**Population Dynamic of insect pests and their natural predators in Okra (*Abelmoschus esculentus* L. Moench) under semi-arid condition of Rajasthan, India**

**ABSTRACT**

This study aims to provide a comprehensive understanding of the pest and natural enemy complex associated with okra during Kharif seasons. Okra (*Abelmoschus esculentus* L. Moench), an important vegetable crop in tropical and subtropical regions, is susceptible to a variety of pests that can significantly impact yield and quality. Pest management in okra is becoming increasingly challenging due to climate change and other environmental factors. These natural enemies include various species of ladybirds, spiders, mantises, and parasitoid wasps, which help regulate pest numbers and reduce the need for chemical pesticides, thereby promoting sustainable pest management practices. The study investigates the pest complex and their natural enemies in okra during the *Kharif* seasons of 2020-21 and 2022-23, aiming to provide insights into pest dynamics and inform integrated pest management (IPM) strategies. The major pests identified include sap-suckers (Jassids, Cotton aphids, Whiteflies, and Mites), defoliators (Red pumpkin beetles, Grasshoppers, and caterpillars), and borers (Blister beetles, fruit borers, and shoot borers), which cause significant damage from the vegetative to maturity stages of the crop. Natural enemies such as Coccinellids, spiders, spraying mantises, and parasitoid wasps play a critical role in regulating pest populations and enhancing biological control. Additionally, pollinators like honeybees contribute to fruit set and overall plant health. The study highlights the seasonal fluctuations of pest populations, the effectiveness of natural enemies, and the potential for sustainable pest management through biological control. Findings from this research will support the development of eco-friendly pest management practices, reducing the reliance on chemical pesticides and promoting a balanced agroecosystem for sustainable okra production.

*Keywords:* Dynamics, Enemies, Natural, Okra and Pest.

**INTRODUCTION**

Insect pests pose major threat from sowing to harvest to this important vegetable. The damage of different insect pests varies from year to year depending upon weather conditions and the intensity of insect pests attack (Khan et al., 2015; Donatti-Ricalde et al., 2023; Mohapatra et al., 2022). Okra (*Abelmoschus esculentus* L. Moench), a widely cultivated vegetable in tropical and subtropical regions, plays an essential role in the agricultural economy. Okra (*Abelmoschus esculentus* L. Moench) is a vital vegetable crop, providing essential Vitamins, Carbohydrates, and minerals for a balanced diet [7]. In India, it is cultivated during both the Rabi and Kharif seasons and holds the top position globally with a total Okra (bhindi/lady’s finger) production in India for 2023-24 is **7.25 megatonnes**. Gujarat is the leading Okra-producing state in India, with 1.132 million tonnes for the year 2023-24[4]. Other top Bhindi-producing states include Madhya Pradesh, West Bengal, Bihar, and Andhra Pradesh[6]. In Rajasthan, okra is grown on 3,619 hectares, yielding 18,152 MT in the state (Anon, 2018-19). The crop is affected by 72 insect pests[2] (Srinivasa and Rajendran, 2003), with major pest issues occurring during the Rabi season in Rajasthan. The damage caused by pests ranges from 45 to 57.10% [3] (Srinivasan and Kumar, 1983; Nderity *et al.,* 2008). Okra is vulnerable to insect pests throughout its growth cycle, from sowing to harvest [2] (Sharma *et al*., 1997; Jagtab *et al.,* 2007). Fruit borers, such as [5] *E. vittella* Fabricius, *E. insulana* Boisduval, and *H. armigera* (Hübner), cause significant damage in the later stages, resulting in a 69% yield loss [7] (Atwal and Singh, 1990). The population of these pests fluctuates based on host availability and weather conditions[9]. Pest management in okra is becoming increasingly challenging due to climate change and other environmental factors.

These natural enemies include various species of ladybirds, spiders, mantises, and parasitoid wasps, which help regulate pest numbers and reduce the need for chemical pesticides, thereby promoting sustainable pest management practices[8].

The major pests of okra can be broadly categorized into sap-suckers, defoliators, borers, and miscellaneous insects. Sap-sucking insects such as jassids (*Amrasca biguttula*), cotton aphids (*Aphis gossypii*), whiteflies (*Bemisia tabaci*), and mites (*Polyphagotarsonemus latus*) can severely damage the plant by feeding on its sap, weakening the plant, and transmitting various viral diseases[10]. Additionally, thrips (*Scirtothrips dorsalis*), another sap-sucker, are known for causing significant injury to okra plants during the early stages of growth, resulting in stunted plants and reduced yields[11].

Defoliators, including red pumpkin beetles (*Aulacophora foveicollis*), grasshoppers (*Hieroglyphus nigrorepletus*), and various caterpillars such as the semi-looper (*Anomis* sp.) and tobacco caterpillar (*Spodoptera litura*), attack the foliage of okra plants. Borers, including blister beetles (*Mylabris pustulata*), chaffer beetles (*Oxycetonia versicolor*), fruit borers (*Helicoverpa armigera*), and shoot borers (*Leucinodes orbonalis*), pose a significant threat to the reproductive structures of okra[12]. In contrast to these destructive pests, natural enemies play an essential role in managing pest populations[15]. The presence of natural enemies such as Coccinellids (*Coccinella septempunctata*), spiders (*Clubiona* sp. and Oxyopidae species), predatory insects, and parasitoid wasps (Apenteles sp.) can help suppress pest populations and reduce the impact of pest infestation[9]. Parasitoid wasps such as Apenteles (Braconidae) are critical in parasitizing the eggs and larvae of several pest species, particularly lepidopteran larvae like the tobacco caterpillar (*Spodoptera litura*) and fruit borers (*Helicoverpa armigera*) [10]. Pollinators, such as honeybees (Apis sp.) and other arthropods like black ants (*Camponotus* sp.), also contribute to the overall health of okra plants by facilitating pollination.

This study aims to provide a comprehensive understanding of the pest and natural enemy complex associated with okra during the *Kharif* seasons of 2020-21 and 2022-23. By evaluating the pest populations and their natural predators, this research will offer valuable insights into pest dynamics, ecosystem interactions, and the potential for sustainable pest control methods.

**MATERIAL AND METHODS**

Ajmer is located in the heart of Rajasthan between 26° 44' north latitudes and 74° 63' east longitudes. The total area is 8,481 km², and area-wise it ranks 14th in the state and ranks 8th in terms of population in Rajasthan [27]. Ajmer is surrounded by the Aravalli ranges. To the north of the city is a large artificial lake, called Anasagar. This district is almost triangular.
The Ajmer district is divided into three physiographic units, *viz,* Eastern Rajasthan upland, Semi-Arid transitional plain, and Aravalli landscape. The climate of the Ajmer district is generally characterized by hot, dry, and semi-arid conditions. It has a hot, dry summer ranging between the months of April to June as well as cold bracing winters from November to February [27]. The research work was conducted at the Crop Cafeteria, Faculty of Agriculture Sciences, Bhagwant University, Ajmer, during the *Kharif* seasons of (2021-22 & 2022-23). The study focused on the population dynamics of insect pests affecting okra (*Abelmoschus esculentus*), particularly targeting the pests *H. armigera* (*Helicoverpa armigera*) and *insulana* (Spodoptera litura), which cause significant damage to fruits in the later stages of growth. *H. armigera* was observed to result in up to 69% yield loss, as reported by Atwal and Singh [17]. The trial was conducted using the variety 'Arka Anamika~~,'~~ sown in a 450 m² plot. Experimental Design: Randomized Block Design (RBD), with 3 replications, Plot size: 450m², Spacing: 60 x 30cm (Row to row and plant to plant). Periodic observations on pest populations were made throughout the growing season, starting from seedling emergence and continuing until the final harvest. These observations included monitoring the number of healthy and damaged fruits from 10 randomly selected plants to assess pest damage. The selected plants were observed for pest infestations, and the collected fruits were cut open to count the larvae of shoot and fruit borers.

**A. Sap Suckers**

**Pest Groups:** Jassid (*Amrasca biguttula*), Cotton aphid (*Aphis gossypii*), Whitefly (*Bemisia tabaci*), Thrips (*Scirtothrips dorsalis*), Mite (*Polyphagotarsonemus latus*)

* **Sampling:** Weekly surveys conducted to assess pest abundance on plant leaves.
* **Impact:** Assess pest damage on growth and health.

**B. Defoliators**

**Pest Groups:** Red pumpkin beetle (*Aulacophora foveicollis*), Kharif grasshopper (*Hieroglyphus nigrorepletus*), Semi looper (*Anomis sp.*), Tobacco caterpillar (*Spodoptera litura*)

* **Sampling:** Bi-weekly surveys for leaf damage, counting pest numbers.
* **Impact:** Monitor defoliation effects on plant health.

**C. Borers**

**Pest Groups:** Blister beetle (*Mylabris pustulata*), Chaffer beetle (*Oxycetonia versicolor*), Fruit borer (*Helicoverpa armigera*), Shoot borer (*Leucinodes orbonalis*)

* **Sampling:** Bi-weekly checks for signs of tunneling and damage to shoots and fruits.
* **Impact:** Assess yield loss and plant health due to borers.

**D. Natural Enemies**

**Natural Enemies:** Coccinellids (*Coccinella septempunctata*), Sac spider (*Clubiona sp.*), Praying mantis (*Mantis sp.*), Green lacewing (*Chrysoperla carnea*), Parasitoid wasp (*Apenteles sp.*)

* **Sampling:** Weekly surveys to observe natural enemies, noting their impact on pests.
* **Impact:** Evaluate natural enemies' effectiveness in pest control.

**E. Pollinators & Other Arthropods**

**Arthropods:** Honey bee (*Apis sp.*), Black ant (*Camponotus sp.*)

* **Sampling:** Weekly observation of pollinators during flowering.
* **Impact:** Correlate pollinator activity with fruit set and yield.

These observations helped in determining the extent of damage caused by these pests, as well as their impact on the overall yield of okra. The data for both *Kharif* seasons in 2020-21 and 2022-23 were combined before conducting any statistical analysis using appropriate mathematical formulas. The data associated with the impact of pest management strategies on insect pest populations and their natural enemies were subjected to square root transformation (√x+1) prior to performing ANOVA analysis (including zero values). Analysis of variance (ANOVA) was carried out for various parameters, including leafhopper, whitefly, aphid, shoot and fruit borer infestation, coccinellid and spider populations.

**RESULTS AND DISCUSSION**

Table 1 presents a comprehensive list of the various pests and natural enemies associated with okra crops. This table summarizes the pests and natural enemies observed on Okra during the Kharif seasons of 2021-22 and 2022-23, categorized by their functional groups (Sap Suckers, Defoliators, Borers, Natural Enemies, and Pollinators & Other Arthropods), along with their scientific names, families, orders, and crop stage of occurrence.

**A. Sap Suckers:** Sap-sucking pests, including Jassids (*Amrasca biguttula biguttula*), cotton aphids (*Aphis gossypii*), whiteflies (*Bemisia tabaci*), thrips (*Scirtothrips dorsalis*), and mites (*Polyphagotarsonemus latus*), were observed throughout the vegetative to maturity stages of the okra crop. These pests typically feed on plant sap, causing damage to the crop through direct feeding and facilitating the spread of various plant diseases. Similar findings were suggested by [12,15,16,19].

**B. Defoliators:** Defoliating insects, such as red pumpkin beetles (*Aulacophora foveicollis*), *Kharif* grasshoppers (*Hieroglyphus nigrorepletus*), semi-loopers (*Anomis sp.*), and tobacco caterpillars (*Spodoptera litura*), were present from the vegetative to maturity stages. These pests feed on the foliage of the okra plant, leading to significant defoliation, which can weaken the plant and reduce yield potential. The present investigation partially concurs with earlier findings by [11,14,16,17,18].

**C. Borers:** Borers, including blister beetles (*Mylabris pustulata*), chaffer beetles (*Oxycetonia versicolor*), fruit borers (*Helicoverpa armigera*), and shoot borers (*Leucinodes orbonalis*), were observed during the flowering to maturity stages. These insects bore into plant tissues, causing damage to the plant’s fruit, flowers, and shoots, often leading to direct losses in yield. Our results corroborate the observations made by [13,19,21,24,26].

**D. Natural Enemies:** Natural enemies of pests, such as Coccinellids (*Coccinella septempunctata*), sac spiders (*Clubiona sp.*), predatory spiders (unidentified species), praying mantises (*Mantis sp.*), green lacewings (*Chrysoperla carnea*), dragonflies (*Agriocnemis sp.*), and parasitoid wasps (*Apenteles*), were also observed throughout the vegetative to maturity stages. These organisms help control pest populations by preying on or parasitizing harmful insects, thus playing a crucial role in integrated pest management. The current study aligns with previous reports by [18,20,22]

**E. Pollinators and Other Arthropods:** Pollinators such as honey bees (*Apis sp.*) and black ants (*Camponotus sp.*) were identified during the vegetative to maturity stages. These species contribute to the pollination of okra flowers, aiding in the reproduction and fruiting of the crop. The data from the *Kharif* seasons reveal a variety of pests and beneficial organisms interacting with okra crops. Proper management of these pests and the encouragement of natural enemies are crucial for maintaining the health and productivity of the crop. The presence of natural enemies and pollinators further highlights the importance of sustainable pest management practices in okra cultivation. Our results are consistent with those previously documented by [23,25,27,28].

**CONCLUSION**

The study of pests and natural enemies associated with okra during the *Kharif* seasons reveals significant insights into the dynamics of pest populations and their impact on crop growth. The major pests identified, including sap suckers, defoliators, and borers, pose substantial threats to okra productivity, affecting the plant from the vegetative stage to maturity. However, the presence of natural enemies, such as coccinellids, spiders, praying mantises, and parasitoid wasps, provides an essential mechanism for controlling these pest populations naturally. The role of pollinators, such as honey bees and black ants, also underscores the importance of maintaining biodiversity and fostering an environment conducive to the growth and development of beneficial arthropods. These natural processes contribute to the overall health of the ecosystem, helping to mitigate the reliance on chemical pesticides. Therefore, integrating pest management strategies that leverage natural enemies, promote pollination, and minimize pesticide use will enhance the sustainability of okra cultivation. Effective monitoring of pests and natural enemy populations throughout the crop's growth stages is essential to ensure balanced pest control and maximize yield potential while promoting environmental health.

**FUTURE SCOPE**

The future scope of pest and natural enemy management in okra cultivation lies in the integration of advanced monitoring techniques, biological control strategies, and sustainable practices. Focus should be placed on refining pest forecasting models, enhancing the efficacy of natural predators and parasitoids, and promoting the conservation of pollinators like honey bees and black ants. Additionally, addressing pesticide resistance, exploring genetic resistance in okra varieties, and assessing the impacts of climate change on pest dynamics will be essential for long-term sustainability. Collaborative research involving farmers and researchers, alongside the widespread adoption of integrated pest management (IPM) practices, will play a critical role in minimizing the reliance on chemical pesticides while fostering a balanced, healthy ecosystem for okra production.

**Declarations**

**Competing interests**

The authors declare that there are no competing interests regarding the publication of this research.

**Ethics declaration**

This study was in accordance with relevant Institutional, National and International guidelines and legislation.

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**Table1: Pests and Natural Enemies of Okra during *Kharif* – 2020-21 and 2022-23**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S.No.** | **Common Name** | **Scientific Name** | **Family** | **Order** | **Crop Stage** |
| **A. Sap Suckers** |  |  |  |  |  |
| 1 | Jassid | *Amrasca biguttula biguttula (Ishida)* | Cicadellidae | Hemiptera | Vegetative to maturity |
| 2 | Cotton aphid | *Aphis gossypii (G.)* | Aphididae | Hemiptera | Vegetative to maturity |
| 3 | Whitefly | *Bemisia tabaci (Genn.)* | Aleyrodidae | Hemiptera | Vegetative to maturity |
| 4 | Thrips | *Scirtothrips dorsalis (Hood)* | Thripidae | Thysanoptera | Vegetative to maturity |
| 5 | Mite | *Polyphagotarsonemus latus (Bank)* | Tetranychidae | Araneae | Vegetative to maturity |
| **B. Defoliators** |  |  |  |  |  |
| 6 | Red pumpkin beetle | *Aulacophora foveicollis Fab.* | Chrysomelidae | Coleoptera | Vegetative to maturity |
| 7 | Kharif grasshopper | *Hieroglyphus nigrorepletus (Bol.)* | Acrididae | Orthoptera | Vegetative to maturity |
| 8 | Semi looper | *Anomis sp.* | Noctuidae | Lepidoptera | Vegetative to maturity |
| 9 | Tobacco caterpillar | *Spodoptera litura (Fab.)* | Noctuidae | Lepidoptera | Vegetative to maturity |
| **C. Borers** |  |  |  |  |  |
| 10 | Blister beetle | *Mylabris pustulata (Thumb.)* | Meloidae | Coleoptera | Flowering to maturity |
| 11 | Chaffer beetle | *Oxycetonia versicolor (Fab.)* | Cetonidae | Coleoptera | Flowering to maturity |
| 12 | Fruit borer | *Helicoverpa armigera (Hubner)* | Noctuidae | Lepidoptera | Flowering to maturity |
| 13 | Shoot borer | *Leucinodes orbonalis* (Guenée) | Crambidae | Lepidoptera | Flowering to maturity |
| **D. Natural Enemies** |  |  |  |  |  |
| 14 | Coccinellids | *Coccinella septempunctata (L.)* | Coccinellidae | Coleoptera | Vegetative to maturity |
| 15 | Sac spider | *Clubiona sp.* | Oxyopidae | Araneae | Vegetative to maturity |
| 16 | Predatory spider | *Unidentified species* | Oxyopidae | Araneae | Vegetative to maturity |
| 17 | Praying mantis | *Mantis sp.* | Mantidae | Dictyoptera | Vegetative to maturity |
| 18 | Green lacewing | *Chrysoperla carnea* | Chrysopidae | Neuroptera | Vegetative to maturity |
| 19 | Dragonfly | *Agriocnemis sp.* | Coenagridae | Odonata | Vegetative to maturity |
| 20 | Apenteles (Parasitoid wasp) | *Apenteles* | Braconidae | Hymenoptera | Vegetative to maturity |
| **E. Pollinators & Other Arthropods** |  |  |  |  |  |
| 21 | Honey bee | *Apis sp.* | Apidae | Hymenoptera | Vegetative to maturity |
| 22 | Black ant | *Camponotus sp.* | Formicidae | Hymenoptera | Vegetative to maturity |