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RESEARCH ARTICLE

Monitoring of fall armyworm infestation status and current attack on maize plants in southern Egypt

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Abstract

Spodoptera frugiperda is the scientific name for the fall armyworm (Family: Lepidoptera: Noctuidae) and its infestation of maize is becoming a major issue that may endanger Egypt's corn yields in the future. It is a severe crop pest that exists worldwide. In the Luxor Governorate in southern Egypt, we monitored the status of *S. frugiperda* infestation and current attack on maize plants. From the third week of June until the time of harvest, *S. frugiperda* larvae were observed on maize plants, indicating the beginning of the invasion and attack of the plants. This occurred at the age of 14 days following sowing. In 2022 and 2023, respectively, three peaks were noted in each season in terms of the number of larvae, number of plants infested with larvae, percentage of infestation, and percentage of attack intensity. These peaks occurred 29, 57 and 85 days after sowing. According to our analysis, throughout the season, there were more plants attacked than healthy ones. Therefore, the percentage of plants attacked by *S. frugiperda* increased as the timing of corn plant inspections increased during the two seasons. Farmers and decision-makers may find these results useful in creating efficient plans to manage this pest.

Keywords: Fall Armyworm; *Spodoptera frugiperda*; Plant age; Attack intensity; Infestation.

1. Introduction

Spodoptera frugiperda, commonly known as the fall armyworm (FAW), is one of the most dangerous pests of maize (Bakry and Abdel-Baky, 2023 a; Lestari *et al.*, 2024), which is also spreading quickly throughout Africa (Goergen *et al.*, 2016). *S. frugiperda* favors maize over a variety of other crops in Africa (Prasanna *et al.*, 2018). According to Caniço *et al.* (2020), Maruthadurai and Ramesh (2020) and Herlinda *et al*. (2023), it is a harmful, migratory, and mobile insect pest. Kumela *et al.* (2018) and Caniço *et al.* (2020) attribute *S. frugiperda's* rapid spread to its excellent dispersion ability and migratory capacity. Every season, *S. frugiperda* larvae produce several generations (Anandhi *et al.*, 2020; Bakry and Abdel-Baky, 2023 a). In one night, they can fly up to 100 kilometers (FAO, 2017). *S. frugiperda* is a voracious, invasive, alien, nocturnal, and damaging pest that can pose a threat to maize yield (Caniço *et al.*, 2020; Yigezu and Wakgari, 2020; Xiao-xu *et al.*, 2021). Because of its short life cycle and polyphagy, this pest is challenging to eradicate (Rios *et al.*, 2014; Montezano *et al.*, 2018; Bakry and Gad, 2023). All stages of maize plant growth and development are at risk from *S. frugiperda*, which can cause severe damage, a reduction in photosynthetic area, slowing down growth, dead and torn hearts, windowing of leaves, and impeded reproduction (Bakry *et al.*, 2023; Chimweta *et al.*, 2020). It can also cause a reduction in growth attributes, such as height,

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stem diameter, and number of green leaves per plant, as well as a decrease in grain, straw, and biological yield (Bakry and Abdel-Baky, 2023 b). FAW can cause direct and indirect damage to the corn plant. Direct damage can result in fungal diseases and aflatoxins associated with larval consumption, while indirect damage can result in grain quality losses (Bangale, 2019).

For maize growers, inadequate knowledge about managing the fall armyworm invasion looks to be a significant issue. Therefore, to develop effective control strategies for this pest, monitoring and early detection are required to ascertain the number of larvae infesting maize as well as the percentage of infestation, severity of attack, percentage of plants attacked, percentage of severity, and percentage prevalence of *S. frugiperda* larvae damaging maize plants.

2. Materials and methods

2.1. Experimental design

Two cropping seasons of field monitoring of *S. frugiperda* populations were carried out on maize plants in the Esna region, Luxor governorate, southern Egypt (32º31'58" E, 25º25'31" N). At the best time to cultivate, which is the first week of June every season. A single-Hybrid 168 Yellow maize cultivar was planted in a 4200 m^2 plot. Standard traditional agricultural techniques (fertilization and irrigation) were implemented in accordance with the Egyptian Ministry of Agriculture's instructions, except for insect control.

2.1.1. S. frugiperda population estimates and infestation

2.1.1.1. Sampling of pest infestation

The first detectable fall armyworm event at the study location was used to determine the sample date. Corn plants were attacked and infested with pests between 15 and 92 days after planting (DAP). Up to harvest, forty randomly chosen maize plants—ten from each replicate—were assessed and estimated every week. A total of 960 plants (10 plants × 4 replicates × 12 dates × 2 seasons) were employed in the sampling process. Plants in each season totaled 480.

After this, Fernández (2002), Caniço *et al.* (2020), Vinay *et al.* (2022) and Sholahuddin *et al.* (2023) reviewed all the samples of maize plants that were randomly selected in "the early morning hours between 6 and 9 a.m. to determine, based on larval feeding behavior, the abundance of *S. frugiperda* larval populations in different locations of the field. They estimated the number of larvae, the number of plants infested with larvae, the number of attacked plants and the number of healthy plants (not infested)."

2.1.2. Variables

A- The number of larvae-infested plants was calculated based on the number of plants where larvae of *S. frugiperda* were observed.

B- The number of healthy (non-infested) plants was calculated by subtracting the number of total plants examined (40 plants) from the number of plants in which *S. frugiperda* larvae were observed.

C- The number of attacked plants was calculated by the number of plants that showed visible signs of *S. frugiperda* infestation or attack, whether larvae were present or not.

D- Number of larvae: the average number of *S. frugiperda* larvae per 10 maize plants.

E- Infestation percentage was calculated by dividing the number of plants on which *S. frugiperda* larvae were observed by the total number of plants examined [infested and uninfested (40 plants)] on each sampling date and converting to percentages. (Note: Whenever *S. frugiperda* larvae were detected on plants, they were considered infested).

F- The percentage of attack intensity was calculated by dividing the number of plants on which *S. frugiperda* larvae were observed by the number of uninfested plants (healthy) and converting them to percentages.

G- The percentage of attacked plants was calculated by dividing the number of plants that exhibited obvious symptoms of infestation or attack by *S. frugiperda* by the total number of

plants examined [infested and uninfested) (40 plants)] on each sampling date and converting it to percentages. (Note that plants were considered attacked or infested whenever visual evidence of feeding by *S. frugiperda* larvae was detected, regardless of whether larvae were present or not.)
To assess the linear relationship between the dependent variables (y), which include percentages of infestation, attack intensity, and plants attacked by *S. frugiperda* estimated over two seasons (2022 and 2023), and the tested independent variables (x), which include plant growth, number of larvae-infested plants, number of larvae, and number of attacked plants.
The differences between the parameters under study as a result of insect infestation were displayed using the simple regression method. Fisher (1950) calculated this approach. Furthermore, to provide crucial information regarding the degree of variation among the variables under study, the coefficient of determination and the percentage of variance explained were computed. All of the data were analyzed using Microsoft Excel (2007), which was also used to construct the graphical representations and conduct the statistical analysis of the data.

3. Results

In two consecutive seasons (2022 and 2023), weekly estimates of the number of larvae, the number of plants infested with larvae, and the number of plants attacked by *S. frugiperda* infesting maize plants under field conditions (Single-Hybrid 168 Yellow cultivar) in Esna Province, Luxor Governorate, are shown in Tables (1 and 2) and Figure (1). The weekly records of the percentage of infection, the severity of the attack, and the plants that *S. frugiperda* attacks are also displayed. According to our findings, *S. frugiperda* larvae were seen on corn plants from the third week of June to the end of the corn crop. This means that the pest started to infest and damage the plants between 15 and 92 days after planting each season.

3.1. Population estimates of S. frugiperda

3.1.1. Number of larvae-infested plants

The average number of larvae-infested plants was 9.08 ± 1.38 and 9.83 ± 1.27 plants per 40 maize plants in the first and second growing seasons, respectively. There were three peaks in each season, occurring at 29, 57 and 85 days post-planting in 2022 and 2023, as shown in Tables (1 and 2).

3.1.2. Number of attacked plants

As the study duration of the corn plants in the two years increased, so did the number of plants attack by *S. frugiperda* (Tables 1 and 2). In each of the two years, the mean number of plants attacked by *S. frugiperda* was 23.00 ± 7.31 and 27.17 ± 7.53 plants per 40 plants. Over the course of the season, there were more attacked plants than affected plants. According to the study, maize plants were better suited to allow *S. frugiperda* larvae to dwell and produce more larvae during their vegetative stage. The findings demonstrate that during the two growing seasons, notable attacks on maize plants during the blooming and reproductive phases led to a progressive increase in the pest's assault count on plants.

3.1.3. S. frugiperda larval estimates

Seasonal larval activity had three maximum values, 29, 57, and 85 days after cultivation in the 2022 and 2023 seasons [see Tables (1 and 2)]. The estimated average population of *S. frugiperda* larvae was 26.25 ± 4.61 and 28.50 ± 5.04 larvae per 40 plants in 2022 and 2023, respectively (Tables 1 and 2).

3.1.4. Percentage of S. frugiperda infestation

The percentage of infestation with *S. frugiperda* varied with the increasing age of corn plants in the two seasons (Tables 1 and 2).

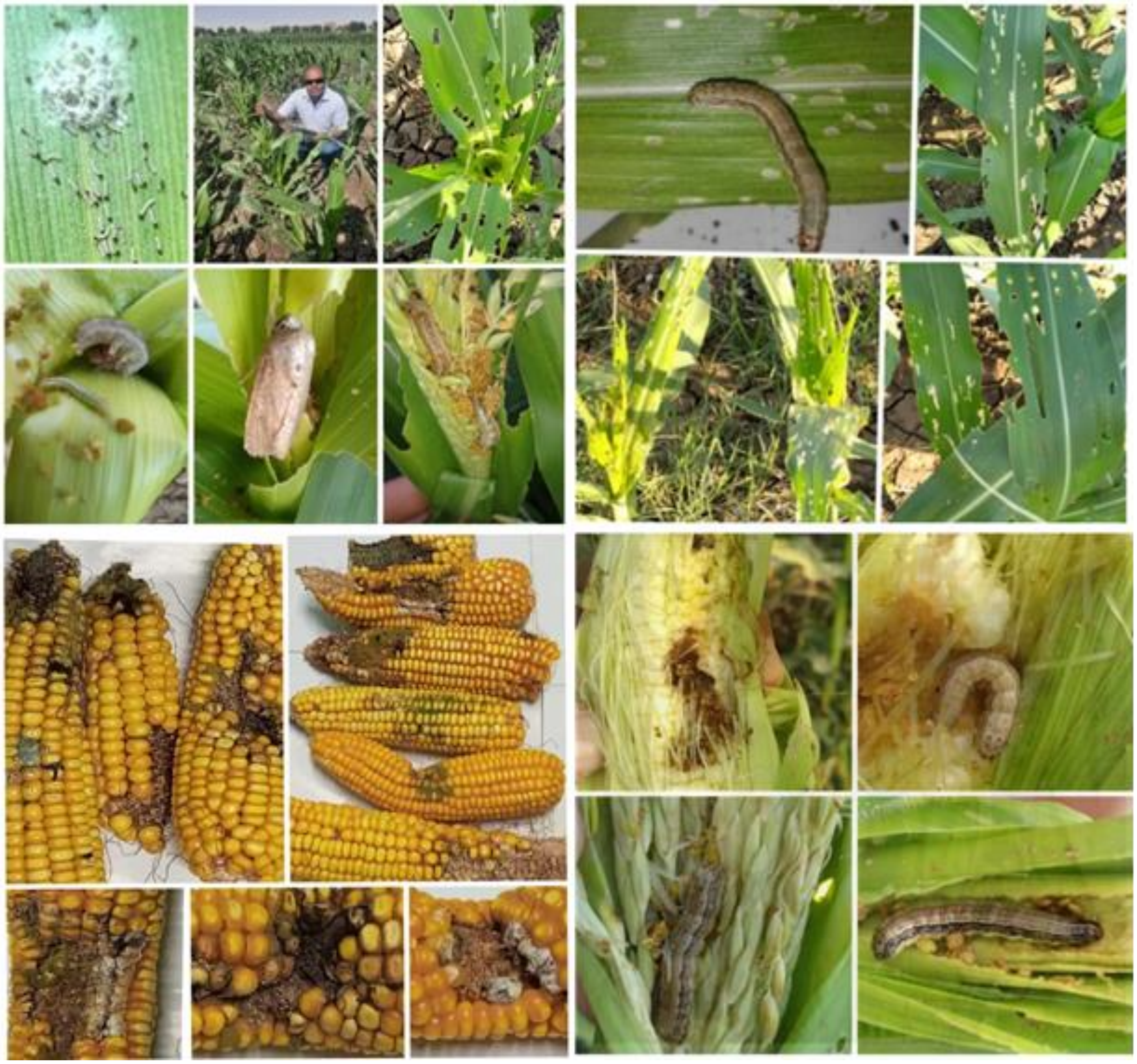

Figure 1. The devastating symptoms of infestation of maize plants by voracious *S. frugiperda* larvae and the direct and indirect attack to maize plants in the field (Single-Hybrid 168 Yellow cultivar). (Source: Moustafa M.S. Bakry).

Three peaks per season were observed at 29, 57, and 85 days after planting (DAP) in the two years. Additionally, the average infestation percentage of *S. frugiperda* was 22.71 ± 3.45 and 24.58 ± 3.17% in the two years, respectively.

3.1.5. Percentage of attack intensity of S. frugiperda

The mean percentage of attack intensity was 29.62 ± 5.76 and 32.82 ± 5.88% in the 2022 and 2023 seasons, respectively. There were three peaks per season that occurred at 29, 57, and 85 days of age after maize planting in both seasons, as shown in Tables (1 and 2).

3.1.6. Percentage of plants attacked by S. frugiperda

As the date of the maize survey progressed in both years, the proportion of plants attacked by *S. frugiperda* also increased (Tables 1 and 2). For each of the two seasons, the mean percentages of plants attacked by *S. frugiperda* were 57.50 ± 18.28 and 67.92 ± 18.82%, respectively. The peak time for an increase in the number of *S. frugiperda* larvae, the number of plants infested by larvae, the percentage of plants infested, and the intensity of attack caused by larvae was 85 days after sowing; the worst time for infestation and attack in the two seasons was 15 days after planting.

3.2. Evaluation of the linear relationship between the changes in the tested independent variables and the difference in the dependent parameters caused by the invasion of S. frugiperda

Table (3) displays the data demonstrating the linear relationship between the dependent variables (y), which are the percentages of infestation, attack intensity, and attacked plants by *S. frugiperda* estimated over two seasons (2022 and 2023), and the tested independent variables (x), which are plant growth (in days), number of larvae infested plants, number of larvae, and number of attacked plants.

The number of plants infested with larvae, the number of plants attacked, the larval population, the percentage of infestation, the percentage of attack intensity, and the percentage of attacked plants all exhibited a highly significant positive correlation with plant development (measured in days) (r values: 0.78, 0.99, 0.69, 0.78, 0.77, and 0.99 in 2022 and 0.62, 0.96, 0.72, 0.62, 0.60, and 0.96 in 2023, respectively). Meanwhile, the linear regression coefficient demonstrated that as maize plant age increased, the percentage of infected (0.11 and 0.08%), percentage of attack intensity (0.18 and 0.14%), percentage of attacked plants (0.71 and 0.72%), number of larvae-infested plants (0.04 and 0.03 plants), number of attacked plants (0.29 and 0.29 plants), larval population (0.13 and 0.14 larvae), and percent of infested plants (0.04 and 0.03 plants) would all rise in 2022 and2023, respectively (Table 3).

The number of plants infested with larvae and the dependent variables, such as the number of plants attacked, the larval population, the percentage of infestation, the percentage of attack intensity, and the percentage of attacked plants, all showed highly significant positive correlations. In the two seasons, these correlations were 0.78, 0.84, 0.99, 0.99, and 0.78 and 0.64, 0.88, 0.99, 0.99, and 0.64, respectively. Furthermore, based on a simple regression analysis, it was found that for every 40 plants, there would be an increase of 1.16 and 3.81 plants, 2.81 and 3.51 larvae in the larval population, 2.50 and 2.50% for the infestation percentage, 4.17 and 4.64% for the attack intensity, and 10.40 and 9.53% for the percentage of attacked plants in 2022 and 2023, respectively (Table 3).

As shown in Table (3) the simple correlation model revealed highly significant positive correlations between the larval population and the dependent variables, namely the number of plants attacked, the percentage of infestation, the intensity of the attack, and the percentage of attacked plants (r values: 0.71, 0.78, 0.78, and 0.99) in 2022 and (0.79, 0.64, 0.62, and 0.99) in 2023. Furthermore, the basic regression analysis demonstrated that in 2022 and 2023, respectively, an increase of one larva per 40 plants would result in a 0.45 and 0.53 increase in the number of attacked plants, a 0.37 and 0.27% increase in the infestation percentage, a 0.61 and 0.48% increase in the attack intensity percentage, and a 2.50 and 2.50% increase in the percentage of attacked plants (Table 3).

The number of attacked plants and the dependent variables, such as the percentage of infestation, the percentage of attack intensity, and the percentage of attacked plants, also exhibited highly significant positive correlations, according to simple correlation analysis (Table 3), with r-values of 0.84, 0.84, and 0.71 in 2022 season, and 0.88, 0.86, and 0.79 in 2023 season, respectively. In a similar vein, the linear regression shows that in 2022 and 2023, respectively, an increase of one attacked plant per 40 plants would result in higher percentages of infestation (0.63 and 0.56%), attack intensity (1.05 and 1.00%), and attacked plants (2.82 and 2.95%).

Table 1. Weekly estimates of larvae counts, the percentages of infestation incidence, attack intensity and attacked plants by *S. frugiperda* on maize plants, and the corresponding biotic variable, at Esna cite, Luxor Governorate in the first season (2022).

Sampling date		DAP* (in days)	No. of plants examined	No. of plants infested with larvae per 40 plants	No. of healthy plants per 40 plants	No. of attacked plants per 40 plants	No. of larvae per 40 plants	% Infestation incidence	% Attack intensity	% Attacked plants
June, 2022	3rd	15	40.00	7.00	33.00	11.00	16.00	17.50	21.21	27.50
	4th	22	40.00	8.00	32.00	13.00	23.00	20.00	25.00	32.50
July	1st	29	40.00	9.00	31.00	15.00	25.00	22.50	29.03	37.50
	2nd	36	40.00	7.00	33.00	19.00	23.00	17.50	21.21	47.50
	3rd	43	40.00	8.00	32.00	20.00	27.00	20.00	25.00	50.00
	4th	50	40.00	9.00	31.00	23.00	29.00	22.50	29.03	57.50
Aug.	1st	57	40.00	11.00	29.00	26.00	33.00	27.50	37.93	65.00
	2nd	64	40.00	10.00	30.00	27.00	27.00	25.00	33.33	67.50
	3rd	71	40.00	9.00	31.00	29.00	24.00	22.50	29.03	72.50
	4th	78	40.00	10.00	30.00	30.00	26.00	25.00	33.33	75.00
Sept.	1st	85	40.00	11.00	29.00	31.00	32.00	27.50	37.93	77.50
	2nd	92	40.00	10.00	30.00	32.00	30.00	25.00	33.33	80.00
Average ± STD			40.00 ± 0.00	9.08 ± 1.38	30.92 ± 1.38	23.00 ± 7.31	26.25 ± 4.61	22.71 ± 3.45	29.62 ± 5.76	57.50 ± 18.28

**DAP refers to days after planting, STD = Standard deviation*

Table 2. Weekly estimates of larvae counts, the percentages of infestation incidence, attack intensity and attacked plants by *S. frugiperda* on maize plants, and the corresponding biotic variable, at Esna cite, Luxor Governorate in the second season (2023).

Sampling date		DAP (in days)	No. of plants examined	No. of plants infested with larvae per 40 plants	No. of healthy plants per 40 plants	No. of attacked plants per 40 plants	No. of larvae per 40 plants	% Infestation incidence	% Attack intensity	% Attacked plants
June, 2023	3rd	15	40.00	8.00	32.00	13.00	18.00	20.00	25.00	32.50
	4th	22	40.00	9.00	31.00	16.00	24.00	22.50	29.03	40.00
July	1st	29	40.00	10.00	30.00	20.00	30.00	25.00	33.33	50.00
	2nd	36	40.00	9.00	31.00	24.00	23.00	22.50	29.03	60.00
	3rd	43	40.00	9.00	31.00	26.00	26.00	22.50	29.03	65.00
	4th	50	40.00	10.00	30.00	28.00	31.00	25.00	33.33	70.00
Aug.	1st	57	40.00	11.00	29.00	32.00	34.00	27.50	37.93	80.00
	2nd	64	40.00	10.00	30.00	31.00	32.00	25.00	33.33	77.50
	3rd	71	40.00	9.00	31.00	32.00	28.00	22.50	29.03	80.00
	4th	78	40.00	10.00	30.00	33.00	30.00	25.00	33.33	82.50
Sept.	1st	85	40.00	13.00	27.00	35.00	36.00	32.50	48.15	87.50
	2nd	92	40.00	10.00	30.00	36.00	30.00	25.00	33.33	90.00
Average ± STD			40.00 ± 0.00	9.83 ± 1.27	30.17 ± 1.27	27.17 ± 7.53	28.50 ± 5.04	24.58 ± 3.17	32.82 ± 5.88	67.92 ± 18.82

Table 3. Various models of correlation and regression analyses for describing the relationships between the plant age and studied parameters of infestation and attack by pest on maize plants in the two seasons (2022 and 2023).

Tested variables		2022 season					2023 season				
Independent (X)	Dependent (Y)	r	b	R^2	E.V.%	P.	r	b	R^2	E.V.%	P.
Days after cultivating (Develop plant)	No. of plants infested with larvae	0.78	0.04	0.60	60.39	0.00	0.62	0.03	0.38	38.04	0.00
	No. of attacked plants	0.99	0.29	0.97	97.28	0.00	0.96	0.29	0.92	92.36	0.00
	No. of larvae	0.69	0.13	0.47	47.02	0.00	0.72	0.14	0.51	51.25	0.00
	% Infestation	0.78	0.11	0.60	60.39	0.00	0.62	0.08	0.38	38.04	0.00
	% Attack intensity	0.77	0.18	0.60	59.69	0.00	0.60	0.14	0.36	36.29	0.00
	% Attacked plants	0.99	0.71	0.97	97.28	0.00	0.96	0.72	0.92	92.36	0.00
No. of plants infested with larvae	No. of attacked plants	0.78	4.16	0.62	61.54	0.00	0.64	3.81	0.41	41.15	0.00
	No. of larvae	0.84	2.81	0.70	70.44	0.00	0.88	3.51	0.78	77.99	0.00
	% Infestation	0.99	2.50	0.99	99.99	0.00	0.99	2.50	0.99	99.97	0.00
	% Attack intensity	0.99	4.17	0.99	99.84	0.00	0.99	4.64	0.99	99.65	0.00
	% Attacked plants	0.78	10.40	0.62	61.54	0.00	0.64	9.53	0.41	41.15	0.00
No. of larvae	No. of attacked plants	0.71	0.45	0.51	50.60	0.00	0.79	0.53	0.62	62.21	0.00
	% Infestation	0.78	0.37	0.62	61.54	0.00	0.64	0.27	0.41	41.15	0.00
	% Attack intensity	0.78	0.61	0.61	60.94	0.00	0.62	0.48	0.38	38.44	0.00
	%Attacked plants	0.99	2.50	0.99	99.98	0.00	0.99	2.50	0.99	99.98	0.00
No. of attacked plants	% Infestation	0.84	0.63	0.70	70.44	0.00	0.88	0.56	0.78	77.99	0.00
	% Attack intensity	0.84	1.05	0.70	70.37	0.00	0.86	1.00	0.74	73.67	0.00
	% Attacked plants	0.71	2.82	0.51	50.60	0.00	0.79	2.95	0.62	62.21	0.00

r = Simple correlation; b = Simple regression; R^2*= Coefficient of determination; E.V% = Explained variance.*

P. refers to probability as significant at $P \leq 0.05$ *or highly significant at* $P \leq 0.01$*.*

4. Discussion

Egypt is facing a severe crop pest, *Spodoptera frugiperda* (Lepidoptera: Noctuidae), which devastates maize plants and reduces crop yields in terms of both quality and quantity. The pest poses a significant threat to Egyptian corn growers, putting the harvest at risk. Destructive activity is a key indicator of pest in crops and can help identify different insect species. Signs of *S. frugiperda* infestation and damage to corn crops include holes and injuries in the leaves, as well as an abundance of larval excretions. As *S. frugiperda* is a new and invasive pest in southern Egypt, monitoring its severity and activity is crucial for understanding the spread of insect infestations in maize-growing areas (Bakry and Abdel-Baky, 2023 a).

Consequently, in order to determine the quantity of larvae infesting maize, the percentage of infestation, the intensity of the attack, the proportion of plants attacked, the percentage of severity, and the prevalence of *S. frugiperda* larvae harming maize plants, monitoring and early detection are required. These findings can aid in the development of efficient pest management plans and a decrease in attacks on maize plants by farmers and decision-makers.

The state of armyworm infestation and monitoring in the southern Egyptian province of Luxor is not well-documented in the scientific literature. Thus, this study is regarded as the first to focus on fungal illnesses linked to larval feeding on maize plants, as well as estimations of armyworm infestation, assault, and prevalence. According to Fernández (2002), Caniço *et al*. (2020), Vinay *et al.* (2022) and Sholahuddin *et al.* (2023), seven variables were used to express the behavior and activity of fall armyworm on corn plants: the number of larvae, the number of plants infested with larvae, the number of healthy plants, the number of attacked plants, the percentage of infestation, the percentage of attack intensity, and the percentage of attacked plants estimated weekly until harvest time.

Our research indicates that *S. frugiperda* invaded and attacked maize plants 15 days after planting until harvest time. Specifically, larvae of the species were found on maize plants between the third week of June and the time of maize harvest. Three peaks were observed in each season, occurring at 29, 57, and 85 days after sowing in 2022 and 2023, respectively, in terms of larval numbers, number of plants infested with larvae, percentage of infestation, and percentage of attack intensity. Fall armyworms have a generation time of 20 to 30 days, according to Sisay *et al.* (2019). This suggests that there may be several re-infestations of the pest (recurrent generations) during the maize growing season. According to Bakry and Abdel-Baky (2023 a), *S. frugiperda* larvae on maize plants exhibit three peaks every season.

According to our analysis, during there were more plants attacked than sick ones during the season. Additionally, the study demonstrated that maize plants were better suited to host a greater number of *S. frugiperda* larvae throughout their vegetative stage. In our study, there were fewer plants infested compared to attacked plants. These results are consistent with Caniço *et al.* (2020) and Fernández (2002).

The decline in the quantity of plants infested with larvae can be attributed to both internal and external factors, including food, climate, competitors, habitat, natural enemies, and the larvae's ability to obtain resources and disperse (Yasa *et al.*, 2020; Supartha *et al.*, 2021). The current data show that leaf assault and spread were facilitated by the presence of caterpillars (larvae), greater food availability, a shorter larval life cycle, and movement from one plant to another (Bakry and Abdel-Baky, 2023 a).

This observation is probably caused by the short time of larval growth compared to the duration of the vegetative stage of maize, since the larvae may have reached the adult stage and abandoned the attacked plants (Caniço *et al.*, 2020; Anjorin *et al.*, 2022). Overlapping corn crops across the growing season is a major cause of the increased population density of larvae, and the voracious feeding behavior of larvae caused by the use of ineffective insecticides or control at the larval stage are the reasons behind the increase in the number of attacked plants (Caniço *et al.*, 2020; Supartha *et al.*, 2021). As a result, during the two seasons, as the amount of time spent inspecting maize plants grew, so did the percentage of plants attack by *S. frugiperda.*

This suggests that the number of plants attacked by the pest rose over the course of the two growing seasons because of notable attacks on maize plants throughout the blooming and reproductive seasons. Gross Junior *et al.* (1982) reported that the vulnerability of different phases of maize growth to *S. frugiperda* infestation varied according to the plant's growth and progress. During the vegetative growth phases of maize, *S. frugiperda* larvae often feed on a large leaf mass, which indirectly limits the area of photosynthetic leaves and lowers output.

According to our research, the length of time plants took to develop (measured in days) affected how much infestation and attack were seen during each season. In both seasons, an increase in *S. frugiperda* larvae numbers, numbers of affected plants, degree of infestation, and intensity of larval attack was noted at 15 days post-planting. The findings align with the findings of Muría *et al.* (2009), who discovered a correlation between the age and growth of maize and the quantity of *S. frugiperda* larvae.

While weekly leaf attacks on plants occurred in both seasons, the proportion of plants attacked by *S. frugiperda* increased as the inspections dates of maize plants in both seasons progressed. Regarding the relationships between changes in a particular favored variable and variations in the independent factors, the results of the simple correlation and regression coefficient calculations showed statistically significant positive correlations in every variable examined. According to Caniço *et al.* (2020), there was a strong correlation between the number of plants attacked and the larvae abundance on the different control dates.

5. Conclusion

In this study, *S. frugiperda* began invading and attacking maize plants 15 days after they were sown and continued until harvest, meaning that larvae of the species were found on maize plants between the third week of June and the time of harvest. Three peaks were found in each season, occurring 29, 57, and 85 days after planting in 2022 and 2023, respectively, in terms of the number of larvae, the number of plants infested with larvae, the percentage of infestation, and the percentage of attack intensity. Our analysis shows that during the season, there were more attacked plants than infected plants. As a result, during the two seasons, the frequency of corn plant inspections rose along with the proportion of plants attacked by *S. frugiperda*. Farmers and decision-makers may find these details useful in creating efficient plans to manage this pest.

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All authors are contributed in this research

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Institutional Review Board Statement

All Institutional Review Board Statements are confirmed and approved.

Data Availability Statement

Data presented in this study are available on fair request from the respective author.

Ethics Approval and Consent to Participate

Not applicable

Consent for Publication

Not applicable.

Conflicts of Interest

The authors disclosed no conflict of interest.

6. References

Anandhi, S., Saminathan, V.R., Yasodha, P., Roseleen, S.S.J., Sharavanan, P.T., Rajanbabu, V. (2020). 'Correlation of Fall Armyworm *Spodoptera frugiperda* (J.E.

Smith) with weather Parameters in maize Ecosystem.', *Int. J. Curr. Microbiol. App. Sci*., 9(8), pp. 1213-1218.

Anjorin, F., Bosede, O.O., Odeyemi, O.A., Kareem, K.T. (2022). 'Fall armyworm (*Spodoptera frugiperda*) (J. E. Smith) (Lepidoptera: Noctuidae) infestation: maize yield depression and physiological basis of tolerance.', *J. of Plant Protection Research*, 62 (1), pp. 12–21.

Bakry, M.M.S., Abdel-Baky, N.F. (2023a). 'Population density of the fall armyworm, *Spodoptera frugiperda* (Smith) (Lepidoptera: Noctuidae) and its response to some ecological phenomena in maize crops.', *Brazilian Journal of Biology*, 83, ID e271354. https://doi.org/10.1590/1519-6984.271354

Bakry, M.M.S., Abdel-Baky, N.F. (2023b). 'Impact of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) infestation on maize growth characteristics and yield loss.', *Brazilian Journal of Biology*, 83, ID e271354. https://doi.org/10.1590/1519-6984.274602.

Bakry, M. M.S., Gad, M.A. (2023). 'Insecticidal efficiency of some pesticides against *Spodoptera frugiperda* (J.E. Smith) (Noctuidae: Lepidoptera) under laboratory conditions.', *Andalasian International Journal of Entomology*, 1(01), pp. 15-19.

Bakry, M.M.S., Dahi, H.F., Gamil, W.E. (2023). 'Prediction of the annual generations of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith) at maize crop using accumulated heat units in south Egypt.', *Egypt. Acad. J. Biolog. Sci.*, 16(2), pp.143-154.

Bangale, S.A. (2019). 'Fall Armyworm (*Spodoptera frugiperda*): A Serious Problem for Maize Cultivation in India.', Biomolecule Reports- An International eNewsletter, BR/10/19/28.

Caniço, A., Mexia A., Santos, L. (2020). 'Seasonal dynamics of the alien invasive insect pest *Spodoptera frugiperda* Smith (Lepidoptera: Noctuidae) in Manica Province, Central Mozambique.', *Insects*, 11, pp. 512. https://doi.org/10.3390/insects11080512.

FAO (Food and agricultural organizations of the United Nations): FAO Advisory Note on Fall Armyworm (FAW) in Africa, (2017). Key messages in: FAO Advisory Note on Fall Armyworm (FAW) in Africa. Rome, Italy, pp. 1-30.

Fernández, J.L., (2002). 'Estimación de umbrales económicos para *Spodoptera frugiperda* (JE Smith) (Lep.: Noctuidae) en el cultivo del maíz. Invest.', *Agr.: Prod. Prot. Veg.*, 17, pp. 467-474.

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

Goergen, G., Kumar, P.L., S.B., Sankung, Togola, A., Tamo, M. (2016). 'First report of outbreaks of the fall armyworm *Spodoptera frugiperda* (JE Smith) (Lepidoptera, Noctuidae), a new alien invasive pest in west and central Africa.', *PLoS One*, 11, ID e0165632.

Gross Jr., H.R., Young, J.R., Wiseman, B.R. (1982). 'Relative susceptibility of a summer planted dent and tropical flint corn variety to whorl stage attack by the fall armyworm (Lepidoptera: Noctuidae).', *J. Econ. Entomol.*, 75, pp.1153-1156.

Herlinda, S.S., Irsan, C., Adrian, R., Fawwazi, F., Akbar F. (2023). 'Species diversity and abundance of parasitoids of fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) from South Sumatra, Indonesia.', *Biodiversitas*, 24(11), pp. 6184–6190. https://doi.org/10.13057/biodiv/d241140.

Kumela, T., Simiyu, J., Sisay, B., Likhayo, P., Mendesil, E., Gohole, L., Tefera, T. (2018). 'Farmers knowledge, perceptions, and management practices of the new invasive pest, fall armyworm (*Spodoptera frugiperda*) in Ethiopia and Kenya.', *Int. J. Pest Manag.*, 65, pp. 1-9.

Lestari, P., Swibawa, I.G., Fitriana, Y., Suharjo, R., Dwi Utomo, S., Hartaman, M. (2024). 'The population dynamics of *Spodoptera frugiperda* after its invasion in Lampung Province, Indonesia.', *J. Trop. Plant Pests Dis.*, 24(1), pp. 98-108.

Maruthadurai, R., Ramesh, R. (2020). 'Occurrence, attack pattern and biology of fall armyworm, *Spodoptera frugiperda* (J.E. smith) (Lepidoptera: Noctuidae) on fodder crops and green amaranth in Goa, India.', *Phytoparasitica*, 48, pp. 5-23.

Montezano, D.G., Specht, A., Sosa-Gomez, D.R., Roque-Specht, V.F., Sousa-Silva, J.C., Paula-Moraes, S.V., Peterson, J.A., Hunt, T.E. (2018). 'Host plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas.', African Entomology, 26, pp. 286–300.

Murúa, M.G., Juárez, M.L., Prieto, S., Gastaminza, G., Willink, E. (2009). 'Distribución temporal y espacial de poblaciones larvarias de *Spodoptera frugiperda* (Smith) (Lepidóptera: Noctuidae) en diferentes hospederos en provincias del norte de la Argentina.', *Revista Industrialy Agrícola de Tucumán*, 86(1), pp. 25-36.

Prasanna; B.M., Huesing, J.E., Eddy, R.R., Peschke, VM. (2018). Fall Armyworm in Africa: A Guide for Integrated Pest Management.', Edn 1, CDMX: CIMMYT, Mexico, pp. 1-107.

Rios, E.S., Martins, I.C.F., de Noronha, M.P., da Silva, J.A., da Silva Filho, J.G., Badji, C.A. (2014). 'Spatial distribution of *Spodoptera frugiperda* in the wasteland of southern Pernambuco state, Brazil Rev.', *Cienc. Agrar.*, 57(3): 297-304.

Sholahuddin, S., Wijayanti, R., Supriyadi, S., Sulistya, A., Subagiya, S., Haq, A. (2023). 'Population and attack intensity of the yellow rice stem borer and its natural enemies in the jajar legowo rice planting system.', *IOP Conf. Ser.: Earth Environ. Sci.*, 1180, pp. 012013.

Sisay, B., Tefera, T., Wakgari, M., Ayalew, G., Mendesil, E. (2019). 'The Efficacy of Selected Synthetic Insecticides and Botanicals against Fall Armyworm, *Spodoptera frugiperda*, in Maize.', *Insects*, 10(2), pp. 45. https://doi.org/10.3390/insects10020045.

Supartha, I.W., Susila, I.W., Srisunari, A.A.A., Mahaputra, I.G.F., Yudha, I.K.W., Wiradana, P. A. (2021). 'Attack characteristics and distribution patterns of invasive pest, *Spodoptera frugiperda* (J.E Smith) (Lepidoptera: Noctuidae) on maize crop in Bali-Indonesia.', *Biodiversitas*, 22(6), pp. 3378-3389.

Vinay, N., Raju, S.V.S., Srinivasa, N., Sharma, K.R. (2022). 'Incidence of fall armyworm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on finger millet and sorghum in Karnataka, India.', *Journal of Entomological Research - Malhotra Publishing House*, 46(3), pp. 636-641.

Xiao-xu, S., Chao-xing, H.U., Hui-ru, J.I.A., Qiu-lin, W.U., Xiu-jing, S., Sheng-yuan, Z., Yu-ying, J., Kong-ming, W.U. (2021). 'Case study on the first immigration of fall armyworm, *Spodoptera frugiperda* invading into China.', *Journal of Integrative Agriculture*, 20(3), pp. 664-67.

Yasa, I.W.S., Supartha I.W., Susila, I.W. (2020). 'Population abundance and parasitization level of indigenous parasitoids to the invasive pest, *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) in Bali.', *Agrotrop J. Agric. Sci.*, 10, pp. 59. https://doi.org/10.24843/AJoAS.2020.v10.i01.p07.

Yigezu, G., Wakgari, M. (2020). 'Local and indigenous knowledge of farmers management practice against fall armyworm (*Spodoptera frugiperda*) (J. E. Smith) (Lepidoptera: Noctuidae): A review.', *Journal of Entomology and Zoology Studies*, 8(1), pp. 765-770.