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Population dynamics of major insect pests of okra under semi arid region of Rajasthan

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Abstract
Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable crop widely cultivated in tropical and subtropical regions. In subsequent mentions throughout the manuscript, the crop is referred to as *Abelmoschus esculentus*. Weekly observations from Standard Weeks (S.W.) 30 to 42 during the Kharif seasons of 2022-23 and 2023-24 revealed distinct trends in the population dynamics of four major insect pests on okra: red pumpkin beetle (*Aulacophora foveicollis*), Kharif grasshopper (*Hieroglyphus nigrorepletus*), semi looper (*Anomis* sp.), and tobacco caterpillar (*Spodoptera litura*). Pest populations generally increased from S.W. 30, peaking around S.W. 38-40, before declining toward the end of the season (S.W. 41-42). Among the pests, the red pumpkin beetle and Kharif grasshopper recorded the highest population densities, especially between weeks 36 and 40. Semi looper and tobacco caterpillar populations were comparatively lower but followed a similar seasonal pattern. Notably, pest incidence was consistently higher in the 2023-24 season compared to 2022-23 for most species. Correlation analysis between pest populations and meteorological parameters indicated several significant relationships. Maximum temperature showed a strong negative correlation with red pumpkin beetle (-0.515**) and tobacco caterpillar (-0.128), while Kharif grasshopper populations had a significant negative correlation with both maximum (-0.543**) and minimum (-0.512) temperatures. Semi looper populations were negatively correlated with maximum temperature (-0.721**) and maximum humidity (-0.525**), suggesting that these factors may suppress its activity. Minimum humidity was negatively correlated with the red pumpkin beetle (-0.342**) and Kharif grasshopper (-0.495**), indicating that drier conditions may favor their proliferation. Interestingly, rainfall showed a positive correlation with semi looper (0.465) and tobacco caterpillar (0.622) in 2023-24, highlighting the influence of rainfall in stimulating larval development and activity in some pest species.
These findings underscore the importance of weather in shaping pest outbreaks and can serve as a foundation for developing predictive pest models and timely implementation of Integrated Pest Management (IPM) strategies in okra cultivation.

Keywords: Red pumpkin beetle, semi looper, tobacco caterpillar and weather

Introduction
Okra (*Abelmoschus esculentus* L.), 2n = 130, belongs to Malvaceae family commonly known as lady's finger, is an important vegetable crop grown extensively in tropical and subtropical regions. It holds significant nutritional and economic value in many developing countries, including India. However, the productivity of okra is often adversely affected by a wide range of insect pests, especially during the Kharif (monsoon) season [2]. Among the most damaging pests of okra are the red pumpkin beetle (*Aulacophora foveicollis*), Kharif grasshopper (*Hieroglyphus nigrorepletus*), semi looper (*Anomis* spp.), and tobacco caterpillar (*Spodoptera litura*) [6]. These pests not only reduce crop yield but also lower market quality, ultimately impacting farmer income and food security [1].
Pest population dynamics are closely influenced by environmental factors such as temperature, humidity, and rainfall [7]. With the increasing unpredictability of weather patterns due to climate change, understanding the relationship between pest incidence and meteorological parameters has become crucial for developing effective pest management strategies [4].Despite the recognized importance of such studies, there remains a lack of comprehensive, location-specific data on seasonal pest fluctuations in okra, particularly during the Kharif season when climatic conditions are most variable and conducive to pest outbreaks [8].

The present study was undertaken to monitor the population trends of four key insect pests on okra during the Kharif seasons of 2022-23 and 2023-24. Weekly observations were recorded to assess pest abundance and distribution patterns across both seasons. Furthermore, the study aimed to analyze the correlation between pest populations and major weather variables, including maximum and minimum temperature, relative humidity, and rainfall [9]. By identifying critical periods of pest infestation and their climatic associations, the findings of this research aim to contribute to the formulation of predictive pest forecasting models and more effective, climate-resilient integrated pest management (IPM) practices for okra cultivation. In conclusion**,** this study aims to provide a comprehensive understanding of the pest and natural enemy complex associated with okra (*Abelmoschus esculentus*) during the Kharif seasons of 2022-23 and 2023-24. By evaluating the seasonal population trends of major insect pests and their natural predators, the research offers valuable insights into pest dynamics, ecological interactions, and the influence of climatic factors. These findings contribute to the development of sustainable pest management strategies, emphasizing the role of natural enemies and reducing reliance on chemical pesticides for long-term agro-ecosystem stability.

Materials and Methods

Ajmer is situated in the heart of Rajasthan, India, between 26° 44' North latitude and 74° 63' East longitude. Covering a total geographical area of 8, 481 km², Ajmer ranks 14th in the state by area and 8th by population [13]. Geographically, the region is surrounded by the Aravalli ranges and features a prominent artificial lake, Anasagar, located to the north of the city. The district is nearly triangular in shape and is divided into three primary physiographic zones: the Eastern Rajasthan Upland, the Semi-Arid Transitional Plain, and the Aravalli Landscape. The climate of Ajmer is generally characterized by hot, dry, and semi-arid conditions. Summers, spanning from April to June, are extremely hot and dry, while winters from November to February are cool and bracing [12].

Experimental site and period

The present investigation was conducted at the Crop Cafeteria, Faculty of Agricultural Sciences, Bhagwant University, Ajmer, during the Kharif seasons of 2022-23 and 2023-24. The study focused on understanding the population dynamics of insect pests associated with okra (*Abelmoschus esculentus*), with special emphasis on key defoliators and fruit borers such as *Helicoverpa armigera* and *Spodoptera litura*. Previous studies by Atwal and Singh [17] have reported that H. armigera alone can cause up to 69% yield loss in okra.

To ensure researcher safety during field visits—particularly in areas known for the presence of reptiles, ants, and other hazards—appropriate protective gear (gumboots, gloves, and field suits) was worn throughout the fieldwork.

Crop details and layout

The experiment was conducted using the okra variety 'Arka Anamika', sown in a total plot area of 450 m². The experiment followed a Randomized Block Design (RBD) with three replications. The crop was planted with a spacing of 60 × 30 cm (row-to-row and plant-to-plant).

Insect Pests Monitored

The investigation focused on monitoring the seasonal abundance of four major insect pests of okra:

1. Red Pumpkin Beetle (*Aulacophora foveicollis*)
2. Kharif Grasshopper (*Hieroglyphus nigrorepletus*)
3. Semi Looper (*Anomis* sp.)
4. Tobacco Caterpillar (*Spodoptera litura*)

These pests are known to cause significant defoliation and yield loss during various growth stages of the okra crop.

Significance Testing

The correlation coefficients were tested for statistical significance at:

5% level ($p \leq 0.05$) — marked with a single asterisk (*)
1% level ($p \leq 0.01$) — marked with a double asterisk (**)

Data Collection Procedure

Observations were made weekly from Standard Week (S.W.) 30 to 42 during both crop seasons. In each replication, five plants were selected randomly following a zig-zag pattern to ensure unbiased sampling across the plot. Insect counts were taken early in the morning (between 7:00 AM and 9:00 AM) when insect activity was moderate and visibility allowed accurate identification. The number of insects per plant was recorded visually or by gentle tapping of the plants onto a white sheet to dislodge and count pests. Collected insects were identified using entomological keys, and confirmation was done through consultation with entomology experts and reference collections in the departmental laboratory.

Results and Discussion

Red Pumpkin Beetle (*Aulacophora foveicol*lis)

The population dynamics of the Red Pumpkin Beetle on okra during the Kharif seasons of 2022-23 and 2023-24 revealed a distinct pattern of gradual buildup and decline in sync with crop growth stages as present in (Table 1). At the start of monitoring (week 30), beetle numbers were negligible or zero, indicating minimal early infestation. However, as the crop progressed into the vegetative and flowering stages, the pest population steadily increased. In 2022-23, the population rose from 0.5 insects per plant in week 31 to a peak of 7.5 insects per plant by week 39. Similarly, in 2023-24, the beetle population increased from 0.45 in week 31 to a peak of 6.6 insects per plant by week 40. This peak population corresponds with the period of active fruit development, during which beetle damage is known to be most severe as per [10, 14].

After reaching the peak, there was a slight decline in the population towards the later weeks (41-42), possibly due to natural population regulation or management interventions. The close similarity in population trends across the two years suggests a consistent seasonal pattern influenced by environmental factors and crop phenology. The population dynamics of the Red Pumpkin Beetle observed during the Kharif seasons of 2022-23 and 2023-24 indicate a clear pattern of infestation closely linked to the phenological stages of okra. The initial low population at the seedling stage (week 30) suggests minimal early crop damage, possibly due to limited host availability or environmental conditions unfavorable for beetle activity during the early crop growth phase. As the crop developed through the vegetative to flowering stages, there was a steady and significant increase in beetle numbers, peaking around week 39-40 in both years.

This peak coincided with active fruit development, a critical period when okra is most vulnerable to beetle feeding. The high densities recorded (up to 7.5 insects per plant) underscore the pest's potential to cause substantial damage, including defoliation and direct fruit injury, which can drastically reduce both yield and market quality. The similarity in population trends across the two cropping seasons suggests that the beetle's life cycle and infestation pressure are consistent year-to-year, likely driven by climatic factors such as temperature, humidity, and rainfall, as well as the crop's growth stage as per the findings of [3, 5, 9].

Following the peak, a gradual decline in population was noted, which might be attributed to natural mortality factors such as predation, parasitism, or adverse weather conditions, as well as human-induced interventions like pest management practices. The slight reduction towards the latter part of the season indicates some degree of natural population regulation or effective control measures. Following the peak, a gradual decline in population was noted, which might be attributed to natural mortality factors such as predation, parasitism, or adverse weather conditions, as well as human-induced interventions like pest management practices. The slight reduction towards the latter part of the season indicates some degree of natural population regulation or effective control measures. Comparable results were reported by Akhila *et al.,* (2019) [1], who examined pest dynamics in okra cv. Arka Anamika under varying weather conditions. Burade *et al.,* (2019) [2] who explored the influence of climatic parameters on pest activity in the Parbhani Kranti variety.

Kharif Grasshopper (*Hieroglyphus nigrorepletus*)

The population of the Kharif Grasshopper showed a similar gradual increase throughout the cropping season in both years, reflecting its role as a major defoliator during the mid to late stages of okra development. Initial counts were very low or absent at week 30, with 0 to 0.03 insects per plant recorded. The pest density steadily increased from week 32 onwards, reaching a peak population of 7.0 insects per plant in week 39 during the 2022-23 season, and closely matching at 7.01 insects per plant in the same week for 2023-24. This peak corresponds with the crop's flowering and early fruiting stages when foliage is tender and most vulnerable to grasshopper feeding. Post peak, the grasshopper numbers gradually declined but remained significant enough to cause continued damage as per the findings of [10, 13]. The consistent peak timing in both years highlights the predictable nature of this pest's infestation and emphasizes the importance of timely monitoring and control measures during critical crop growth stages. Parallel conclusions were drawn by Das *et al.,* (2021) [10] who studied pest and predator succession in the okra ecosystem. Mishra *et al.,* (2018), who assessed the dynamics of major sucking pests in okra.

The Kharif Grasshopper population showed a steady increase during the okra cropping seasons of 2022-23 and 2023-24, with minimal presence at the early stage (week 30) and a peak around week 39. This peak coincided with the flowering and early fruiting stages, when the tender foliage is most susceptible to damage. The similar population trends across both years indicate a consistent seasonal pattern, underscoring the pest's role as a major defoliator in mid to late crop growth stages. Although numbers declined after the peak, the population remained significant enough to cause damage. These findings highlight the need for timely pest monitoring and management during vulnerable crop stages to minimize yield loss. Saroj *et al.,* (2017), who found significant correlation. However, the Semi Looper populations recorded during the study were relatively lower in magnitude compared to the other pests but still displayed clear seasonal dynamics. Initial infestation levels were almost negligible in the early weeks (30 to 33), with a slow rise in numbers observed after week 34. In 2022-23, the pest population peaked at 4.44 insects per plant around week 39, while in 2023-24, the maximum population was slightly lower at 3.80 insects per plant during week 40. These peaks coincide with the late vegetative to early fruiting phases of the crop, suggesting that the Semi Looper prefers the more mature foliage for feeding. Although the overall population densities were lower than those of Red Pumpkin Beetle and Kharif Grasshopper, the Semi Looper's feeding can still cause significant defoliation and yield reduction if unmanaged as per the findings of [11, 12, 15]. The data imply that the Semi Looper emerges as a secondary but important pest in the okra ecosystem during the Kharif season.

The Semi Looper population remained relatively low compared to other major pests but showed distinct seasonal trends during the Kharif seasons of 2022-23 and 2023-24. Initial infestation was minimal during early weeks (30 to 33), followed by a gradual increase peaking around weeks 39-40, coinciding with the late vegetative to early fruiting stages. This indicates the pest's preference for mature foliage. Although its population density was lower than that of the Red Pumpkin Beetle and Kharif Grasshopper, the Semi Looper can still cause significant defoliation and impact yields if not managed properly. These findings suggest that the Semi Looper acts as a secondary yet important pest in okra during the Kharif season. Noopur *et al.,* (2022) [11] also noted variability in resistance among okra genotypes under specific agro-climatic conditions, reinforcing the role of environmental interactions.

Tobacco Caterpillar (*Spodoptera litura*)

The Tobacco Caterpillar showed a distinct population pattern with very low numbers during the initial weeks of crop growth, followed by a steady increase in later stages, particularly coinciding with fruit development. In the 2022-23 season, the population rose from zero or near zero in the first weeks to a peak of 3.50 insects per plant in week 39. The following year, the population peak was recorded slightly later at week 40, with a higher maximum of 4.17 insects per plant. This caterpillar is a notorious fruit borer and its presence during the reproductive stage poses a direct threat to yield quality and quantity. The initial low population could be attributed to early crop resistance or unfavorable conditions, whereas the peak population reflects favorable environmental conditions and increased host availability as suggested by [11, 15]. The steady rise and peak population at fruiting stages underscore the importance of targeted pest management strategies during this period to prevent severe crop losses. Shanthi *et al.,* (2020) [15] emphasized the impact of associated weeds on pest and natural enemy populations, offering ecological insights consistent with the present study.

The Tobacco Caterpillar exhibited a clear population trend, with very low numbers during early crop growth stages, followed by a steady increase peaking around fruit development. In 2022-23, the population peaked at 3.50 insects per plant in week 39, while in 2023-24, it peaked slightly later at week 40 with a higher count of 4.17 insects per plant. As a significant fruit borer, its presence during the reproductive phase directly threatens okra yield and quality. The initial low infestation may result from early crop resistance or unfavorable conditions, while the later peak aligns with favorable environmental factors and increased availability of host tissue. These observations highlight the need for timely and focused pest management during the fruiting stage to mitigate potential crop losses. Pal *et al.*, (2013) [12] reported similar pest incidences in the red lateritic zones of West Bengal, demonstrating geographic consistency in pest behavior.

Table 1: Population of Red Pumpkin Beetle, Kharif Grasshopper, Semi Looper, and Tobacco Caterpillar on Okra during Kharif 2022-23 and 2023-24

S.M.W	Red Pumpkin Beetle (*Aulacophora foveicollis*)		Kharif Grasshopper (*Hieroglyphus nigrorepletus*)		Semi Looper (Anomis sp.)		Tobacco Caterpillar (*Spodoptera litura*)	
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24
30	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.05
31	0.50	0.45	0.00	0.00	0.00	0.05	0.00	0.55
32	1.00	1.01	1.25	1.30	0.00	0.00	0.00	0.00
33	2.50	2.35	1.75	1.82	0.00	0.00	0.00	0.00
34	3.25	3.45	2.50	2.52	0.50	0.10	0.00	0.00
35	4.00	3.91	3.25	3.28	1.50	1.60	1.25	1.55
36	5.00	5.03	4.00	4.01	2.50	2.55	2.00	2.05
37	6.00	5.00	5.50	5.65	3.00	3.03	2.50	2.57
38	7.00	6.00	6.25	6.30	3.50	3.75	3.00	3.00
39	7.50	5.80	7.00	7.01	4.00	4.44	3.50	4.00
40	6.50	6.60	6.25	6.55	3.75	3.80	3.25	4.17
41	5.00	4.95	4.75	4.87	3.00	3.44	2.75	2.65
42	4.00	5.00	3.75	3.80	2.50	2.65	2.00	2.32
Max Temp (°C)	-0.515**	0.321	-0.543* *	-0.612**	-0.721**	-0.458**	0.059	-0.128
Min Temp (°C)	-0.222	-0.512	0.411	0.287	-0.393	-0.530	0.122	-0.127
Max Humidity (%)	-0.287	-0.282	0.443	0.311	-0.525**	-0.149	0.1.88	-0.111
Min Humidity (%)	-0.342**	-0.353	-0.212	-0.495**	0.332	0.139	-0.122	-0.129
Rainfall (mm)	-0.543	-0.372	-0.332	0.666	-0.232	0.465	0.622	-0.133
Sunshine (Hours)	0.605	0.588	0.512	0.540	0.540	0.679	0.720	0.735

CC: (r) = Correlation of Coefficient *5% level of significance & **1% level of significance

Conclusion

In conclusion, the Tobacco Caterpillar (*Spodoptera litura*) exhibited a distinct and consistent population trend across the two Kharif seasons studied. The pest population remained very low during the early stages of okra crop growth, likely due to initial crop resistance or less favorable environmental conditions. However, as the crop progressed into the fruit development stage, the caterpillar population increased steadily, reaching peak infestation levels of 3.50 insects per plant in week 39 during 2022-23, and a slightly later and higher peak of 4.17 insects per plant in week 40 during 2023-24. Given its status as a notorious fruit borer, the timing and magnitude of these peaks are critical, as they coincide with the reproductive phase when okra fruits are most vulnerable to damage. This infestation directly threatens both the quantity and quality of the harvest, emphasizing the need for vigilant monitoring. These findings highlight the importance of implementing targeted pest management interventions during the critical fruiting period to effectively reduce Tobacco Caterpillar damage and safeguard okra yields. Early detection and timely control measures could significantly mitigate crop losses caused by this pest.

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