ONLINE ISSN: 3007-3197 | PRINT ISSN: 3007-3189
http://amresearchreview.com/index.php/Journal/about

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 3, Issue 6 (2025)

Seasonal Activity of Fall Armyworm, *Spodoptera frugiperda* (Smith) in Maize Agroecosystem of South Punjab, Multan, Pakistan

[1]*Saleem Riaz, [2]Sheraz Ul Haq, [3]Abdul Muqeet, [4]Muhammad Nouman, [5]Ijaz Hussain, [6]Shah Muhammad Bheekh, [7]Muhammad Aizaz, [8]Fayyaz Hussain

Article Details

Keywords: Maize, Fall Armyworm, Population Dynamics, Climatic Influence, Pest Management

[1]Saleem Riaz*
Institute of Plant Protection, MNS University of Agriculture Multan, Multan, Pakistan.
Corresponding Author Email:
saleemriaz7511@gmail.com
[2]Sheraz Ul Haq
Department of Entomology, University of Agriculture, Faisalabad 38000, Pakistan.
sherazulhaq182@gmail.com
[3]Abdul Muqeet
Department of Entomology, University of Agriculture, Faisalabad 38000, Pakistan.
abdulmuqeet7474@gmail.com
[4]Muhammad Nouman
Department of Entomology, University of Agriculture, Faisalabad 38000, Pakistan.
2017ag10086@uaf.edu.pk
[5]Ijaz Hussain
Department of Plant Protection, Ghazi University, Dera Ghazi Khan 32200, Pakistan.
ijazkhosa184@gmail.com
[6]Shah Muhammad Bheekh
Department of Entomology, University of Agriculture, Faisalabad 38000, Pakistan.
sm915579@gmail.com
[7]Muhammad Aizaz
Institute of Plant Protection, MNS University of Agriculture Multan, Multan 60000, Pakistan.
muhammadaizaz28081999@gmail.com
[8]Fayyaz Hussain
Institute of Plant Protection, MNS University of Agriculture Multan, Multan, Pakistan.
fiyazfiyazhussain7@gmail.com

ABSTRACT

Maize (*Zea mays* L.) holds substantial significance as a cereal crop in Pakistan. The fall armyworm (*Spodoptera frugiperda*) (FAW) is acknowledged as a major pest that adversely impacts the quality and yield of maize worldwide. Our research explored the dynamics of fall armyworm moth populations and the resultant damage caused by their larvae on maize crops during fall 2022 and spring 2023. Significantly, higher average moth trap catches per week were observed in September, followed by October in the fall season of 2022. In the spring season of 2023, increased moth catches were noted in March, followed by April. Moth catches exhibited a gradual ascent from crop emergence, reaching their peak during the vegetative growth stage (V8 to VT), followed by a decline from the onset of the reproductive stage and no moth catches during crop maturity to the harvesting stage (MH) in both seasons. Similarly, a significantly greater percentage of fall armyworm damage was observed in September, followed by August and October during the fall of 2022, and in March, followed by February and April during the spring of 2023. Also, higher FAW percent damage was recorded during vegetative growth of the crop (V8 to VT) and lower during the reproductive stage (R1 to R6), and no damage during maturing to harvesting (MH) during both seasons. Both sites showed no significant difference in moth catches and percent damage in both seasons. The Pearson correlation analysis of moth catches revealed a substantial positive correlation with morning relative humidity and rainfall, while the maximum temperature exhibited a significant negative correlation in both years. The insights derived from this study can help in timely management practices adopted to specific times and crop stages, thereby mitigating potential yield losses in maize cultivation.

1. Introduction

Maize is a globally significant food and feed crop (Luo et al., 2022). Pakistan ranks it as the third most important cereal crop among its cereal crops (Rashid and Rasul, 2011). Maize, a crop that contributes 3.4% to total agricultural value and 0.6% to GDP, is cultivated for food, fodder, and feed, with 85% consumed for livestock feed and industrial purposes. Its germ contains 45-50% oil, used in cooking and salads (Shah et al., 2016). Maize is extensively utilized for producing byproducts like fermented drinks and leather bronzing chemicals. (Chaudhary, 2003). Pakistan Economic Survey 2022-23 shows a 4.1% increase in maize cultivation on 1720,000 hectares, and a production increase from 9.525 million tons to 10.18 million tons (Anonymous, 2022-23).

The production of maize has experienced a decline attributable to a variety of both living organisms and non-living elements, resulting in significant economic setbacks (Assefa and Ayalew, 2019). Principal contributors to this reduction in agricultural output include climate change, intensified pressure from insect pests, and heightened susceptibility to diseases (Caffarra et al., 2012). Among the detrimental insect pests affecting maize, lepidopterans such as stem borers, cutworms, armyworms, and ear borers stand out as particularly destructive (Kotey et al., 2020). Notably, borers, with a specific emphasis on the fall armyworm, exert considerable negative influence on maize production (Harish Kumar, 2002). A comprehensive survey reveals that the unbridled proliferation of the fall armyworm (FAW) could precipitate annual maize yield losses ranging from 8.3 to 20.6 million tons, consequently leading to a substantial 21–53 percent decline in overall output (Bhandari et al., 2020; Omwoyo, 2021). Presently, the control of fall armyworm predominantly relies on synthetic pesticides; however, the indiscriminate use and overreliance on these agents have given rise to complications such as insecticide resistance, particularly within organophosphates, pyrethroids, and carbamates (Ishaaya and Degheele, 2013). The pressing imperative for the development of novel, efficient, and ecologically sustainable methods to control fall armyworm cannot be overstated.

Efforts to control the spread of this invasive pest encounter formidable challenges characterized by numerous uncertainties. Formulating an effective strategy for pest management within a designated area necessitates foundational ecological knowledge, particularly pertaining to the dynamics of pest populations (Rahmathulla et al., 2015). Pheromones serve as an invaluable tool for the timely implementation of management procedures and the surveillance of pest populations (Nandagopal et al., 2008). Environmental variables, such as temperature, relative humidity, rainfall, and precipitation, wield a pivotal influence on the fluctuations in population dynamics observed in any pest species (Prasad et al., 2008). Biotic factors, encompassing the quantity and composition of natural enemies, the reproductive capacity of herbivores in relation to their hosts, intra- and interspecific competition, and the availability of resources, also exert a significant impact on pest populations (Rahmathulla et al., 2015). Understanding the correlation between fluctuations in pest populations and meteorological variations is crucial for interpreting survey data, predicting pest outbreaks, developing forecasting systems, and implementing judicious pest management strategies.

Therefore, it's crucial to grasp the biotic and abiotic factors that impact the population dynamics of Fall Armyworm (FAW). The growth stage of the crop also plays a role in the abundance of FAW in maize. FAW damage tends to be more significant during the stages of vegetative growth of maize, specifically up to 9 weeks after emergence. Additionally, environmental variables such as fecundity, speed of development, and survival significantly affect the rate of change in the pest population over time (Prasad et al., 2008; Rahmathulla et al., 2015). To formulate an effective integrated management strategy for *Spodoptera frugiperda*, it's essential to have information on how this pest population fluctuates over time in its new habitat due to environmental influences.

The present study was conducted to examine the dynamics of Fall Armyworm (FAW) moth populations and assess the damage inflicted by their larvae on maize crops throughout the fall of 2022 and spring of 2023. The objective of this research is to analyze the pattern of FAW moth emergence, and the resultant harm caused by FAW larvae over the entire season, with the aim of implementing effective control measures for this highly destructive pest. The findings of this study can prove instrumental in guiding timely management practices at specific intervals and crop stages of maize cultivation, thereby mitigating the risk of substantial yield losses.

2. Materials and methods

2.1. Study site and crop establishment

An experiment was conducted at two research sites, namely B and C research blocks, within the premises of the Muhammad Nawaz Sharif University of Agriculture, Multan, Pakistan. A fixed maize plot size of 3 acres per site was utilized for cultivation during each season. Maize hybrid DK 6789 (Bayer Crop Sciences) was employed, with a planting configuration of 60 × 7 cm between rows and plants. The experiment spanned two consecutive seasons, specifically Fall 2022 and Spring 2023. The research blocks, located at Muhammad Nawaz Sharif University of Agriculture in Multan, Pakistan, are positioned at geographical coordinates N 30°9'1.5912" E 71°26'31.1856" and N 30°8'34.0548" E 71°26'48.5484". A seed rate of 10 kg per acre was utilized, treated with a combination of imidacloprid and tebuconazole at a ratio of 10 ml per kg. The crop was cultivated following all recommended agricultural practices, except plant protection measures.

2.2. Trap placement

Two pheromone traps designed for capturing Fall Armyworm (FAW) moths, scientifically known as *Spodoptera frugiperda* (SF), were strategically placed in the maize fields of research blocks B and C at Muhammad Nawaz Sharif University of Agriculture, Agricultural Research Farms (two distinct sites). The traps were installed on the central bund of each plot concurrently with the sowing of maize seeds. Initially, the traps were suspended from a vertical pole measuring 4 meters in length, positioned at a height of 1.25 meters above ground level. As the maize crop progressed, the height of the traps was adjusted weekly, maintaining a distance of 1 foot above the crop (FAO and PPD 2020). To ensure optimal efficacy, the commercially available pheromone lure in each trap was replaced at regular intervals, specifically every 18 days.

2.3. Data collection

FAW moth trap captures and the percentage of plant infestation were documented from the 7th to the 8th day post-planting, covering the developmental stages of maize from the two-ligulate leaf stage to maturity. The maize growth phases, as classified by Prasanna et al., (2018) and FAO and PPD, 2020 encompass VE-V6 (early whorl stage) and V7-VT (late whorl stage) under the vegetative stage, and R1-R3 (tasseling to milk stage) and R4-R6 (dough to maturity stage) under the reproductive stage and maturity to harvesting stage (MH). Regular trap maintenance involved weekly emptying with the enumeration of male FAW individuals. Systematic inspection of maize plants followed a 'W' pattern (zigzag) technique, as per Prasanna et al., (2018), spanning the field while consciously avoiding the 5-meter border rows to mitigate edge effects. Within each research block, scrutiny was applied to 125 plants at five distinct locations, with 25 plants examined at each site for visual indications of FAW feeding weekly (FAO and PPD 2020).

2.4. Data analysis

The correlation between moth captures and weather parameters including temperature, relative humidity, and rainfall as well as maize growth stages, was assessed using statistical software Statistix 8.1. Statistical analyses, including analysis of variance and the Tukey HSD All-Pairwise Comparisons Test, were conducted to evaluate these comparisons. The percentage of damage was determined using the formula established by Murua et al., (2006).

$$Percentage\ of\ Infested\ Plants\ =\frac{Number\ of\ Plants\ Infested}{Total\ Number\ of\ Plants\ Observed}\times 100$$

3. Results

Mean (± SE) and analysis of variance of trap catches of FAW moths/months during fall 2022 and spring 2023

In fall 2022, significantly higher numbers of FAW moth catches were recorded in September, followed by October 2022 (F =22.08, df = 3, $P < 0.001$) (Fig. 1A). Similarly in spring 2023, significantly higher FAW moth catches were recorded in March followed by April (F = 33.22, df = 3, $P < 0.001$) (Fig. 1B).

Mean (± SE) and analysis of variance of FAW percent damage /months during fall 2022 and spring 2023

In Fall 2022, a significantly higher percentage of damage was recorded in September, followed by October, which is not significantly different from damage done in August (F = 31.42, df = 3, $P < 0.001$) (Fig. 1C). Similarly, in Spring 2023, significantly higher percentages of damage were recorded in March, followed by April, which is not significantly different from damage done in February (F = 41.79, df = 3, $P < 0.001$) (Figure 1D). Conversely, the recorded percentage of damage was significantly lower in November for Fall 2022 (Fig. 1C) and in May for Spring 2023 (Fig. 1D).

Mean (± SE) and analysis of variance of trap catches of FAW moths/ sites during fall 2022 and spring 2023

There was no statistically significant difference were observed in moth catches of FAW across various sites where data was collected on maize crops during Fall 2022 (F = 0.01, df = 1, P = 0.96) (Fig. 2 E) and Spring 2023 (F = 0.08, df = 1, P = 0.77) (Fig. 2 F).

Mean (± SE) and analysis of variance of percent damage per site during fall 2022 and spring 2023

There was no statistically significant variation observed in the percentage of damage inflicted by Fall Armyworm (FAW) across different sites where data was collected for maize crops during both Fall 2022 (F = 0.15, df = 1, P = 0.70) (Fig 2 G) and Spring 2023 (F = 0.41, df = 1, P = 0.52) (Fig. 2 H).

Correlations (Pearson) Statistix 8.1 of weather parameters with FAW moth catches during fall 2022 and spring 2023

In Fall 2022, a significant positive correlation was observed between moth catches and morning relative humidity ($r = 0.5290$, $p < 0.001$), as well as rainfall ($r = 0.3530$, $p < 0.047$). Conversely, a significant negative correlation was observed between maximum temperature and moth catches ($r = -0.5962$, $p < 0.001$). Similarly, in spring 2023, moth catches also exhibited a significant positive correlation with morning relative humidity ($r = 0.5938$, $p < 0.001$) and rainfall ($r = 0.5023$, $p < 0.003$) while maximum temperature also exhibited a significant negative correlation with moth catches ($r = -0.5218$, $p = 0.002$).

Mean (± SE) and analysis of variance of maize crop stages with fall armyworm moth catches during fall 2022 and spring 2023

Significant difference was recorded in FAW moth catches as the crop grows from its early stage to maturity and harvesting stages during both the Fall of 2022 ($F = 16.54$, df = 14, $P < 0.001$) and the spring of 2023 ($F = 33.88$, df = 14, $P < 0.001$) (Table 1). In Fall 2022, there was significantly higher moth catches were observed during the vegetative stage of maize crop V12V13 significantly different from rest of stages expect V10V11 and V14 (late whorl stage). No moth catches were observed in first two early whorl stages (V2V3 and V4V5) and maturity to harvesting stage (MH). While in Spring 2023, there was significantly higher moth catches were observed during the vegetative stage of maize crop V10V11 significantly different from rest of stages expect V12V13 and V14 (late whorl stage). No moth catches were observed in first early whorl stage (V2V3) and last two reproductive stages (R5, R6) and maturity to harvesting stage (MH) (Table 1).

Correlation mean (± SE) and analysis of variance (Tukey HSD) of all weeks with fall armyworm moth catches during fall 2022 and spring 2023

Significant difference was observed in FAW moth catches across various weeks, reflecting alterations in the number of FAW moth catches as the crop grows from the first to the final week in both the fall of 2022 ($F = 14.53$, df = 15, $P = <0.001$) and the spring of 2023 ($F = 29.76$, df = 15, $P < 0.001$). In Fall 2022, there was significantly higher moth catches were observed during the 6th week significantly different from rest of stages expect 5th and 7th. No moth catches were observed in the first and last two weeks of maize crop. In Spring 2023, there was significantly higher moth catches were observed during the 5th week significantly different from rest of stages expect 6th and 7th. No moth catches were observed in the first two and last three weeks of maize crop (Table 2).

Correlation mean (± SE) and analysis of variance of maize crop stages with FAW percent damage during fall 2022 and spring 2023

Significant difference was recorded in FAW percent damage as the crop grows from its early stage to maturity and harvesting stages during both the Fall of 2022 ($F = 39.04$, df = 14, $P < 0.001$) and the Spring of 2023 ($F = 51.89$, df = 14, $P < 0.001$).

In Fall 2022, there was significantly higher FAW damage observed during the vegetative stage of maize crop V12V13 significantly different from rest of stages expect V10V11 and V14 (late whorl stage). No damage was observed in the first two early whorl stages (V2V3) and maturity to the harvesting stage (MH). While in Spring

2023, there was significantly higher FAW damage were observed during the vegetative stage of maize crop (V12V13) significantly different from rest of stages. No damage was observed in the first early whorl stage (V2V3) and last three reproductive stages (R5, R6) and maturity to harvesting stage (Table 3).

Correlation mean (± SE) and analysis of variance (Tukey HSD) of all weeks with FAW percent damage during fall 2022 and spring 2023

Significant difference was observed in FAW damage across various weeks, reflecting alterations in FAW damages as the crop grows from the first to the final week in both the fall of 2022 (F = 34.29, df = 15, P = <0.001) and the spring of 2023 (F = 47.43, df = 15, P < 0.001). In Fall 2022, there was significantly higher FAW damage were observed during the three weeks ($5^{th,}$ $6^{th,}$ 7^{th}) significantly different from rest of weeks expect 4^{th} and 8^{th}. No FAW damage was observed in the first and last two weeks of the maize crop. Similarly, in Spring 2023, there was significantly higher FAW damage was observed during the 6^{th} week, only significantly different from the rest weeks. No moth catches were observed in the first and last four weeks of the maize crop (Table 2).

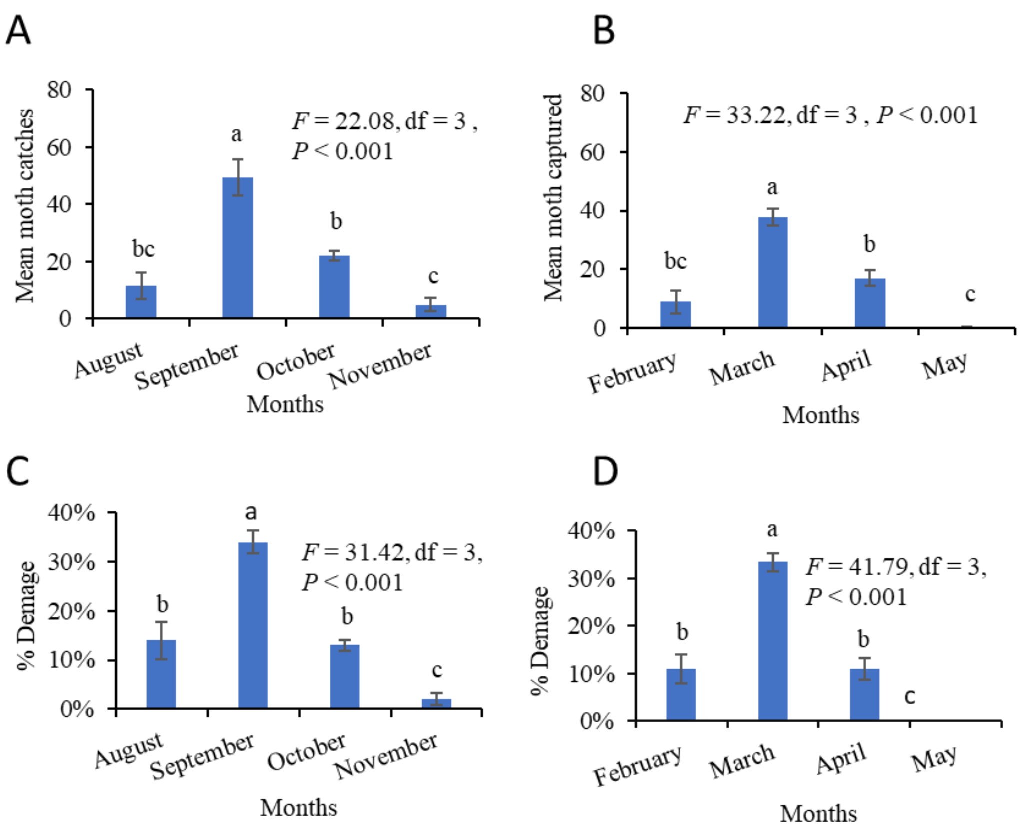

Figure 1. Mean abundance (± SE) and analysis of variance of FAW moths catches during different months of fall 2022 (a), spring 2023 (b), and percentage damage during different months of fall 2022 (c), spring 2023 (d)

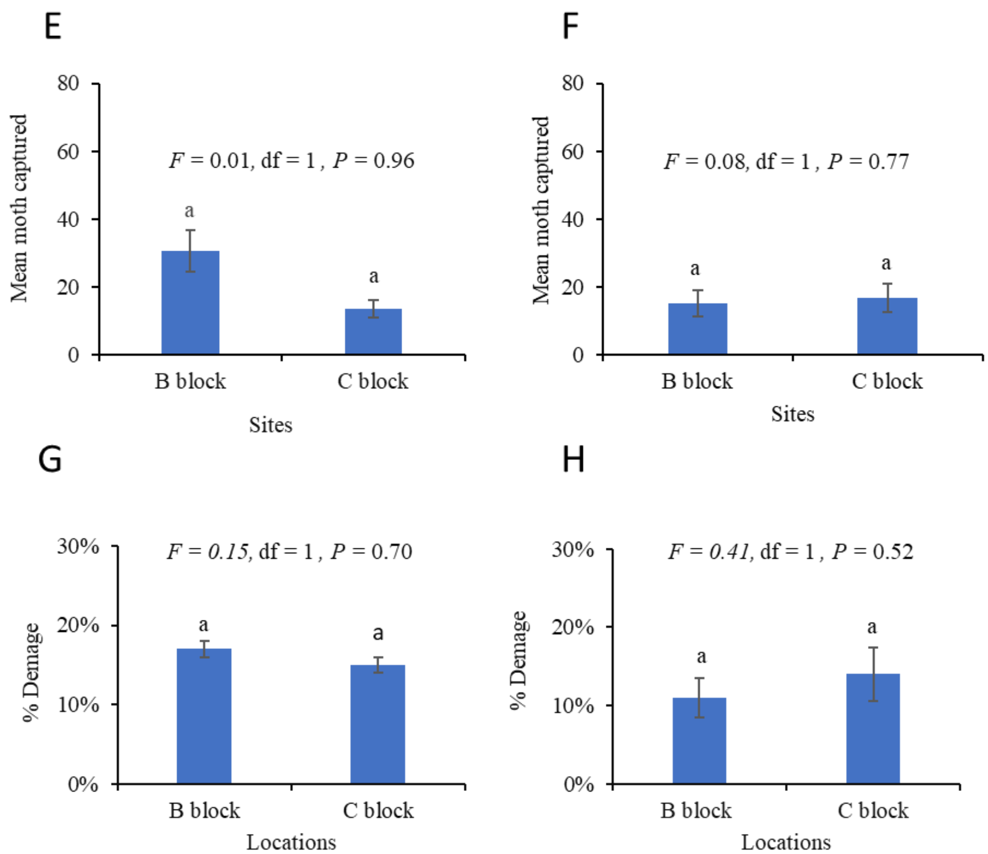

Figure 2. Mean abundance (± SE) and analysis of variance of FAW moths catches during fall 2022 (e), spring 2023(f), and percentage damage of all sites during fall 2022 (g), spring 2023 (h)

Table 1. Mean (± SE) and analysis of variance of maize crop stages with fall armyworm moth catches during fall 2022 and spring 2023

Maize crop growth stages	FAW moth catches (Fall 2022)	FAW moth catches (Spring 2023)
V2V3	0.0 ± 0.0 de	0.0 ± 0.0 h
V4V5	0.0 ± 0.0 de	1.0 ± 1.0 gh
V6V7	17 ± 2.0 cde	11.5 ± 5.5 efgh
V8V9	29 ± 2.0 bc	23 ± 6.0 cde
V10V11	48.5 ± 2.5 ab	47 ± 4.0 a
V12V13	69 ± 18 a	41.5 ± 1.5 ab
V14	48.5 ± 7.5 ab	35 ± 4.0 abc
VT	32 ± 4 bc	27.5 ± 1.5 bcd

R1	27.5 ± 3.5 bcd	25 ± 4.0 cde
R2	23 ± 4 bcde	19.5 ± 2.5 cdef
R3	20.5 ± 2.5 bcde	16 ± 3.0 defg
R4	17.5 ± 1.5 cde	7 ± 1.0 fgh
R5	15.5 ± 0.5 cde	1 ± 1.0 gh
R6	4.5 ± 1.5 cde	0.0 ± 0.0 h
MH*[1]	0.0 ± 0.0 e	0.0 ± 0.0 h
F, df	16.54, 14	33.88, 14
P	< 0.001	< 0.001

V1 to V14= Vegetative growth stages, **VT to R6=** Reproductive development stages, **V1 to V7 =** Early whorl stage, **V8 to VT** = Late whorl stage, **VT to R3 =** Tasseling to milking stage, **R4 to R6 =** Dough to maturity stage, **MH*[1]** = Maturity to Harvesting stage

Table 2. Correlation mean ± SE and analysis of variance (Tukey HSD) of all weeks with fall armyworm moth catches during fall 2022 and spring 2023

No. of Weeks	FAW moth catches (Fall 2022)	FAW moth catches (Spring 2023)
1st	0.0 ± 0.0 d	0.0 ± 0.0 f
2nd	0.0 ± 0.0 d	1.0 ± 1.0 f
3rd	17 ± 2.0 cd	11.5 ± 5.5 def
4th	29 ± 2.0 bc	23 ± 6.0 cde
5th	48.5 ± 2.5 ab	47 ± 4.0 a
6th	69 ± 18 a	41.5 ± 1.5 ab
7th	48.5 ± 7.5 ab	35 ± 4.0 abc
8th	32 ± 4 bc	27.5 ± 1.5 bcd
9th	27.5 ± 3.5 bcd	25 ± 4.0 bcd
10th	23 ± 4 bcd	19.5 ± 2.5 cde
11th	20.5 ± 2.5 bcd	16 ± 3.0 def
12th	17.5 ± 1.5 cd	7 ± 1.0 ef
13th	15.5 ± 0.5 cd	1 ± 1.0 f
14th	4.5 ± 1.5 cd	0.0 ± 0.0 f

15th	0.0 ± 0.0 d	0.0 ± 0.0 f
16th	0.0 ± 0.0 d	0.0 ± 0.0 f
F, df	14.53, 15	29.76, 15
P	<0.001	< 0.001

Table 3. Correlation mean (± SE) and analysis of variance of maize crop stages with FAW percent damage during fall 2022 and spring 2023

	% Damage Caused by FAW	
Maize crop growth stages	**%Mean ± SE (Fall 2022)**	**% Mean ± SE (Spring 2023)**
V2V3	0.0 ± 0.00 f	0.0 ± 0.00 h
V4V5	10 ± 0.01 def	9 ± 0.02 ef
V6V7	19 ± 0.03 cd	14 ± 0.01 e
V8V9	27 ± 0.01 bc	23 ± 0.01 cd
V10V11	38 ± 0.06 ab	34 ± 0.01 b
V12V13	39 ± 0.02 a	41 ± 0.00 a
V14	32 ± 0.01 ab	32 ± 0.01 b
VT	27 ± 0.01 bc	27 ± 0.02 c
R1	16 ± 0.00 cde	19 ± 0.02 d
R2	14 ± 0.02 de	14 ± 0.01 e
R3	13 ± 0.02 de	7 ± 0.00 fg
R4	9 ± 0.00 def	4 ± 0.01 gh
R5	5 ± 0.04 ef	0 ± 0.00 h
R6	4 ± 0.04 ef	0 ± 0.00 h
MH*1	0.0 ± 0.00 f	0 ± 0.00 h
F, df	39.04, 14	51.89, 14
P	< 0.001	< 0.001

V1 to V14= Vegetative growth stages, **VT to R6=** Reproductive development stages, **V1 to V7 =** Early whorl stage, **V8 to VT** = Late whorl stage, **VT to R3** = Tasseling to milking stage, **R4 to R6** = Dough to maturity stage, **MH*1** = Maturity to Harvesting stage

Table 4. Correlation mean ± SE and analysis of variance (Tukey HSD) of all weeks with FAW percent damage during fall 2022 and spring 2023

	% Damage Caused by FAW	
No. of Weeks	**%Mean ± SE (Fall 2022)**	**% Mean ± SE (Spring 2023)**
1st	0.0 ± 0.00 e	0.0 ± 0.00 h
2nd	10 ± 0.01 cde	9 ± 0.02 ef
3rd	19 ± 0.03 bc	14 ± 0.01 e
4th	27 ± 0.01 ab	23 ± 0.01 cd
5th	38 ± 0.06 a	34 ± 0.01 b
6th	39 ± 0.02 a	41 ± 0.00 a
7th	32 ± 0.01 a	32 ± 0.01 b
8th	27 ± 0.01 ab	27 ± 0.02 c
9th	16 ± 0.00 bcd	19 ± 0.02 d
10th	14 ± 0.02 cd	14 ± 0.01 e
11th	13 ± 0.02 cd	7 ± 0.00 fg
12th	9 ± 0.00 cde	4 ± 0.01 gh
13th	5 ± 0.04 de	0 ± 0.00 h
14th	4 ± 0.04 de	0 ± 0.00 h
15th	0.0 ± 0.00 e	0 ± 0.00 h
16th	0.0 ± 0.00 e	0 ± 0.00 h
F, df	34.29, 15	47.43, 15
P	< 0.001	< 0.001

4. Discussion

Our research findings indicate that there is no difference found in FAW moth catches across the sites. FAW moth catches showed a positive correlation with relative humidity and rainfall and a negative correlation with maximum temperature. It is reported from two maize seasons, 2017-18 in three different sites that showed no significant difference between the moth catches in all three regions in both years, with rainfall only climatic factor that influenced FAW moth catches. Significant positive correlation with rain in both years and three regions with positive correlation of FAW moth catches reported, which also concurs with our findings during both seasons, Fall 2022 and Spring 2023 (Nboyine et al., 2020; Pradeep et al., 2022). Muthukrishnan et al., (2022) also showed that FAW moth catches showed a significant positive correlation with relative humidity

(Morning) during the year 2019-20 and a significant positive correlation with rainfall, which also accordance to our findings. Pradeep et al. (2022) also reported from India in four consecutive seasons of maize crop Kharif 2019-20 and Rabi 2019-20 that moth catches showed a negative correlation with maximum temperature.

Similarly, research indicates the maximum FAW moth caches and percent damages as maize grows up to months. India with almost similar climatic conditions for the maize crop as in Pakistan, with slight changes in sowing and harvesting timings. The maximum attack of FAW and the moth captured is recorded on maize when it is two months old. The reason behind this high larval load as the crop grows, larval load also increases on the crop (Paradeep et al., 2022). It was also reported from two maize seasons, 2017-18, in three regions that the moth trap catches increase as the crop grows and peak in July and August till the reproductive stage of the crop (Nboyine et al., 2020). Fall armyworm moth catches increased in August and September due to differences in the time and date of sowing of maize in Pakistan with other countries. Two peaks in moth catches in a year. One peak was recorded in December and January, and the second peak was recorded in July and August (rainy season). These findings are synchronized with the production periods of maize as one to two months after planting of seed (6 to 12 plant leaves), which also accordance to our findings (Muturiki et al., 2019; Ahissou et al., 2022).

Pradeep et al., (2022) also found that during the first two months after sowing, the crop was in the vegetative stage, indicating the most preferred stage by FAW. As the crop passed the vegetative stage and entered the reproductive stage, the percentage of infested plants by FAW was reduced significantly in both kharif and rabi seasons.

5. Conclusion

The current study reports the FAW moths catches and damage inflicted with respect to Months, crop growth stages and meteorological factors like Temperature, Humidity and Rainfall in the maize Ecosystem of Pakistan.

References

1. Ahissou, BR, Sawadogo WM, Sankara F, Brostaux Y, Bokonon-Ganta AH, Somda I, Verheggen FJ (2022) Annual dynamics of fall armyworm populations in West Africa and biology in different host plants. Scientific African, 16,e01227. https://doi.org/10.1016/j.sciaf.2022.e01227
2. Anonymous (2022-2023) Economic survey of Pakistan Chapter 2:21-22.
3. Assefa F, Ayalew D (2019) Status and control measures of fall armyworm (*Spodoptera frugiperda*) infestations in maize fields in Ethiopia: A review. Cogent food agric. Jan 1;5(1):1641902. https://doi.org/10.1080/23311932.2019.1641902
4. Bhandari S, Bhattaraia R, Pandey KR, Adhikari S (2020) Assessment Of Infestation Of *Spodoptera frugiperda* (JE Smith) on Maize and its Implemented Management Practices with Their Efficacy in Kailali, Nepal. Malaysian J. Sustainable Agric. 5(1):10-5. http://doi.org/10.26480/mjsa.01.2021.10.15
5. Caffarra A, Rinaldi M, Eccel E, Rossi V, Pertot I (2012) Modelling the impact of climate change on the interaction between grapevine and its pests and pathogens: European grapevine moth and powdery mildew. Agric Ecosyst Environ. Feb 15;148:89-101. https://doi.org/10.1016/j.agee.2011.11.017

6. Chaudhary AR (1983) Maize in Pakistan, Punjab Agri. Research Coordination Board Univ. of Agri. Faisalabad
7. FAO and PPD (2020) Manual on Integrated fall armyworm management. Yangon, FAO https://doi.org/10.4060/ca9688en
8. Kotey DA, Siamey J, Egbadzor KF, Bissah MN (2020) Towards the identification of new sources of resistance to stem borer pests of maize in Ghana: Preliminary findings and matters arising. Ghana J. Forestry 36(1):22-33.
9. Kumar H (2002) Plant damage and grain yield reduction by fall armyworm and stem borers on certain maize hybrids containing resistance genes from varying sources under experimental and farmers field conditions. Crop Protection Aug 1;21(7):563-73 https://doi.org/10.1016/S0261-2194(01)00146-6
10. Luo Y, Huang D, Miao H, Wu L, Zhu J (2022) Impact of advanced storage facilities on households' maize storage losses and food security in China. Environ. Dev. Sustain. Jan;24(1):221-37 https://doi.org/10.1007/s10668-021-01406-z
11. Murúa G, Molina-Ochoa J, Coviella C (2006) Population dynamics of the fall armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) and its parasitoids in northwestern Argentina. Florida Entomologist. Jun;89(2):175-82 https://doi.org/10.1653/0015-4040(2006)89[175:PDOTFA]2.0.CO;2
12. Muthukrishnan N, Rajisha PS, Nelson SJ, Jerlin R, Karthikeyan R. Population dynamics of fall army worm *Spodoptera frugiperda* (JE Smith) on maize. Indian Journal of Entomology. 2022 Jul 26:134-6 https://doi.org/10.55446/IJE.2021.337
13. Nandagopal V, Prakash A, Rao J (2008) Know the pheromones: Basics and its application. J. Biopestic 1:210-5. http://www.jbiopest.com/users/lw8/efiles/V.Nandagopal_6_1.pdf
14. Nboyine JA, Kusi F, Abudulai M, Badii BK, Zakaria M, Adu GB, Haruna A, Seidu A, Osei V, Alhassan S, Yahaya A (2020) A new pest, *Spodoptera frugiperda* (JE Smith), in tropical Africa: Its seasonal dynamics and damage in maize fields in northern Ghana. Crop Protection Jan 1;127:104960 https://doi.org/10.1016/j.cropro.2019.104960
15. Omwoyo CO (2021) Assessment of Yield Losses and Farmers' Perceptions on Control Practices of Fall Armyworm: the Case of Maize Infestation in Trans-nzoia County, Kenya (Doctoral dissertation, University of Nairobi) http://erepository.uonbi.ac.ke/handle/11295/155738
16. Pradeep P, Deshmukh SS, Sannathimmappa HG, Kalleshwaraswamy CM, Firake DM (2022) Seasonal activity of *Spodoptera frugiperda* (JE Smith) in maize agroecosystem of South India. CURRENT SCIENCE Jul 10;123(1):81.
17. Pradeep P, Deshmukh SS, Sannathimmappa HG, Kalleshwaraswamy CM, Firake DM (2022) Seasonal activity of *Spodoptera frugiperda* (JE Smith) in maize agroecosystem of South India. CURRENT SCIENCE Jul 10;123(1):81.
18. Prasad TV, Nandagopal V, Gedia MV (2008) Seasonal abundance of sesbania thrips, Caliothrips

indicus Bagnall in groundnut. Journal of Agrometeorology Jan 1;10:211-4.

19. Prasanna, BM, Huesing JE, Eddy R, Peschke VM (2018). Fall armyworm in Africa: a guide for integrated pest management.

20. Rahmathulla VK, Sathyanarayana K, Angadi BS (2015) Influence of abiotic factors on population dynamics of major insect pests of mulberry. Pakistan Journal of Biological Sciences.;18(5):215-23 https://www.cabdirect.org/cabdirect/abstract/20153390166

21. Rashid K, Rasul G (2011) Rainfall variability and maize production over the Potohar Plateau of Pakistan. Pakistan Journal of Meteorology 8(15):63-74.

22. Rouf Shah T, Prasad K, Kumar P (2016) Maize—A potential source of human nutrition and health: A review. Cogent Food & Agriculture. Dec 31;2(1):1166995 https://doi.org/10.1080/23311932.2016.1166995