Total number in control}}\right)$$

The means of the temperature and the relative humidity were obtained from the Meteorological Station at A.R.C.

4. Effect of Biotic and Abiotic Factors on Certain Piercing Sucking Insect Pests Infesting Spinosad Treated and Untreated Okra Plants:

The effect of temperature (maximum, minimum) and relative humidity % (RH) were tested for population fluctuation of *A. gossypii*, *B. tabaci* and *E. discipiens*, and aphid parasitoid, *A. colemani*. Also, the relation between aphid and its parasitoid was studied. The data of weather parameter viz. temperature (max., &; min.) and relative humidity (mean) were obtained from http://www.wunderground.com.

5. Statistical Analysis:

Comparisons between the sprayed and unsprayed were performed by using the t-test.

The relation between the weather factors and the populations of insects and between aphid and its parasitoid on treated and untreated okra plants, through the two growing seasons of 2022 and 2023 was carried out using simple correlation according to Fisher (1950).

RESULTS AND DISCUSSION

1.- Population Density of Certain Piercing Sucking Insect Pests Infesting Spinosad Treated and Untreated Okra Plants:

1.1.- *Aphis gossypii*:

Data in Figures (1) and (2), showed that the population density of *A. gossypii* in Spinosad treated and untreated plots during 2022 and 2023 seasons, respectively. Aphid started to infest okra plants from the last week of April with few numbers in both treated and untreated plots then the numbers increased sharply to form two and three peaks of activity during the two seasons, respectively in case of control. The peaks were recorded in June 27th (909.0 aphids/ 10 leaves) and July 25th (311.0 aphids/ 10 leaves) during 2022, and in June 13th (841.3 aphids/ 10 leaves) June 27th (715.0 aphids/ 10 leaves) and July 25th (394.8 aphids/ 10 leaves) during 2023. On the other hand, the numbers decreased in Spinosad treatment comparing to control, one peak was formed after 6 weeks from spraying in June 27th by 341.8 and 313.8 aphids/ 10 leaves through 2022 and 2023 seasons, respectively. After that the numbers was decreased gradually to the end of the season.

In agreement with the present results, Eid *et al.* (2008) indicated that the percentage of infestation caused by *A. gossypii* on okra ranged from 10.11 to 59. 21% with an average of 31.34% in the first season, and ranged from 11.59 to 76.25% with an average of 34.18% in the second season. Mohamed and El-Solimany (2019) reported that the highest mean number of *A. gossypii* infesting okra was observed during June in both seasons. In partial agreement, Yaqoob *et al.* (2019) indicated that the population of *A. gossypii* started by few numbers of 3.30 aphids/3 leaves, and then the aphid count gradually increased and reached its peak of 47.28 aphids/3leaves, thereafter the population declined and was again minimum (5.19 aphids/3 leaves).

The present data are similar to those reported by Patil *et al.* (2016) that the treated plots by Spinosad recorded mean number of 6.96 aphids/ plant compared to 12.20 aphids/ plant in control.

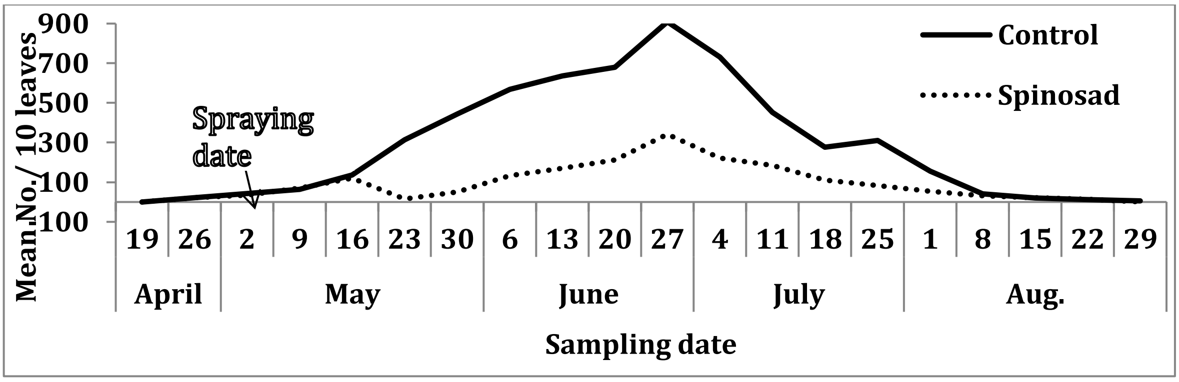

Fig. 1: Population density of *Aphis gossypii* on Spinosad treated and untreated okra plants during 2022 season at Sohag Governorate.

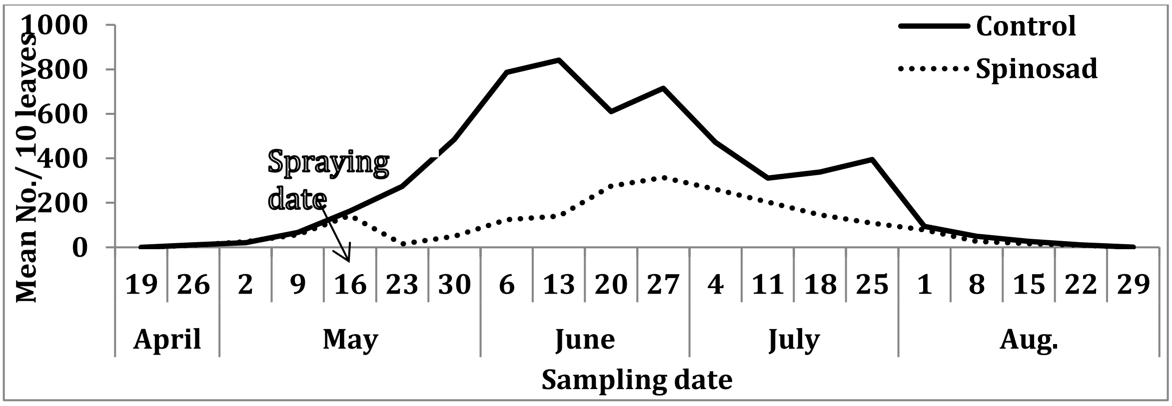

Fig. 2: Population density of *Aphis gossypii* on Spinosad treated and untreated okra plants during 2023 season at Sohag Governorate.

1.2.- *Bemisia tabaci*:

Dat in Figures (3) And (4), showed that the population density of *B. tabaci* in Spinosad treated and untreated plots during 2022 and 2023 seasons, respectively. Whitefly was detected in okra fields from the first week of inspection during the 3rd week of April with few numbers in both treated and untreated plots then the numbers increased gradually to form one and two peaks of activity during the two seasons, respectively in case of control. The peak was observed in May 30th (231.8 individuals/ 10 leaves) in the first season, and in June 6th (234.8 individuals/ 10 leaves) and June 4th (157.5 individuals / 10 leaves). Concerning Spinosad treatment, the numbers decreased after spraying comparing to control, whitefly needed 8 weeks to form its peak at June 27th by 88.0 and 79.8 individuals/ 10 leaves in 2022 and 2023 seasons, respectively. After that the numbers was decreased gradually and disappeared completely during the last three to four weeks of inspection in both Spinosad and control plots.

This finding is in agreement with the results of Abdel Hamed *et al.* (2011) who found that the maximum numbers of *B. tabaci* was recorded in June-July. Also, Sahito *et al*. (2012) showed that okra plants attacking by *B. tabaci* from germination and showed three peaks in its population. Mohamed and El-Solimany (2019) stated that the immature stage of whitefly recorded two and three peaks in 2017 and 2018 seasons, respectively. Manju *et al.* (2018) suggested that the use of Spinosad as foliar spray over conventional insecticides for formulating a successful management strategy for whitefly in okra.

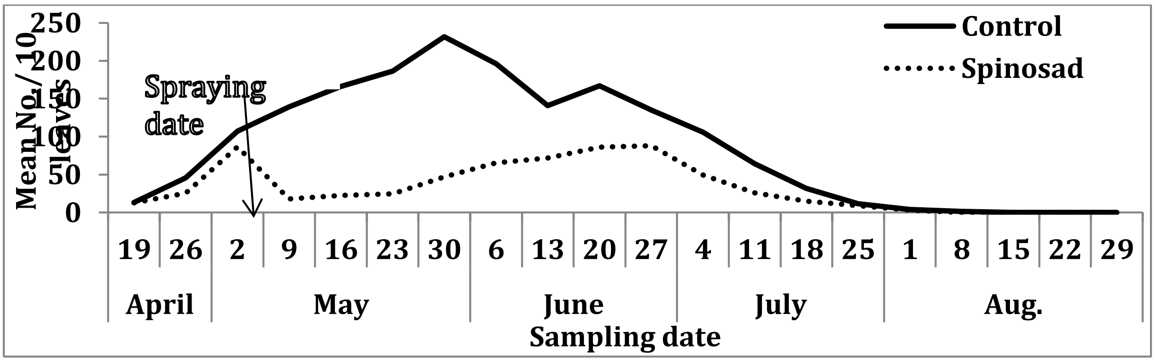

Fig. 3: Population density of *Bemisia tabaci* on Spinosad treated and untreated okra plants during 2022 season at Sohag Governorate.

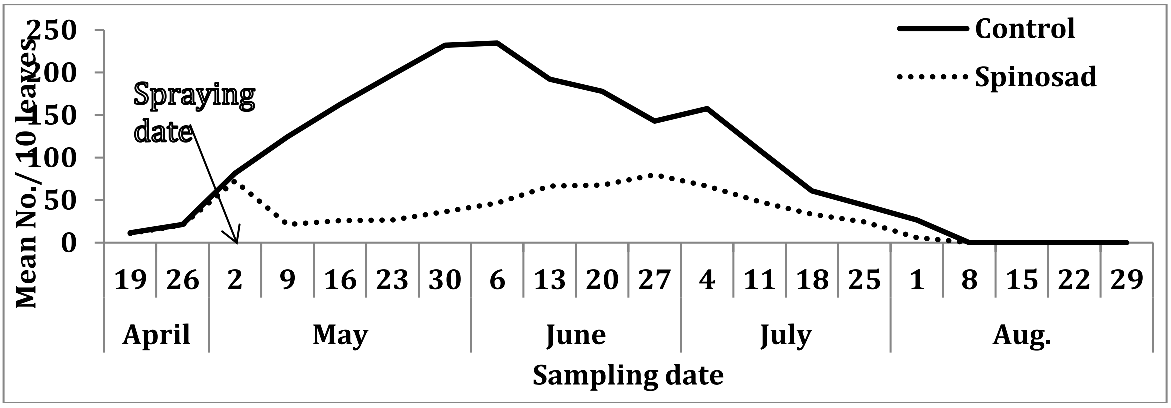

Fig.4: Population density of *Bemisia tabaci* on Spinosad treated and untreated okra plants during 2023 season at Sohag Governorate.

1.3.- *Empoasca discipiens*:

Data in Figures (5 & 6), showed that the population density of *E. decepiens* in Spinosad treated and untreated plots during 2022 and 2023 seasons, respectively. Leafhopper was started to occur in okra fields from the first week of inspection during the 3rd week of April with few numbers in both treated and untreated plots then the population increased gradually and maximized two and three times during the two seasons, respectively in case of control. The peak was observed in June 13th (29.3 individuals/ 10 leaves) in the first season, and in May 23rd (29.5 individuals. The numbers decreased after spraying with Spinosad treatment comparing to control, the leafhopper needed 9 weeks to form its peak at July 11th by 18.8 and 17.8 individuals/ 10 leaves in 2022 and 2023 seasons, respectively. After that the numbers were decreased gradually and disappeared completely during the last two to three weeks of inspection in control plots, and three to four weeks of inspection in Spinosad plots.

In agreement with these results, Benchasri (2013) indicated that the number of leafhoppers, *Amrasca biguttula* Ischida had increased in the same direction, with the most average occurrence of 52.44±3.99 and 54.44±4.51during June to October were observed in both 2009 and 2010, respectively. Srasvan*et al.* (2017) reported that the leafhopper started to occur in okra field after 2 weeks from sowing and observed up to3rdweek of November with a mean population of 13.92/ 3 leaves. Also, El-Mewafy, H.E. (2020) noticed that, the highest abundance of population of leafhopper concentrated during June to September in both seasons, and forming two peaks in the two seasons. Sarkar *et al.* (2016) indicated that okra plots applied by spinosad recorded lowest mean number of leafhoppers compared to control one. In the same line, Akramuzzaman *et al.* (2018) observed that Spinosad decreased the number of jassid (*Amrasca devastans*) in comparing to untreated control.

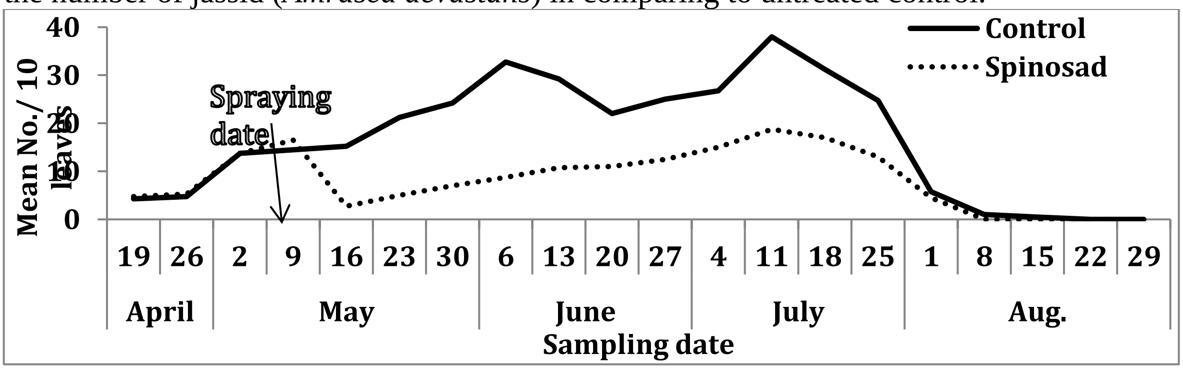

Fig. 5: Population density of *Empoasca discipiens* on Spinosad treated and untreated okra plants during 2022 season at Sohag Governorate.

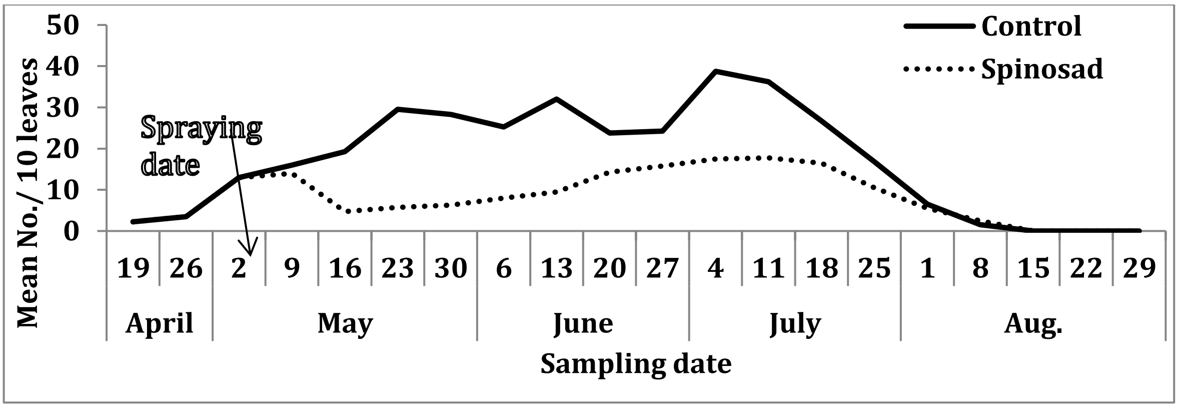

Fig. 6: Population density of *Empoasca discipiens* on Spinosad treated and untreated okra plants during 2023 season at Sohag Governorate.

2.- Parasitism Percentage of *Aphis gossypii* by *Aphidius colemani* on Spinosad Treated and Untreated Okra Plants:

Data in Figures (7 & 8), show that the parasitism percentage of *Aphidius colemani* on *A. gossypii* in Spinosad treated and untreated plots during 2022 and 2023 seasons, respectively. The parasitoid started its activity in last week of April and the first week May in 2022 and 2023 seasons, respectively. Parasitism percentage on aphid maximized 4 and 5 times in control plots in the two seasons, respectively. The peaks were recorded in May 9th (12.4%), June 6th (10.5%), July 18th (14.2%) and August 8th (52.6%) in the first season, and in May 2nd (10.4%), May 30th (8.4%), June 20th (8.4%), July 11th (11.7%) and August 15th (31.9%) in the second season. Also, 4 and 5 peaks were observed in Spinosad plots during the two seasons, respectively. The peaks were recorded in May 9th (9.0%), May 23rd (35.6%), June 13th (9.5%) and August 8th (23.1%) in the first season, and in May 2nd (12.7%), May 23rd (17.7%), June 13th (11.6%), July 11th (4.2%) and August 15th (14.6%) in the second season.

It is clear that the parasitism percentage increased in the end of the two seasons in both treated and untreated plots. Similarly, Eid *et al.* (2008) evaluated the percentage of parasitism on *A.gossypii* infesting okra plant at El-Arish, North Sinai Govemorate, and found that the percentages of parasitism ranged from 1 to 2% with an average of 0.25% in 2005 season, and varied from 1 to16% with an average2.25% in 2006 season.

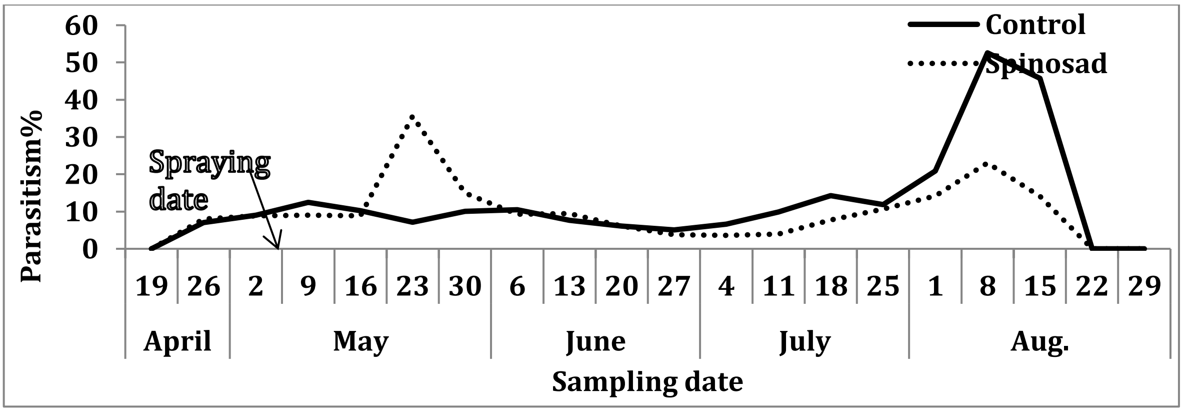

Fig. 7: Parasitism percentage of *Aphis gossypii* by *Aphidius colemani* on Spinosad treated and untreated okra plants during 2022 season at Sohag Governorate.

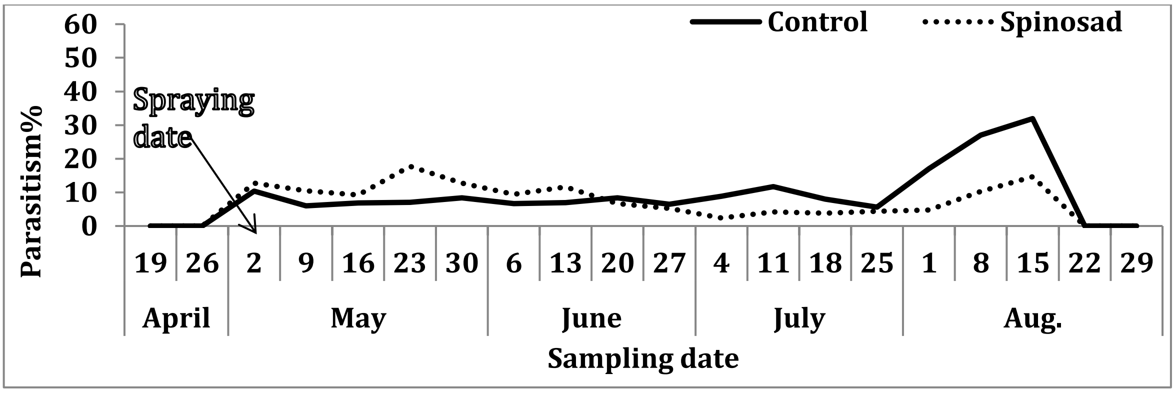

Fig. 8: Parasitism percentage of *Aphis gossypii* by *Aphidius colemani* on Spinosad treated and untreated okra plants during 2023 season at Sohag Governorate.

3.- The Effect of Spinosad on The Infestation of Okra by Certain Piercing Sucking Insect Pests and Aphid Parasitoid:

Data illustrated in Table (1), show the effect of Spinosad treatment on the infestation of okra plants by *A. gossypii*, *B. tabaci* and *E. decepiens* during the two successive seasons of 2022 and 2023. Spinosad decreased the infestation by the three pests in the two seasons, depending on the total number of each pest. The T values clear indicated that the differences between Spinosad treated and untreated plots were highly significant in both seasons of the study in case of all insect pests.

For *A. gossypii*, the total number decreased from 5819.50 and 5674.50 aphids/ plot in control to 1889.50 and 2005.50 aphids/ plot in Spinosad with reduction percentage of 67.53% and 64.66% in the two seasons, respectively. Also, the total number of *B. tabaci* decreased from 1746.50 and 1976.75 individuals/ plot in control to 649.75 and 652.50 individuals/ plot in Spinosad with reduction percentage of 62.80% and 66.99% in the two seasons, respectively. However, Spinosad decreased the total number of *E. decepiens* from 335.00 and 343.50 individuals/ plot in untreated plots to 166.25 and 167.25 individuals/ plot in treated plots with reduction percentage of 50.37% and 51.31% in the two seasons, respectively.

For the parasitism of *A. gossypii* by *Aphidius colemani*, it is clear that the parasitism percentage decreased from 12.35% and 8.87% in control to 9.56% and 7.01% in Spinosad with reduction percentage of 22.64% and 21.00% in the two seasons, respectively. The T values clear indicated that the differences between Spinosad treated and untreated plots were highly significant and significant in the two seasons, respectively.

The same results were obtained from Dhar and Bhattacharya (2015) found that single application of imidacloprid followed by two applications of Spinosad recorded the maximum reduction in infestation of whitefly in okra. Bahy El-Din, (2020) who reported that the use of Spinosad on control of *Brevicoryne brassicae* (L.) infesting cabbage reduced its parasitoid, *Diaeretiella rapae* (McIntosh) by 21.24%. Reddy and Kumar (2022) found that application with Spinosad recorded the most reduction of jassid population of okra with 80.64%. Narwade *et al.* (2023) suggested the use of bio-insecticide in combination with chemical insecticides to control sucking pest complex infesting okra.

Table 1: The effect of Spinosad on the infestation of okra by certain piercing sucking insect pests and aphid parasitod during 2018 and 2019 seasons at Sohag Governorate**.**

Season	Parameter	*Aphis gossypii*		Parasitism%		*Bemisia tabaci*		*Empoasca discipiens*	
		Control	Spinosad	Control	Spinosad	Control	Spinosad	Control	Spinosad
2022 season	Mean season	290.98	94.48	12.35	9.56	87.33	32.49	16.75	8.31
	Total season	5819.50	1889.50	----	--	1746.50	649.75	335.00	166.25
	Reduction%	67.53%		22.64%		62.80%		50.37%	
	T. value	43.32**		7.80**		42.76**		20.50**	
2023 season	Mean season	283.73	100.28	8.87	7.01	98.84	32.63	17.18	8.36
	Total season	5674.50	2005.50	-----	----	1976.75	652.50	343.50	167.25
	Reduction%	64.66%		21.00%		66.99%		51.31%	
	T. value	23.41**		3.39*		46.29**		27.23**	

(*): The difference between sprayed and unsprayed is significant at $P \leq 0.05$
(**): The difference between sprayed and unsprayed is highly significant at $P \leq 0.05$

4. Effect of Biotic and Abiotic Factors on Certain Piercing Sucking Insect Pests Infesting Spinosad Treated and Untreated Okra Plants:

Data in Tables (2 & 3), show the effect of maximum & minimum temperature and the mean relative humidity on population fluctuations of *A. gossypii*, *B. tabaci* and *E. discipiens* infesting treated and untreated okra and aphid parasitoid, *A. colemani* during 2022 and 2023 seasons, respectively. Also, the relation between aphid and its parasitoid was included. It is clear that parasitoid showed highly positive significant effect on *A. gossypii* activity in both treated and untreated okra in the two seasons. The "r" values were found to be 0.7792 and 0.7513 in treated and untreated okra, respectively, in the first season, and 0.9651 and 0.8171, respectively, in the second season. However, the mean temperature and relative humidity showed positively and negatively insignificant and weak effects, respectively, on *A. gossypii* activity in both treated and untreated okra in the two seasons. For *B. tabaci*, the four of tested factors showed almost negatively insignificant and weak effects in both seasons, expect the relative humidity in the first season, which showed highly negative significant effect (-0.6034). As previous, no significant effects were detected for all tested factors in case of *E. discipiens* in regard to treats and seasons. According to the "r" values in Tables (2) and (3), minimum and mean temperature showed positively significant effects on aphid parasitoid, *A. colemani* in control during 2023 season only with "r" values of 0.5310 and 0.5053, respectively. No significant effects were found for the rest factors.

The present results are in partial agreement with those of Abdel Hamed *et al.* (2011), Sahito *et al.* (2012), Srasvan *et al.* (2017) Yaqoob *et al.* (2019) who found that the temperature and relative humidity varied in their effect depending on factor, insect and season.

Table 2. Effect of certain biotic and abiotic factors main piercing sucking insect pests infesting okra during 2022 season.

Insect	Treats	Factors (r value)				
		Max. Temp.	Min. Temp.	Mean Temp.	Mean R.H%	Parasitoid
Aphis gossypii	Control	0.3167	0.2324	0.2834	-0.2729	0.7792**
	Spinosad	0.2769	0.1665	0.2263	-0.1706	0.7513**
Bemisia tabaci	Control	-0.1133	-0.1873	-0.1626	-0.6034**	------
	Spinosad	0.1250	-0.1793	-0.0476	-0.4992	------
Empoasca discipiens	Control	0.1931	0.1420	0.1732	-0.3408	------
	Spinosad	-0.0105	-0.0927	-0.0592	-0.1618	------
Aphidius colemani	Control	0.3360	0.3639	0.3701	-0.3793	------
	Spinosad	0.3360	0.3639	0.3701	-0.3793	------

r= Simple correlation. * Significant difference. ** Highly significant difference.

Table 3. Effect of certain biotic and abiotic factors main piercing sucking insect pests infesting okra during 2023 season.

Insect	Treats	Factors (r value)				
		Max. Temp.	Min. Temp.	Mean Temp.	Mean R.H%	Parasitoid
Aphisgossypii	**Control**	0.4228	0.4676	0.4504	-0.2975	0.9651**
	Spinosad	0.2699	0.3111	0.2939	0.0843	0.8171**
Bemisia tabaci	**Control**	0.0054	0.0498	0.0285	-0.3913	------
	Spinosad	-0.0774	-0.0252	-0.0510	-0.1784	------
Empoasca discipiens	**Control**	0.1691	0.2033	0.1887	-0.2244	------
	Spinosad	0.0642	0.0697	0.0680	-0.0684	------
Aphidius colemani	**Control**	0.4680	0.5310*	0.5053*	-0.2376	------
	Spinosad	0.2223	0.2637	0.2458	-0.0980	

r= Simple correlation. * Significant difference. ** Highly significant difference.

Declarations

Ethical Approval: Ethical Approval is not applicable.

Competing Interests: The authors declare no conflict of interest.

Authors Contributions: I hereby verify that all authors mentioned contributed to the study plan, sample collection and preparation of field experiment and carrying out it interpretation of results and writing reviewing and editing the manuscript.

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Availability of Data and Materials: All datasets analysed and described during the present study are available from the corresponding author upon reasonable request.

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