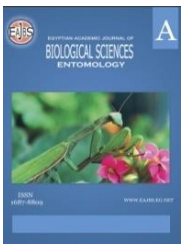
Citation: *Egypt. Acad. J. Biolog. Sci. (A. Entomology) Vol. 16(3) pp.45-53 (2023)*
DOI: 10.21608/EAJBSA.2023.314692

Egypt. Acad. J. Biolog. Sci., 16(3):45-53 (2023)

Egyptian Academic Journal of Biological Sciences
A. Entomology

ISSN 1687- 8809
http://eajbsa.journals.ekb.eg/



Survey of Corn Insect Pests and Evaluation of Some Ecological Factors on The Population Density of *Spodoptera frugiperda* (J. E. Smith) (Lep.: Noctuidae) in Egypt

El-Hadary, W. A.,[1] Halima M. Ibrahim [1] and Esmat S. A. Zaghlol [2]

[1]Biological Control Dept., Agricultural Research Center, Plant Protection Research Institute, Egypt.
[2]Field Crop Pests Research Dept., Agricultural Research Center, Plant Protection Research Institute, Egypt.

*E-mail: **hadary76@yahoo.com**

ARTICLE INFO

Article History
Received:15/7/2023
Accepted:20/8 /2023
Available:25/8/2023

Keywords:
Spodoptera frugiperda, population density, climatic factors, *Bacillus thuringiensis*, Egypt

ABSTRACT

Survey insect pests associated with maize plants at Beni-Suef and Al Qalubia Governorates during the growing season of 2022. Results revealed the occurrence of twelve insect pest species belonging to four orders and seven families. The fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) is a new invasive destructive insect pest. It was first recorded at Beni-Suef and Al Qalubia Governorates in this study on maize fields in 2022. The population density of *S. frugiperda* fluctuated with four distinct peaks (the highest peak was in December) in the two Governorates. The combined effect of max., min. temperatures and relative humidity were highly significant for this pest in the two Governorates. Using bio-pesticide (*Bacillus thuringiensis*) resulting in decreasing the infestation of *S. frugiperda* by 64.8 % and 75.3% in the field in the two Governorates, respectively. This information and prediction could be helpful to proper integrated control management.

INTRODUCTION

After rice and wheat, corn (Zea mays L.) is the third-most significant cereal crop in Egypt and the rest of the globe. Because it is consumed by people and animals as well as a source of industrial raw materials for goods like oil, flour, and alcohol, maize forms the basis of the world's food security. Egypt's total maize cultivated area reached 871,076 hectares in 2020, with a total production of about 8154,48 tons of grains (El-Rasoul *et al*., 2020).

Many insect pests attack corn plants at different growth stages in Egypt like Lepidoptera e.g *Sesamia cretica*, *Spodoptera exigua*, *S. littoralis*, *Agrotis ipsilon*, aphids e.g *Rhopalosiphum maidis*, *R. padi* and the green bug, *Nezara viridula* (Youssef, 2018). Some weather factors had a significant effect on the main insect pests of maize (Youssef, 2018).

One of the corn pests is the fall armyworm, *Spodoptera frugiperda* (J.E Smith) (Lepidoptera: Noctuidae) which is considered a polyphagous pest that attacks a variety of cultivated crops, causing serious damage (Montezano, *et al*.,2018). It was recorded feeding up to 186 plant species belonging to 42 families (Casmuz Augusto *et. al*., 2010 and Dahi *et. al*., 2020). It is causing a risk to food and nutrition security (Huesing *et al*. 2018). The

dangerous stage is the larvae, with caterpillars feeding on the vegetative and reproductive parts of the host plants, causing high grain production loss. (Sarmento *et al*. 2002). The lepidopterous pests have resistance against many insecticides. Bio-pesticides are an alternative strategy for the program of integrated pest management (IPM) (Abd El-Samei *et al.* 2019). Bacterial insecticides are safer insecticides, easily degradable, eco-friendly and target specific compared to chemical insecticides (Chattopadhyay *et al*., 2017).

S. frugiperda was first discovered in Africa by Goergen et al. in 2016 in Nigeria, and it quickly spread to more than 28 countries in eastern and southern Africa (Day et al., 2017; Cock et al., 2017 and FAO, 2018). It reduced corn yields by 70% and other crops' yields to a lesser extent (Baudron, 2019 and FAO, 2019).

In Egypt, the Agricultural Pesticide Committee (APC) of the Ministry of Agriculture reported the first case of *S. frugiperda* in May 2019 on a maize field in a village in Kom Ombo City of Aswan Governorate, Upper Egypt (Dahi *et al*., 2020), then spread to Luxor, Qena, Sohag and Assuit Governorates in 2021. The capacity of fall armyworms to spread to new places where they have no natural adversaries poses a serious threat to food security (Mohamed *et al*., 2022).

Recently, despite the harmful environmental impact, as well as human and animal health consequences, insecticides are the preferred method for controlling this pest. However, due to the location of larvae on the host plant when feeding, success is limited. More ecologically and effective acceptable methods of control are required (Luciane *et al*., 2006).

The aim of the present study is to survey corn insect pests and evaluate the combined effect of max., min. temperatures and relative humidity on fall armyworm, *S. frugiperda* and to study the efficiency of *Bacillus thuringeinsis* var. kurstaki on larvae of *S. frugiperda* in the field. These Data are important for planning IPM strategies. Also, This study documents the initial detection and early occurrence of S. frugiperda infestation on maize crops in the Egyptian governorates of Beni-Suef and Qalubia.

MATERIALS AND METHODS

Survey of Insect Pests Associated with Corn Plants in The Two Governorates:

Field observations were carried out in Beni-Suef and Qalubia Governorates during the summer growing season of 2022 from 24th July to 9th October.

A Survey of different corn insect pests was carried out at two days intervals starting after a week of the planting date until the harvest in the two Governorates. Two sampling techniques were used, sweeping net and plant inspection standing in the field Specimens of insect pests observed in the field were collected and identified by specialists in the different departments of Plant Protection Institute, Egypt.

Effect of Some Weather Factors on The Population Density of *S. frugiperda*:

- **Identification of *S. frugiperda*:**

70% alcohol was used to preserve the larval samples that were taken from affected maize plants. For better identification, samples of larvae were raised on fresh maize leaves in plastic containers (20 x 13 x 8 cm), covered with muslin, and kept in rearing conditions (27 1 °C; > 60% RH and 12L: 12D) until adult emergence.

The Seasonal Population of Fall Armyworm, *S. frugiperda*:

The seasonal activity of *S. frugiperda* over a year extending from the beginning of March 2022 to the middle of February 2023 was detected at Beni-suef and Qalubia Governorates. Four pheromone traps were hung and fixed on steel bars approximately 1.5-2 m above the ground inside the corn fields at the four directions 10 km far from each other in each Governorate. The baited sex pheromones were replaced with new ones every

month. The number of moths in pheromone traps were counted biweekly and the average amount of moths per trap was calculated and recorded at each corresponding date.

- **Metrological Factors:**

The Meteorological Observatory of Agricultural Research Center, Dokki, Giza provided the weather data, which included the highest temperature (Max. T.), minimum temperature (Min. T.) (°C), and relative humidity (R.H.%) for both governorates on a bimonthly basis.

Using the SPSS Computer Program V.20, correlation and partial regression coefficient values between the seasonal population density of S. frugiperda (the dependent variable Y) and various meteorological conditions (the independent variable X) were obtained.

Analysis of variance (F- test and the percentage of explained variance) was estimated using the formula of the C- multipliers described by Fisher (1950). Percentage of explained variance E.V.% was calculated with the following equation:

$$E.V.\% = r^2 \times 100 \text{ (Where, r = correlation value)}$$

Efficiency of the Bio-Pesticide, *Bacillus thuringiensis* on Infested Corn Plants with *S. frugiperda*:

- **Field Experiments:**

In each Governorate, an area of about 2 feddans was cultivated with yellow corn (*Zea mays* L.) (Shami, Triple Cross 324) and then divided into two plots. The 1st plot was treated with bio-pesticide and the other was sprayed with water only as a control. To avoid drafting, a 10m width along the field was used to separate the two plots in the two Governorates. Each plot was about 20×40 m^2.

The experiments were carried out during the summer growing season of 2022 from 24th Jul. to 9th Oct. to study the effectiveness of *Bacillus thuringiensis* against 1st, 2nd and 3rd larvae of *S. frugiperda* in the two regions, Beni-Suef (Middle Egypt) and Qalubia (Lower Egypt).

Corn plants were normally planted during the first week of July and regular conventional agricultural practices were normally performed (agricultural methods, irrigation, fertilization and weeds removal according to the recommendations of the Ministry of Agriculture of Egypt) and no pesticides were used during the study period.

- **Compound Used:**

Protecto®: *Bacillus thuringiensis* var. kurstaki, (32000 I.U. /mg) was applied in the two Governorates in the field at the rate of 400 gm/feddan as a wettable powder. The commercial bio-pesticide was obtained from the Unit of Bio-insecticide Production, Plant Protection Research Inst.; A. R. C.; Giza, Egypt.

Spraying was done three times at the end of the day; the first was at the age of 8 days after planting, the second was on the one day before the first irrigation at the age of 19 days and the third one was done immediately before the second irrigation that was at the age of 34 days from cultivation. The dorsal motor was used in the first spray to cover the plant surfaces completely. While in the second and third sprays, the dorsal sprayer was used with low pressure to direct sap into the whorl of the corn plants.

Regular samples were checked weekly consisting of 25 random plants using the zigzag method from the two plots (control & treated) in the two Governorates. These samples were examined in the field. The number of *S. frugiperda* larvae was counted and recorded in each sample at its investigation date. The mean numbers of larvae per 10 plants were calculated and recorded at each inspection date in the two Governorates.

The percentage of reduction is detected by using the Percentage Decrease Calculator online (https://www.calculatorsoup.com/calculators/algebra/percentage-decrease-calculator. php).

RESULTS

Survey Of Insect Pests Associated with Corn Plants in The Two Governorates:

Table (1) shows the survey of insect pests of yellow corn plants at Beni-Suef and Qalubia Governorates which resulted in twelve insect pest species belonging to four orders and seven families.

Table 1: Survey of insect pests infesting yellow corn plant (*Zea mays* L.) grown in Beni-Suef and Qalubia Governorates during the season of 2022.

Order	Family	Species	Common name	Beni-Suef	Qalubia
Hemiptera	Aphididea	*Rhopalosiphum maidis* (Fitch)	The corn leaf aphid	++	++
		Rhopalosiphum padi L.	The bird cherry-oat aphid	++	++
	Pentatomidae	*Nezara viridula* L.	The green bug	+	+
Lepidoptera	Noctuidae	*Agrotis ipsilon* (Hufnagel)	Black cutworm	+	+
		Sesamia cretica Led.	Corn stem borer	++	+
		Spodoptera exigua (Hubner)	Beet armyworm	+	+
		Spodoptera frugiperda (J.E. Smith)	The fall armyworm	+++	+++
		Spodoptera littoralis (Boisduval)	Cotton leafworm	+	+
	Pyraltidae	*Ostrinia nubilalis* Hubner	European corn porer	+	+
Orthoptera	Gryllotalpidae	*Gryllotalpa gryllotalpa* L.	Mole cricket	+	+
	Acrididae	*Anacridium aegyptium* L..	Egyptian locust	+	+
Thysanoptera	Thripidae	*Thrips tabaci* Lind	Onion thrips	+	++

+ = low number (1 to 3 individuals/10 plants); ++ = medium no. (3 to 9 individuals/10 plants); +++ = high no. (up to 9 individuals/10 plants).

The fall armyworm, *S. frugiperda* was recorded for the first time in the Beni-Suef (Middle Egypt) and Qalubia (lower Egypt) Governorates.

These results agree with Zaghlol (2013) who surveyed the same pests except *S. frugiperda* at Qalubia Governorate.

Youssef (2018) surveyed the insect species associated with corn plants. Recorded 73 species, some of which are pests like *S. cretica*, *S. exigua*, *S. littoralis*, *A. ipsilon*, *R. maidis*, *R. padi* and *N. viridula*.

Dahi *et al.* (2020) recorded *S. frugiperda* for the first time in Aswan Governorate, (Upper Egypt) in the maize fields. Hassan (2021) found *R. maidis* and *R. padi* on corn plants in Qalubia Governorate.

These results disagree with Ibrahim (2010) who found the leaf miner, *Pseudonapomyza spicata* Malloch (Diptera, Agromyzidae) on *Zea mays* L. in Beni-Suef Governorate. Also, Haikal (1969) found the same leaf miner in Qalubia Governorate.

Effects of Some Weather Factors on Population Density of *S. frugiperda*:

i. The Seasonal Population of *S. frugiperda*:

The biweekly monitoring of the *S. frugiperda* seasonal fluctuation in the pheromone traps showed the presence of four peaks in the two Governorates during the season of 2022/ 2023.

The peaks of Beni-Suef Governorate were on 3rd week of April (3.25 moths /trap), 1st week of July (4.5 moths /trap), 3rd week of September (4 moths /trap) and 3rd week of

December (22.5 moths /trap) (Fig. 1). While the peaks of Qalubia Governorate were on 3rd week of April (5 moths /trap), 1st week of July (5.75 moths /trap), 3rd week of September (6.25 moths /trap) and 1st week of December (29.75 moths/ trap) (Fig. 2). The highest peaks were recorded in December in the two Governorates.

These results were similar to Hong et al. (2022) who recorded four peaks of the *S. frugiperda* in Korea, while Bakry and Abdel-Baky (2023) recorded three peaks at Luxor Governorate, Egypt.

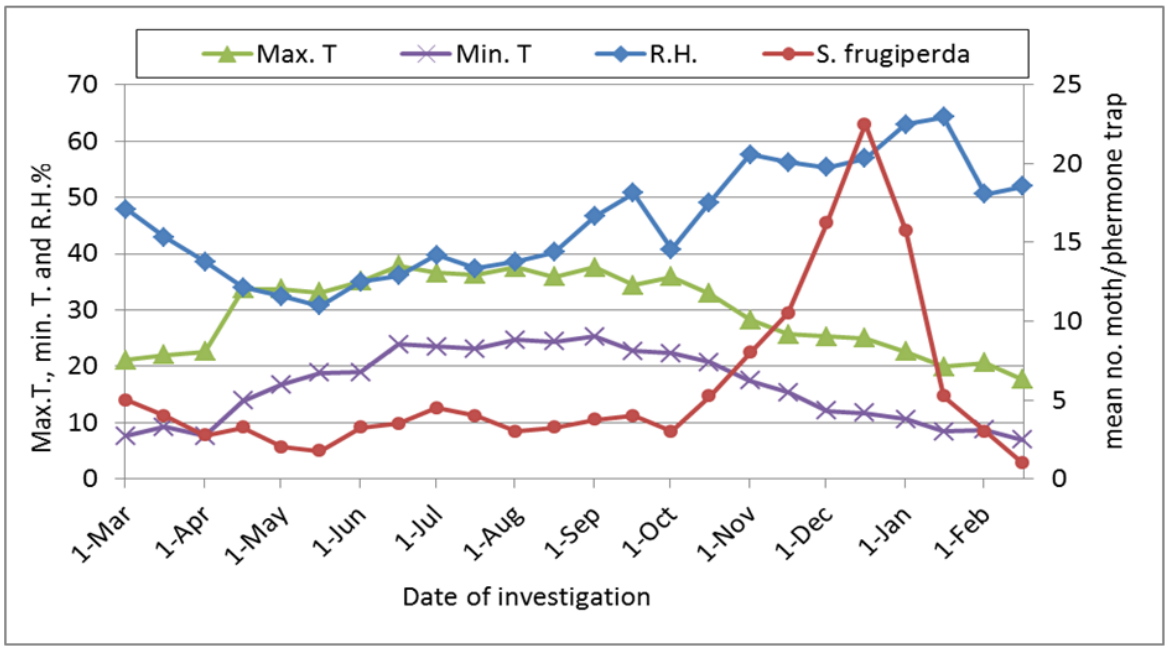


Fig. 1: Biweekly means of seasonal population fluctuation of *S. frugiperda* / pheromone trap and the corresponding means of Max. T., Min. T. and R.H.% during the season, 2022/ 2023 in Beni-Suef Governorate, Egypt**.**

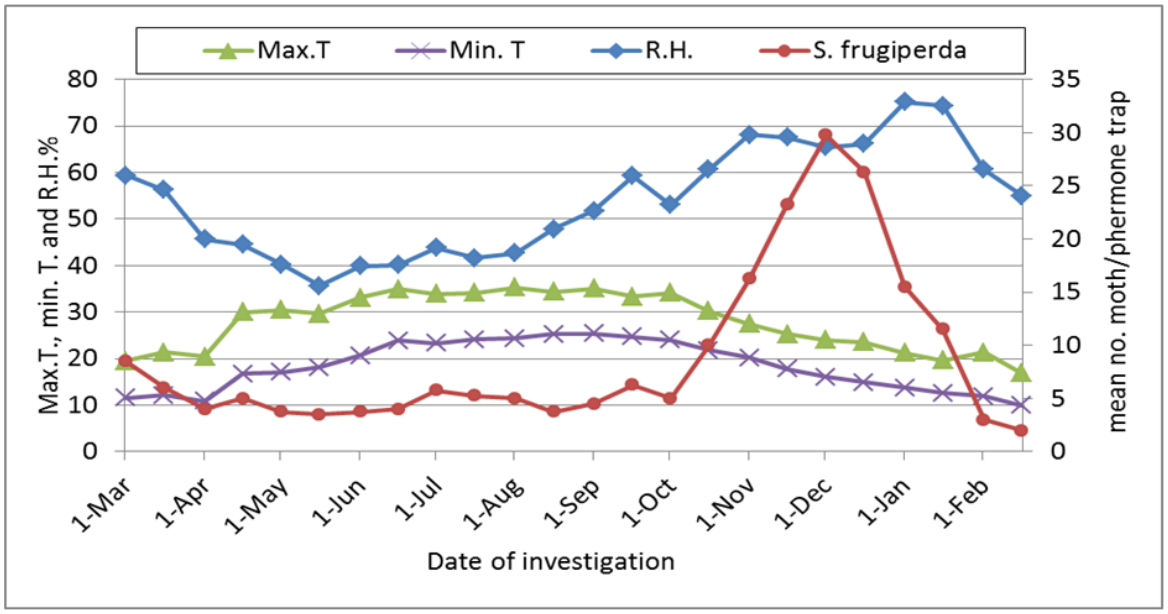


Fig.2: Biweekly means of seasonal population fluctuation of *S. frugiperda* / pheromone trap and the corresponding means of Max. T., Min. T. and R.H.% during the season, 2022/ 2023 in Qalubia Governorate, Egypt**.**

ii.Effect of Climatic Factors on The Population Density of *S. frugiperda*:

As regard *S. frugiperda* sensitivity to the three tested environmental weather factors, the results compiled in Table (2) revealed that the population density of *S. frugiperda* was highly significantly correlated with max., min. temperatures and relative humidity along the season (at P > 0.01) in the two Governorates.

While the F values for the two Governorates were 7.14 and 6.25, respectively, the percentages of the explained variance values were 51.7% and 48.4%. According to expectations, the remaining variation was caused by the effects of additional, unaccounted-for factors, such as the total amount of rainfall or wind speed, in addition to the experimental standard error, which affected the population density of S. frugiperda throughout the study season, 2022/2023, in the two Governorates.

These results were similar to Bakry and Abdel-Baky (2023) who found that the effect of max., min. temperatures and relative humidity were highly significant (at P > 0.01) on the population density of *S. frugiperda* in Luxor, Egypt

Table 2: Correlation and partial regression coefficient between, maximum, minimum temperatures, relative humidity and population density of *S. frugiperda* during 2022/2023 in Beni-Suef and Qalubia Governorates, Egypt.

Governorate	X factor	Analysis of partial regression				Analysis of variance	
		r	B	SE	t	F	E.V. %
Beni-Suef	Max. T.	0.72	1.29	±0.58	2.22	7.14*	51.7%
	Min. T.		-1.11	±0.53	-2.1		
	R.H.%		0.58	±0.14	4.11		
Qalubia	Max. T.	0.69	0.78	±1.21	0.64	6.25*	48.4%
	Min. T.		-0.63	±1.23	-0.51		
	R.H.%		0.58	±0.2	2.91		

*Highly significant (at probability level 0.01), correlation (r), coefficient value (B), standard error (SE), t-values (t), F- test (F) and percentage of explained variance E.V. %).

Efficiency of the Bio-Pesticide, *Bacillus thuringiensis* on Infested Corn Plants with *S. frugiperda*:

Applied the bio-pesticide to control the larvae of *S. frugiperda* in the corn field in the two Governorates during the planting season (from 24th Jul. to 9th Oct. 2022) succeeded in decreasing the population of this pest compared with the control plot. The percentage of infestation reductions in the population density of *S. frugiperda* larvae were 64.8% and 75.3 % in both Governorates, respectively (Figs. 3 & 4).

These results were similar to Aly and Ibrahim (2023) who found a high efficacy of two bacterial strains, *Lysinibacillus macroides* and *Brevundimonas olei* against *S. frugiperda* with more than 60% reduction percent in the field.

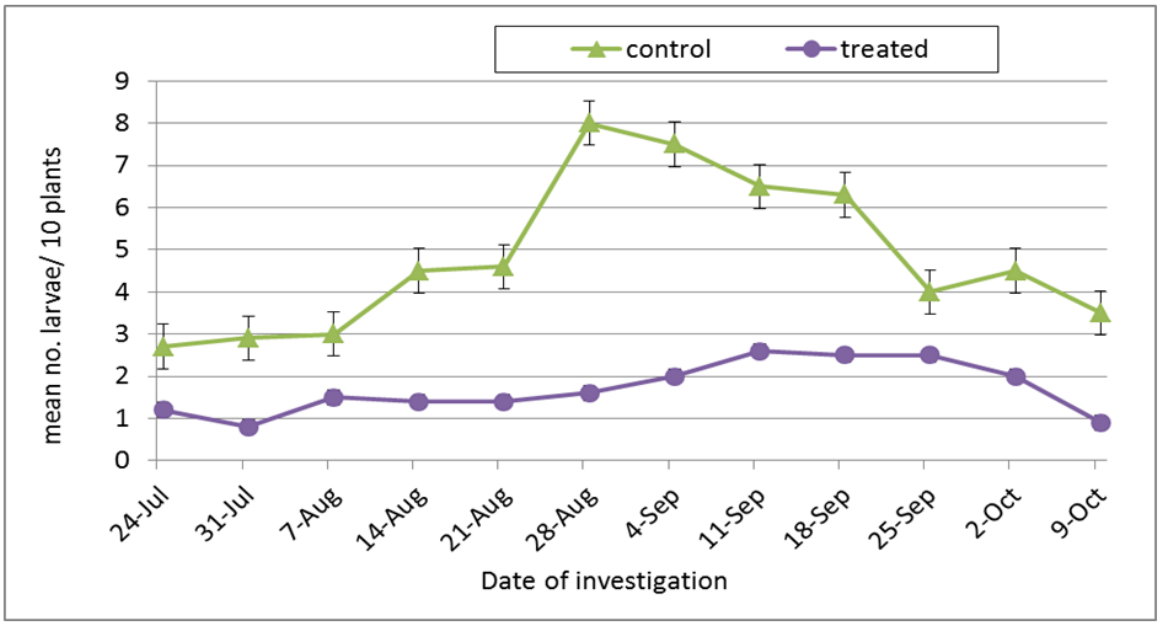


Fig. 3: Weekly means of population density of *S. frugiperda* larvae/ 10 plants of corn in the control and treated field with the bio-pesticide (*Bacillus thuringiensis*) during the planting season, 2022 (from 27th Jul. to 9th Oct.) in Beni-Suef Governorate, Egypt.

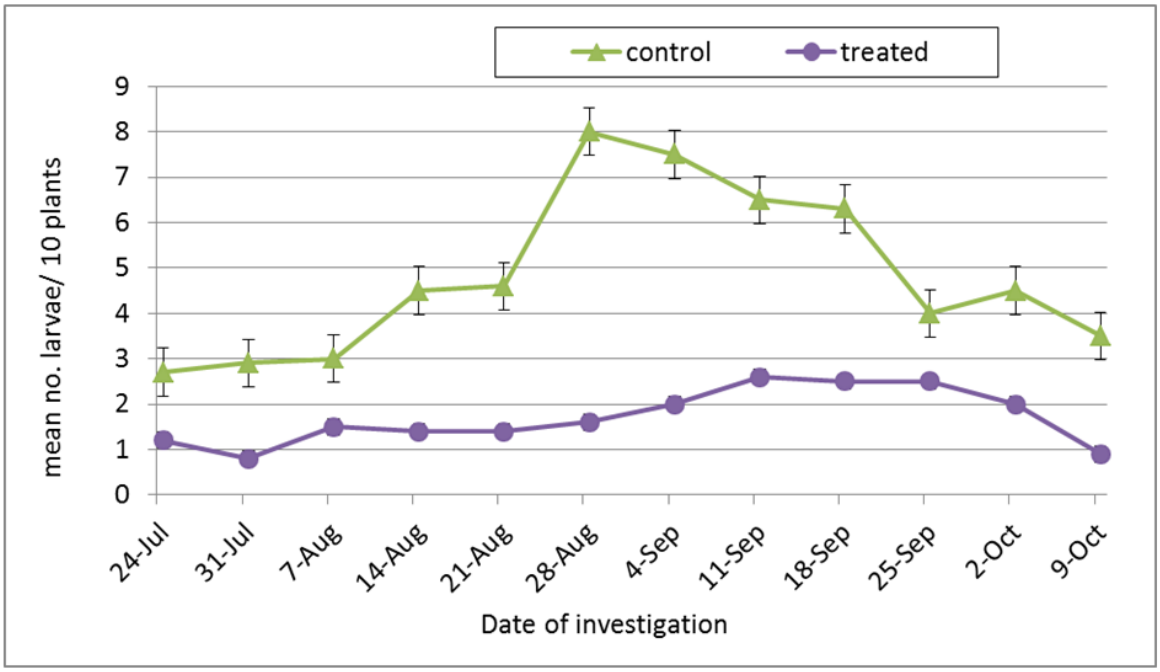


Fig. 4: Weekly means of population density of *S. frugiperda* larvae/ 10 plants of corn in the control and treated field with the bio-pesticide (*Bacillus thuringiensis*) during the planting season, 2022 (from 27th Jul. to 9th Oct.) in Beni-Suef Governorate, Egypt.

CONCLUSION

The fall armyworm, *S. frugiperda* was first recorded in Beni-Suef and Qalubia Governorates during the season of 2022/2033. It had four peaks annually and the weather factors had a highly significant effect on the population density of this pest in the two Governorates. Using B. *thuringiensis* as a bio-control succeeded in reducing the larval density of this pest to 64.8% and 75.3 % in the two Governorates respectively. These

results may be helpful in the IPM program to detect the best time for bio-control of *S. frugiperda* on corn plants. However, it needs more investigation in Egypt.

REFERENCES

Abd El-Samei, E.M.; Hamama, H.M.; El-Enien, M.G.A.A. and Awad, H.H. (2019). Interaction of spinosad and *Bacillus thuringiensis* on certain toxicological, biochemical and molecular aspects in the Egyptian cotton leaf worm, *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae). *African Entomology*, 27(2): 508-522.

Ali, E. A., and Ibrahim, G. A. (2023). Biological Control for some Insects by Using Plant Growth Promoting Bacteria in Laboratory and Field Conditions. *Journal of Plant Protection and Pathology*, 153-164.

Bakry, M. M. S., and Abdel-Baky, N. F. (2023). Population density of the fall armyworm, *Spodoptera frugiperda* (Smith)(Lepidoptera: Noctuidae) and its response to some ecological phenomena in maize crop. *Brazilian Journal of Biology*, 83, e271354.

Baudron, F., Zaman-Allah, M. A., Chaipa, I., Chari, N. and Chinwada, P. (2019). Understanding the factors influencing fall armyworm (*Spodoptera frugiperda* JE Smith) damage in African smallholder maize fields and quantifying its impact on yield. A case study in Eastern Zimbabwe. *Crop Protection*, 120, 141-150.

Casmuz Augusto, J. M. L.; Socias M. Guillermina; Murua M. Gabriela and Prieto Silvina, M. S. (2010): Revision de los hospederos del gusano cogollero del maiz, *Spodoptera frugiperda* (Lepidoptera: Noctuidae). Review Society of Entomology. *Argentina*, 69, 209-231.

Chattopadhyay, P., Banerjef, G. and Mukherjee, S. (2017): Recent trends of modern bacterial insecticides for pest control practice in integrated crop management system. 3 *Biotechnology*, 7(1): 60–71.

Cock, M. J. W., Beseh, P. K., Buddie, A. G., Cafá, G. and Crozier, J. (2017): Molecular methods to detect *Spodoptera frugiperda* in Ghana, and implications for monitoring the spread of invasive species in developing countries. *Scientific reports*, 7(1), 1-10.

Dahi, H. F., Sherehan A. S., Walaa E. G. and Hend O. M. (2020): Heat requirements for the fall armyworm *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) as a new invasive pest in Egypt. *Egyptian Academic J. of Biological Sciences. A, Entomology*, 13(4), 73-85. http://dx.doi.org/10.21608/eajbsa.2020.120603.

Day, R., Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., Colmenarez, Y., Corniani, N., Early, R. and Godwin, J. (2017): Fall armyworm: impacts and implications for Africa. *Outlooks on Pest Management*, 28, 196–201.

El-Rasoul, A.A.E.Y., Shehab, S.M.H. and Maghraby, H.E.S., (2020). Trends and decomposition growth analysis of the most important cereal crops in Egypt. Munich Personal RePEc Archive, no. 100231, pp. 1-10.

FAO (2018): Integrated management of the fall armyworm on maize a guide for farmer field schools in Africa. http://www.fao.org/faostat/en/

FAO (2019): Briefing note on FAO actions on fall armyworm. http://www. fao.org/3/BS183E/bs183e.pdf

Fisher, R. A. (1950): Statistical methods for research workers. Oliver and Boyed Ltd. Edinburgh, London, 12th ed. 518pp.

Goergen, G.; Kumar, P.L.; Sankung, S.B.; Togola, A. and Tamo, M. (2016): First report of outbreaks of the fall armyworm *Spodoptera frugiperda* (J E Smith) (Lepidoptera:

Noctuidae), a new alien invasive pest in west and Central Africa. *PloS ONE,* DOI: 10.137/ Journal.pone.0165632.

Haikal, A.A. (1969): Ecological and biological studies on the leaf-miner, *Pseudonapomyza spicata* Mall. (Diptera, Agromyzidae) attacking maize plants in A. R. E. M. Sc. Thesis, Fac. Agric., Ain-Shams Univ. Egypt.

Hassan, Mona, E. H. (2021). Studies on corn aphids species attacking corn plants in Qalubia Governorate. M.Sc. Thesis, Fac. Agric., Benha univ.

Hong, S. Y., Yi, H. J., Yoon, Y. N., Jang, Y. W., Park, K. D., and Maharjan, R. (2022). Evaluation of commercial pheromones on the population dynamics of *Spodoptera frugiperda* (JE Smith) and *Mythimna loreyi* (Duponchel) (Lepidoptera: Noctuidae). *Korean Journal of Crop Sciences,* 67, 285-295.

Huesing, J.E.; Prasanna, B.M.; McGrath, D.; Chinwada, P.; Jepson, P.; John, L. and Capinera, J.L. (2018): Integrated pest management of fall armyworm in Africa: An introduction. In Fall Armyworm in Africa: A Guide for Integrated Pest Management, 1st ed.; Prasanna, B.M., Huesing, J.E., Eddy, R., Peschke, V.M., Eds.; CIMMYT: Mexico City, Mexico.

Ibrahim, Halima, M. (2010). Studies on leaf miners species and their natural enemies common in agricultural areas in middle Egypt. M.Sc. Thesis, Fac. Agric., Beni-Suef univ.

Luciane G., Batista-Pereira, Kathrin Stein, André F. de Paula, Jardel A. Moreira, Ivan Cruz, Maria de Lourdes C. Figueiredo, José Perri Jr. and Arlene G. Corrêa 2006. Isolation, Identification, Synthesis, and Field Evaluation of the Sex Pheromone of the Brazilian Population of *Spodoptera frugiperda.* *Journal of Chemical Ecology*, 32, 1085–1099. https://link.springer.com/article/10.1007/s10886-006-9048-5

Mohamed, Hend O., El-Heneidy, A. H., Dahi, H. F., and Awad, A. A. (2022). First Record of the Fall Armyworm, *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) on Sorghum Plants, A new invasive pest in Upper Egypt. *Egyptian Academic Journal of Biological Sciences. A, Entomology,* 15(1), 15-23.

Montezano, D. G., Sosa-Gómez, D. R., Specht, A., Roque-Specht, V. F., Sousa-Silva, J. C., Paula-Moraes, S. D., Peterson, J. A. and Hunt, T. E. (2018). Host plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas. *African entomology,* 26(2), 286-300.

Sarmento, D.A.R.; Souza Aguiar, D.R.W.; Vieira, S.M.J.; Oliveira, D.H.G. and Holtz, A.M. (2002): Biology review, occurrence, and control of *Spodptera frugiperda* (Lepidoptera: Noctuidae) in corn in Brazil. *Bioscience Journal,* 18, 41–48.

Yossif, M. A. M. (2018). Ecological studies on certain insect pests infesting corn plants in sohag region. Ph. D. Thesis Fac. Of Agric. Sohag Univ. 165pp.

Zaghlol, Esmat, S. A. M. (2013). Evaluation of some methods to control insect pests attacking corn (*Zea mays* L.) crop. M.Sc. Thesis, Fac. Agric., Moshtohor, Benha univ.