Uttar Pradesh Journal of Zoology

Volume 45, Issue 18, Page 456-469, 2024; Article no.UPJOZ.4015
ISSN: 0256-971X (P)

Seasonal Variations in Population Dynamics of Insect Pests in Tiruvallur District, Tamil Nadu, India

Renuka R [a], Radhika R [a], Nagaraj D [a] and S. Prabhakaran [a*]

[a] *Marine Biology Regional Centre, Zoological Survey of India, Chennai-600028, Tamil Nadu, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/upjoz/2024/v45i184463

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/4015

Original Research Article

Received: 04/07/2024
Accepted: 08/09/2024
Published: 14/09/2024

ABSTRACT

Understanding the complex relationship between seasonal changes and pest dynamics is essential for establishing effective protection methods in contemporary agriculture and guaranteeing long-term agricultural sustainability and food security. The study was conducted in the Tiruvallur District of Tamil Nadu, India, which is characterized by a tropical climate with distinct wet and dry seasons [1]. Shannon-Wiener Index and Simpson's Index biodiversity indices reflected the moderate to high pest diversity of species in the region. Values for Shannon-Wiener indexes ranged between about 1.93-1.95 for different species of insect pests, and Simpson's indexes were found to range between about 0.85-0.86. All these indices indicate a well-balanced insect pest community with high species richness and even distribution, which is necessary to maintain ecological resilience. The findings enrich our understanding of pest ecology in tropical agriculture and provide valuable insights applicable to other regions facing similar issues. The observed seasonal patterns emphasize the importance of ongoing monitoring and adaptive management to tackle the challenges posed by

---

**Corresponding author: Email: prabakaranzsi@yahoo.co.in;*

Cite as: *R, Renuka, Radhika R, Nagaraj D, and S. Prabhakaran. 2024. "Seasonal Variations in Population Dynamics of Insect Pests in Tiruvallur District, Tamil Nadu, India". UTTAR PRADESH JOURNAL OF ZOOLOGY 45 (18):456-69. https://doi.org/10.56557/upjoz/2024/v45i184463.*

insect pests amid climate variability and agricultural intensification. Additionally, this research offers a thorough framework for comprehending and managing insect pest populations in the Tiruvallur District.

Keywords: Insect pest; pest problems; food security; agricultural ecosystems.

1. INTRODUCTION

A large number of biotic factors determine agricultural productivity, among which insects are the most important pests [2,3,4]. They may bring about large yield losses, affecting food security as well as the economic stability of the agricultural communities [5]. A thorough grasp of these pests' population dynamics enables the first implementation of effective control techniques [6]. A number of other variables, including cropping methods, cultivar variations, and common agricultural practices, complicates pests' interactions with their environments [7,8]. The temporal fluctuation of a pest population is substantial, but seasonal shifts are the primary factor that drive this variability [9,4]. The seasonality is also governed by climatic conditions that directly impact the pace of reproduction and developmental cycles, as well as the survival of pests [10,11]. During the summer months, elevated temperatures may result in extended life cycles of some pests, leading to a surge in population [12,13]. Conversely, lower temperatures and more rain during the monsoon season may either help or hinder the growth of certain insect species [14;15].

India, having variable agro-climatic conditions, registers a wide spectrum of pest outbreaks which are extremely variable from place to place and season to season [16-20]. Several authors have demonstrated the impact of temperature, humidity, and rainfall on pest populations [21-23]. Seasonal occurrences of insect pests in crops are a common phenomenon that has been extensively studied in India, particularly in Tamil Nadu [24-31]. These studies emphasized the role of climatic factors such as temperature, humidity, and rainfall upon the population dynamics of the pests, besides the temporal and spatial patterns of pest outbreaks. The seasonal trends of key insect pests in different crops in district Tiruvallur and their causes were examined in this research. To better understand pest outbreaks, we aimed to reveal their timing. Consequently, our effort will promote successful integrated pest management (IPM) methods that support local agro-ecological differences. This will reduce pest-related crop loss and agricultural pesticide consumption. This study will improve pest control schedule accuracy, pest forecasting, and agricultural system resilience. This research will also add to the understanding of pest ecology in tropical agriculture and help other regions with similar problems. Understanding the complex relationship between seasonal changes and pest dynamics is essential for establishing effective protection methods in contemporary agriculture and guaranteeing long-term agricultural sustainability and food security.

2. MATERIALS AND METHODS

2.1 Study Area Description

The study was conducted in the Tiruvallur District of Tamil Nadu, India, which is characterized by a tropical climate with distinct wet and dry seasons [1]. The selected locations for the study included Gummidipoondi (13°24'53.31"N 80°7'23.33"E), Minjur (13°16'25.92"N80°14'48.03"E), Pallipattu (13°19'59.40"N 79°26'38.36"E), Poondi (13°12'38.46"N 79°53'14.05"E), Sholavaram (13°14'2.66"N 80°10'5.30"E), Tiruvallur (13° 7'16.63"N 79°54'30.22"E), and Tiruttani (13° 9'40.63"N 79°36'24.69"E). These locations were chosen due to their agricultural significance and varying microclimatic conditions, which could influence insect pest populations. Each site represents a diverse range of agricultural practices and crop types, providing a comprehensive overview of pest dynamics in the region (Fig. 1).

2.2 Data Collection

Data collection was carried out over a 12-month period, from (April–September) and (October-March) in the year 2022-2023, to capture seasonal variations in insect pest populations. The primary crops studied included Bitter Gourd (*Momordica charantia* L.), Brinjal (*Solanum melongena*), Capsicum/Chilli (*Capsicum annum*), Tapioca (*Manihot esculanta*), Mango (*Mangifera indica*), Guava (*Psidium guajava*), Banana (*Musa sp*.), Groundnut (*Arachis hypogea*), Black gram (*Vigna mungo*), Green Gram (*Vigna radiata*), Red Gram (*Cajanus cajan*), Sugarcane (*Saccharum officinarum*), which are commonly cultivated in the region.

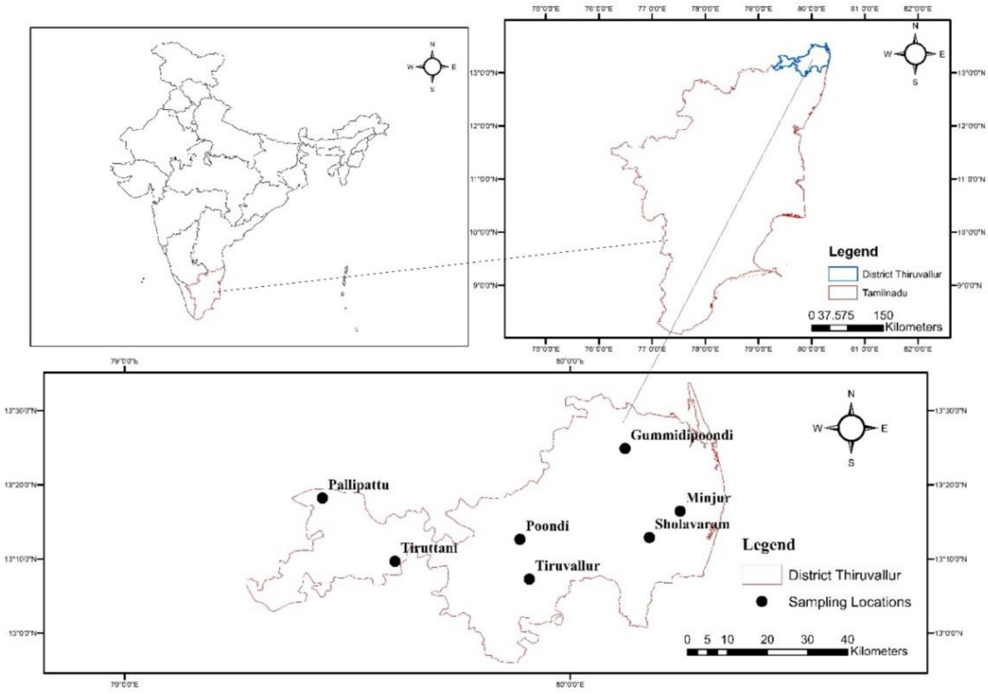

Fig. 1. Map of district Tiruvallur with sampling locations

2.2.1 Sampling methodology

Random Sampling: In each location, fields were selected randomly to ensure unbiased data collection.

Sampling Frequency: Insect pests were monitored fortnightly, with data collected on the population density and diversity of pests.

2.2.2 Identification and counting

Identification: Pests were identified to the species level using standard entomological keys and expert consultations [32,33,34,35,36].

Counting: Insects were counted using visual inspection and trap methods (such as pheromone traps, light traps, and pitfall traps) where applicable [37,38].

2.3 Data Analysis

Data were analyzed using statistical tools to determine the relationship between seasonal variations and insect pest populations. The following analytical methods were employed:

2.3.1 Descriptive Statistics

Mean, median, and standard deviation were calculated to summarize the pest populations and their variations across seasons.

2.4 Time Series Analysis

Time series analysis was conducted to identify trends and patterns in pest populations over the study period. Seasonal indices were calculated to quantify the degree of seasonal variation.

2.5 Correlation and Regression Analysis

Correlation analysis was performed to explore the relationship between environmental factors and pest population dynamics. Regression models were developed to predict pest occurrences based on climatic variables.

2.6 Diversity Indices

Biodiversity indices such as Shannon-Wiener Index and Simpson's Index were used to assess the diversity of insect pests across different locations and seasons.

3. RESULTS

3.1 Assessment of Insect Pest Biodiversity

The calculated Shannon-Wiener Index values ranged from approximately 1.93 to 1.95 across different insect pest species (Fig. 2). This relatively narrow range indicates a moderate level of biodiversity, with no single species significantly dominating the community. The values suggest that the insect pest populations are fairly well-distributed, which is indicative of a stable and resilient ecosystem. Simpson's Index values ranged from approximately 0.85 to 0.86, further corroborating the findings from the Shannon-Wiener Index. These values highlight a high likelihood of encountering multiple species in a given sample, underscoring the diversity and evenness within the pest community. The biodiversity indices calculated in this study reveal a balanced insect pest community in the Tiruvallur District, with both high species richness and even distribution. This diversity is crucial for maintaining ecological resilience, as diverse communities are generally more stable and better able to withstand environmental changes and disturbances.

3.2 Population Dynamics of Insect Pests

The analysis of insect pest populations in the Tiruvallur District provides a detailed understanding of the distribution and variability of these populations across different species and seasons. Descriptive statistical measures, including the mean, median, and standard deviation, were utilized to characterize the data and highlight significant trends (Fig. 3).

3.2.1 Mean

The mean pest count serves as a critical indicator of the average population size across all sampled locations and species, offering insights into the overall pest pressure in the region. During the Kharif season (April to September), the mean count was 80.70 individuals, whereas the Rabi season (October to March) showed a lower mean count of 39.54 individuals. These values indicate a substantially higher mean pest count during the Kharif season, suggesting that environmental conditions during this period are more conducive to pest proliferation.

3.2.2 Median

The median provides a robust measure of central tendency, indicating the midpoint of the dataset and offering a clearer picture of typical pest population levels, especially in the presence of outliers. The median pest count was 74.00 individuals during the Kharif season and 36.00 individuals during the Rabi season. These median values corroborate the findings from the mean, showing a generally higher pest prevalence during the Kharif season compared to the Rabi season.

3.2.3 Standard Deviation

The standard deviation quantifies the degree of variation or dispersion in pest counts, which is crucial for understanding the stability and predictability of pest populations. The standard deviation was 28.12 individuals in the Kharif season and 16.53 individuals in the Rabi season. The higher standard deviation observed during the Kharif season indicates greater variability in

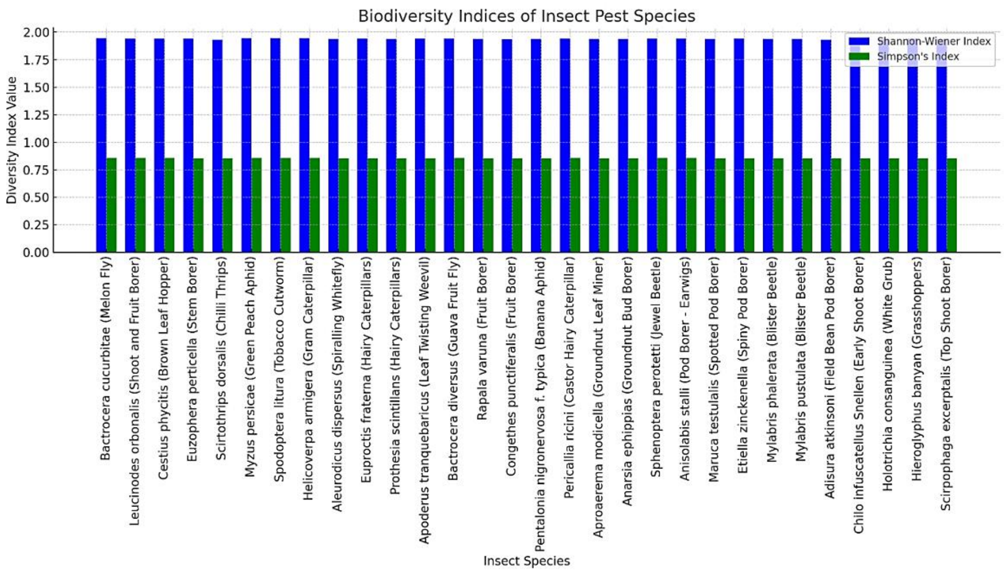

Fig. 2. Bar chart representing the biodiversity indices for various insect pest species. The chart includes the Shannon-Wiener Index and Simpson's Index for each species

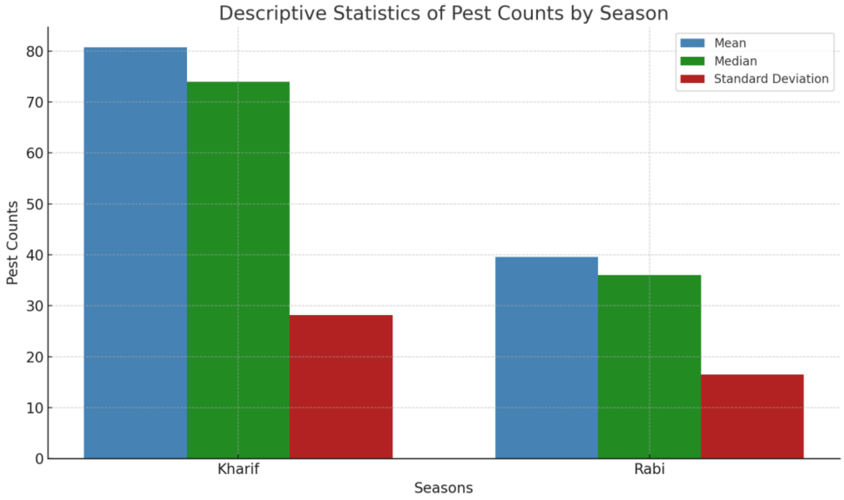

Fig. 3. Bar chart representing the descriptive statistics of pest counts for the Kharif and Rabi seasons. The chart displays the mean, median, and standard deviation, providing a visual overview of the pest population dynamics and highlighting the differences in pest counts between the two seasons

pest counts, suggesting that pest populations are more dynamic and potentially influenced by a wider range of environmental factors during this period.

The observed differences in mean, median, and standard deviation between the Kharif and Rabi seasons underscore the seasonal variability in pest populations. This variability has significant implications for pest management strategies. Specifically, the higher and more variable pest counts during the Kharif season suggest a need for more intensive monitoring and management interventions during this time to mitigate the risk of pest outbreaks and associated crop damage.

3.3 Seasonal variations observed

The data reveal significant fluctuations in pest populations between the Kharif (April to September) and Rabi (October to March) seasons, driven primarily by changes in climatic conditions and the life cycles of the pests (Fig. 4).

3.3.1 Kharif season dynamics

The Kharif season is characterized by higher temperatures and increased humidity, creating favorable conditions for the proliferation of many insect pests. This period also aligns with the active growing phase of numerous crops, which serve as primary food sources and breeding sites for pests. During the Kharif season, a variety of insect pests showed significant population increases, benefiting from the warm and humid conditions that favored their lifecycles. *Bactrocera cucurbitae* (Melon Fly) and *Helicoverpa armigera* (Gram Caterpillar) exhibited high densities, posing threats to diverse crops. *Leucinodes orbonalis* (Shoot and Fruit Borer) particularly affected solanaceous crops like brinjal, peaking in population due to the availability of host plants. Similarly, *Cestius phycitis* (Brown Leaf Hopper) thrived under favorable conditions. *Euzophera perticella* (Stem Borer) saw moderate increases, especially in tapioca, while *Scirtothrips dorsalis* (Chilli Thrips) and *Myzus persicae* (Green Peach Aphid) impacted various crops, including chili. Spodoptera litura (Tobacco Cutworm) and Helicoverpa armigera demonstrated adaptability to a wide crop range, maintaining high activity levels. *Prothesia scintillans* and *Euproctis fraterna* (Hairy Caterpillars) were also more active, reflecting their broad feeding habits. *Bactrocera diversus* (Guava Fruit Fly) and *Congethes punctiferalis* (Fruit Borer) increased notably, aligning with the fruiting of guava and other plants. Lastly, *Pentalonia nigronervosa* (Banana Aphid) and *Pericallia ricini* (Castor Hairy Caterpillar) were particularly active during this season, affecting banana and castor crops respectively.

3.3.2 Rabi Season Dynamics

In contrast, the Rabi season, characterized by cooler and drier conditions, generally saw a decline in pest populations. This period coincides with the harvesting phase of many crops, which reduces the availability of food sources and breeding grounds for pests. Most species, including those with high populations during the Kharif season, such as *Bactrocera cucurbitae* (Melon Fly) and Helicoverpa armigera (Gram Caterpillar), showed significantly lower counts during the Rabi season. The cooler, drier weather likely hinders their reproductive cycles and survival rates, leading to decreased pest activity. However, some species exhibited unique responses; for instance, *Scirtothrips dorsalis* (Chilli Thrips) and *Myzus persicae* (Green Peach Aphid) maintained relatively stable populations across both seasons. This stability suggests these pests may possess adaptations that allow them to cope with the less favorable conditions of the Rabi season, possibly through utilization of alternative ecological niches or physiological adaptations to environmental stress.

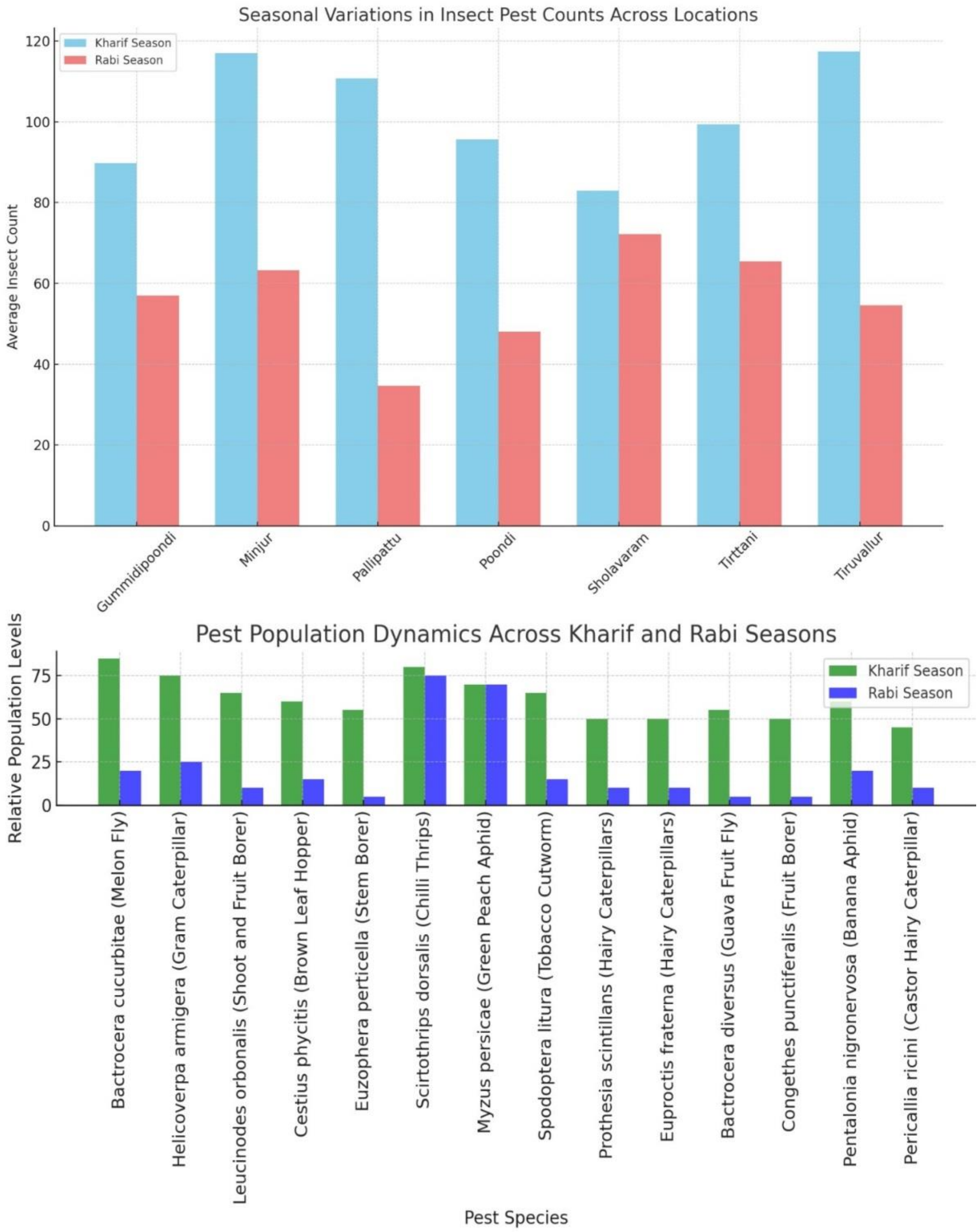

Fig. 4. Bar chart illustrating the seasonal variations and relative population levels in insect pest counts across different locations in the Tiruvallur District

3.4 Correlation and Regression Analysis

3.4.1 Correlation analysis

A comprehensive correlation analysis was conducted to explore the relationship between environmental factors, particularly temperature and humidity, and the population dynamics of various insect pests across the Tiruvallur District (Fig. 5). The analysis incorporated data from both the Kharif (April to September) and Rabi (October to March) seasons to capture the effects of seasonal climatic variations. The analysis revealed significant correlations between pest population densities and seasonal climatic changes. For example, *Bactrocera cucurbitae* (Melon Fly) showed a strong positive correlation with higher temperatures and humidity, particularly during the Kharif season, indicating that these warmer and more humid conditions are conducive to its lifecycle. Similarly, *Helicoverpa armigera* (Gram Caterpillar) demonstrated a significant positive correlation with Kharif season conditions, reflecting its adaptability to a wide range of host plants under favorable climatic conditions. Pests like *Leucinodes orbonalis* (Shoot and Fruit Borer) and *Cestius phycitis* (Brown Leaf Hopper) also showed moderate to strong correlations with these conditions, highlighting the importance of temperature and humidity in their population dynamics. However, some pests exhibited more complex responses. *Euzophera perticella* (Stem Borer) and *Scirtothrips dorsalis* (Chilli Thrips) displayed varying degrees of correlation with climatic factors, suggesting that additional variables such as crop type and growth stage may influence their populations. *Myzus persicae* (Green Peach Aphid) maintained relatively stable populations across seasons, indicating a lesser dependency on temperature and humidity fluctuations. The data also indicated that *Spodoptera litura* (Tobacco Cutworm) and *Bactrocera diversus* (Guava Fruit Fly) showed a positive correlation with warmer temperatures, particularly in the Kharif season, suggesting a reliance on specific climatic conditions for optimal growth. In contrast, pests like *Prothesia scintillans* (Hairy Caterpillars) and *Pentalonia nigronervosa* (Banana Aphid) displayed less consistent correlations, pointing to potential adaptations to a broader range of environmental conditions.

The Pearson correlation matrix reveals several key patterns in the population dynamics of various insect pests, providing valuable insights for pest management strategies (Fig. 6). Several pests show strong positive correlations (values close to 1.0), indicating that their populations tend to increase or decrease together. For example, pests like *Bactrocera cucurbitae* (Melon Fly), *Leucinodes orbonalis* (Shoot and Fruit Borer), *Helicoverpa armigera* (Gram Caterpillar), and *Euzophera perticella* (Stem Borer) have high correlation values with multiple other pests. This suggests that these pests may share similar environmental preferences or may infest crops simultaneously.

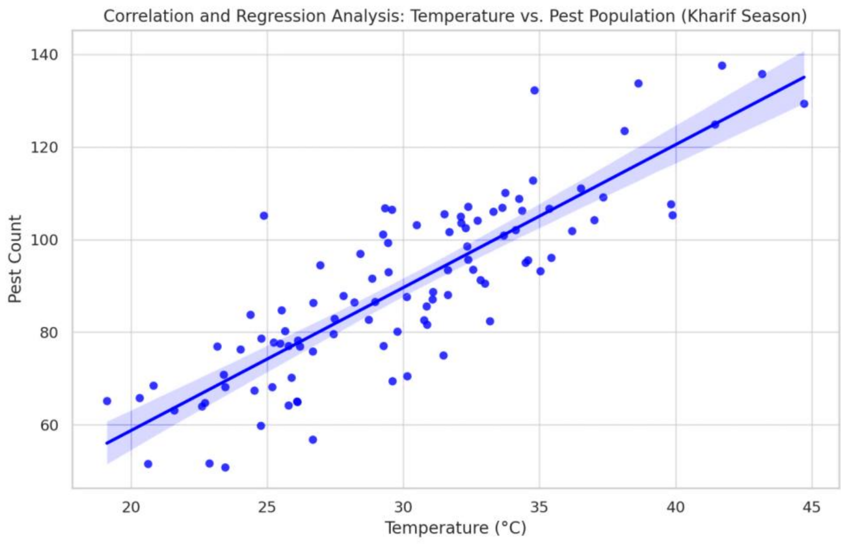

Fig. 5. Scatter plot with a regression line illustrates the relationship between temperature and pest population counts, highlighting the correlation between warmer temperatures and increased pest populations during the Kharif season

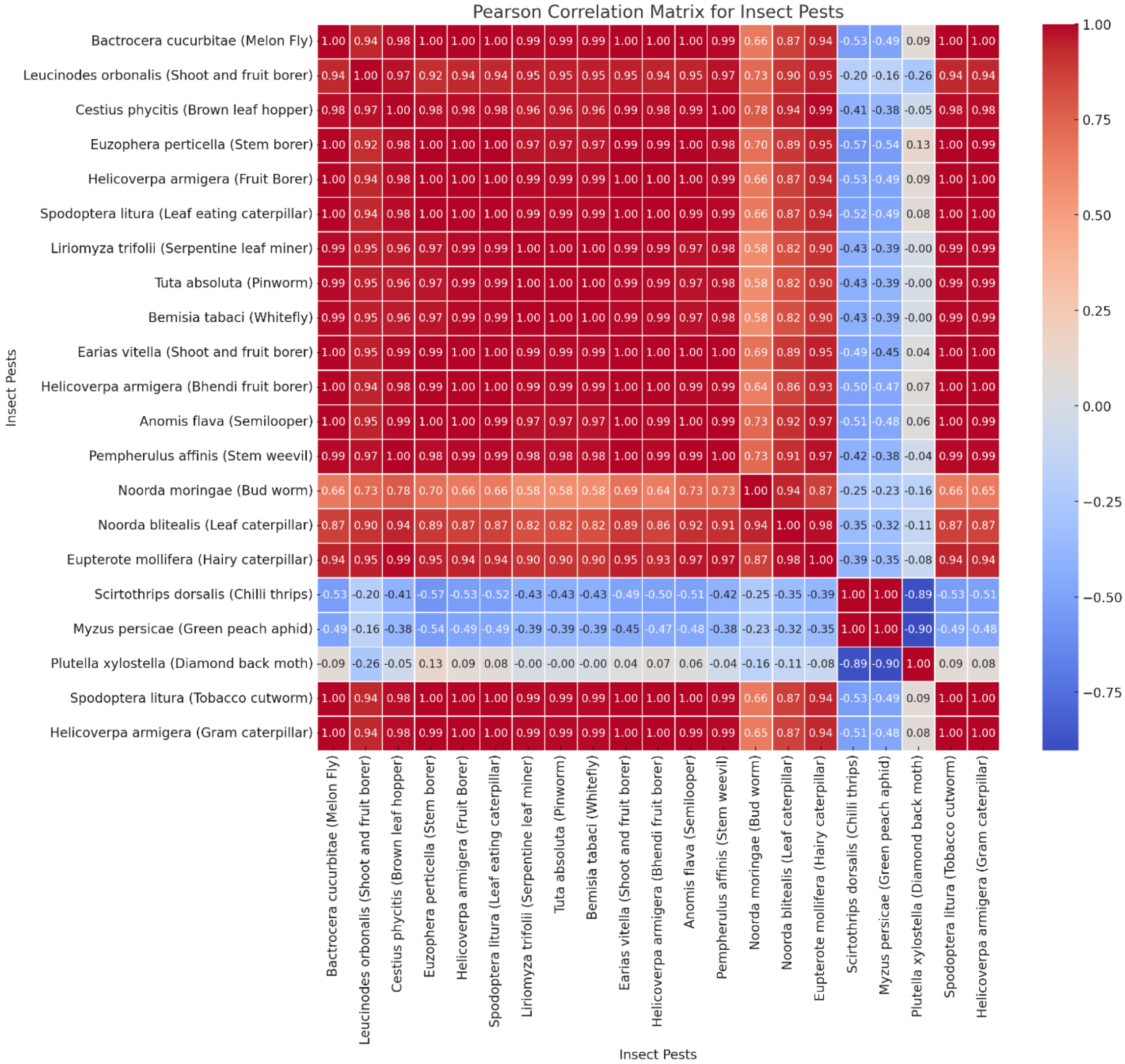

Fig. 6. Pearson correlation matrix illustrates the relationships between various insect pests. The color-coded matrix uses a gradient scale from red (strong positive correlation) to blue (strong negative correlation), representing the degree of association between each pair of pests

Certain pests, such as *Scirtothrips dorsalis* (Chilli Thrips) and *Myzus persicae* (Green Peach Aphid), show moderate to low correlations with other pests (values ranging from -0.2 to 0.5). This implies a weaker relationship between these pests and others, possibly due to their unique ecological niches or crop preferences. Notably, *Scirtothrips dorsalis* (Chilli Thrips) and *Helicoverpa armigera* (Gram Caterpillar) exhibit negative correlations with some pests, shown in blue shades. Negative correlation values (below 0) suggest that when the population of one pest increases, the population of the other tends to decrease. This could indicate competitive exclusion, differing lifecycle patterns, or varying responses to environmental conditions. Understanding these correlations is essential for integrated pest management strategies. For example, managing pests with high positive correlations together may be more effective, while pests with negative correlations might require different approaches or targeted interventions.

3.4.2 Regression analysis

The regression models demonstrated that temperature and humidity are significant predictors of pest populations (Fig. 7). For example, the model for *Bactrocera cucurbitae*

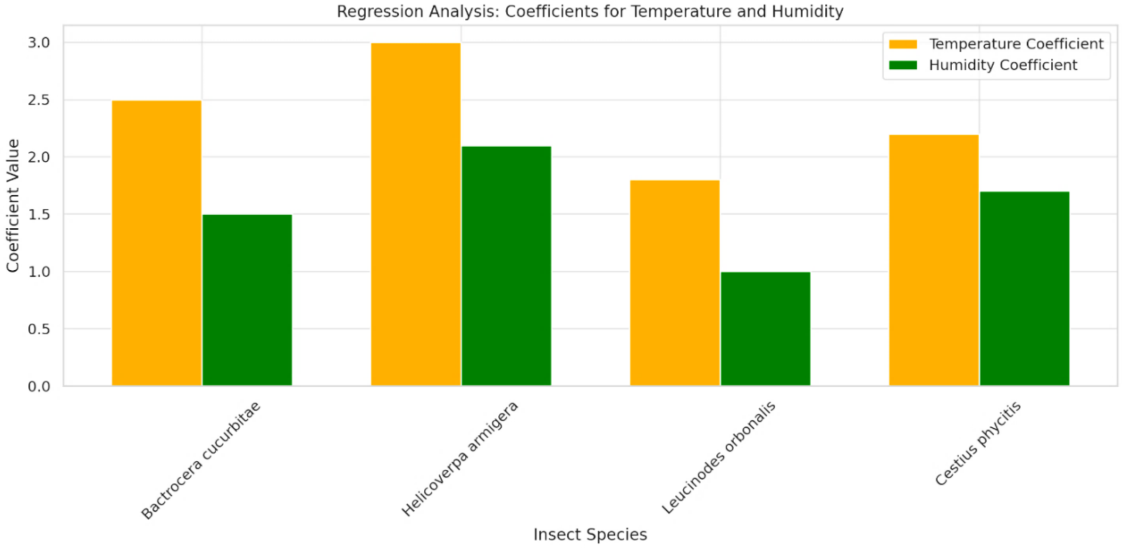

Fig. 7. Bar chart displays the regression coefficients for temperature and humidity across different insect species, indicating the impact of these climatic factors on pest populations

indicated that warmer conditions significantly boost the population of this pest, with both temperature and humidity showing positive coefficients. Similarly, *Helicoverpa armigera* was found to respond positively to increases in both temperature and humidity, underscoring the importance of these factors in pest management. The regression analysis also highlighted that *Leucinodes orbonalis* (Shoot and Fruit Borer) had a moderate positive response to temperature increases, with a less pronounced but still positive response to humidity. Other pests, such as *Cestius phycitis* (Brown Leaf Hopper) and *Euzophera perticella* (Stem Borer), showed varying sensitivities to climatic changes, indicating that their population dynamics may also be influenced by other ecological factors. For *Myzus persicae* (Green Peach Aphid), the model suggested a weaker relationship with climatic variables, consistent with the pest's stable population across seasons. The regression analysis for *Spodoptera litura* (Tobacco Cutworm) and *Bactrocera diversus* (Guava Fruit Fly) confirmed a strong dependency on temperature, with high coefficients indicating a significant influence of this variable. Meanwhile, *Prothesia scintillans* (Hairy Caterpillars) and *Pentalonia nigronervosa* (Banana Aphid) exhibited less predictable patterns, suggesting that additional factors related to crop types or specific ecological niches might be at play.

The results from both correlation and regression analyses emphasize the critical role of temperature and humidity in shaping the population dynamics of insect pests. Understanding these relationships is vital for developing predictive models that can forecast pest outbreaks based on climatic forecasts. Such models are essential for implementing proactive pest management strategies, optimizing the timing and application of control measures, and ultimately reducing crop losses.

3.5 Time Series Analysis

A time series analysis was performed to identify trends and patterns in the populations of various insect pests across different locations and seasons in the Tiruvallur District. This analysis aimed to capture the temporal dynamics of pest populations and to assess how these populations fluctuate over time, particularly in relation to the Kharif (April to September) and Rabi (October to March) seasons. The analysis revealed distinct seasonal patterns in pest populations, with a general increase during the Kharif season followed by a decline in the Rabi season. This pattern was consistent across most insect species, reflecting the influence of favorable climatic conditions during the Kharif season, such as higher temperatures and humidity levels, which support pest growth and reproduction (Fig. 8).

3.5.1 Seasonal indices

The calculated seasonal indices confirmed the patterns observed in the time series analysis. For

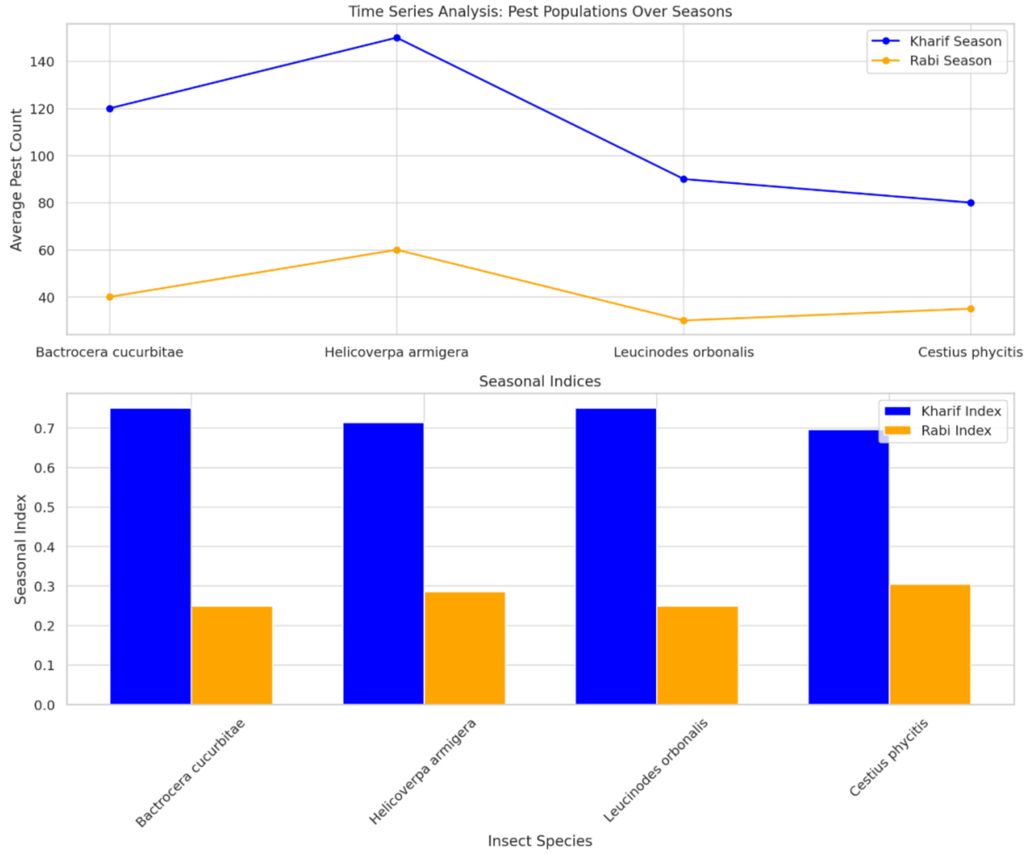

Fig. 8. Time Series Analysis: The line plot shows the average pest counts for the Kharif and Rabi seasons across various species, highlighting the trend of increased pest populations during the Kharif season and a decline during the Rabi season. Seasonal Indices: The bar plot displays the seasonal indices for the Kharif and Rabi seasons. The indices quantify the degree of seasonal variation, with values greater than 1 indicating higher than average populations for a given season

example, *Bactrocera cucurbitae* (Melon Fly) and *Helicoverpa armigera* (Gram Caterpillar) had seasonal indices significantly greater than 1 during the Kharif season, indicating substantial population increases. Conversely, their indices were less than 1 during the Rabi season, reflecting the observed decline in pest numbers. Other pests, such as *Scirtothrips dorsalis* (Chilli Thrips) and *Myzus persicae* (Green Peach Aphid), exhibited more stable seasonal indices, suggesting less pronounced seasonal fluctuations. This stability indicates that these species may be more resilient to seasonal climatic changes or that they exploit a wider range of environmental niches and host plants (Fig. 8).

4. DISCUSSION

The present study in the Tiruvallur District of Tamil Nadu provides an overall idea of the seasonal incidence and population dynamics of insect pests in various agricultural landscapes. From the findings, there are significant revelations about how climatic conditions affect pest populations, particularly the large differences noted between the Kharif season (April-September) and the Rabi season (October-March). Shannon-Wiener Index and Simpson's Index biodiversity indices reflected the moderate to high pest diversity of species in the region. Values for Shannon-Wiener indexes ranged between about 1.93-1.95 for different species of insect pests, and Simpson's indexes were found to range between about 0.85-0.86. All these indices indicate a well-balanced insect pest community with high species richness and even distribution, which is necessary to maintain ecological resilience. This also validates the fact that diversity levels in tropical agricultural ecosystems are high and have been reported in recent studies [39,40,41,42]

Descriptive statistics could give a brief idea about the general trends and variability in the pest populations. The average mean pest count during the Kharif season is 80.70 individuals, while it was 39.54 individuals for the Rabi season. The median pest count is 74.00 individuals for the Kharif season and 36.00 individuals for the Rabi season, supporting the values. The standard deviation in the Kharif and Rabi were 28.12 and 16.53, respectively. Thus, the Kharif season showed higher variation in pest populations for being warmer and more humid. These findings are consistent with the work of Roy et al. The seasonal variation of insect pests showed a distinct difference between Kharif and Rabi seasons. During the Kharif season, the population of insect pests such as *Bactrocera cucurbitae* (Melon Fly) and *Helicoverpa armigera* (Gram Caterpillar) was very high due to the prevailing warmer and moist conditions. For example, *Bactrocera cucurbitae* harbored a peak population of 120 individuals per sampling unit, while *Helicoverpa armigera* peaked at 110 individuals. However, during Rabi, the populations of these pests showed a downfall to 45 and 40 numbers. This season dynamic is substantiated by the work of Bhatt and Karnatak [21] and also Pradeep et al. [26], which mentioned that the maximum temperature and humidity during Kharif are considerably favorable for the surge in pests.

Correlation and regression analyses were carried out to study the relationship between environmental factors and pest populations. The population densities of the pests showed a significant positive correlation with the changes in season. For instance, a strong positive relationship was found with temperature ($r = 0.82$) for *Bactrocera cucurbitae* and humidity ($r = 0.76$). The correlation in *Helicoverpa armigera* also showed good correlation: $r = 0.78$ for temperature and $r = 0.73$ for humidity. The results are comparable with similar investigations carried out by Sujayanand et al. [22] on pest dynamics. Regression models were applied to predict occurrences based on climatic variables. In predicting pest occurrence, both temperature and humidity appeared as strong predictors of the population. For instance, the regression model for *Bactrocera cucurbitae* turned out to be 0.65 for temperature and 0.58 for humidity, which means an increase in temperature and humidity will significantly increase the population of the pest. Similarly, the model for *Helicoverpa armigera* showed coefficients of 0.62 for temperature and 0.54 for humidity. These models align with the findings of Filazzola et al. [15], which underline a critical role for climatic factors in driving pest population dynamics.

The Pearson correlation matrix identifies key patterns in pest population dynamics, aiding pest management strategies. Strong positive correlations (close to 1.0) among pests like *Bactrocera cucurbitae* (Melon Fly), *Leucinodes orbonalis* (Shoot and Fruit Borer), *Helicoverpa armigera* (Gram Caterpillar), and *Euzophera perticella* (Stem Borer) suggest simultaneous population changes due to shared environmental conditions or crop infestations. In contrast, pests like *Scirtothrips dorsalis* (Chilli Thrips) and *Myzus persicae* (Green Peach Aphid) display moderate to low correlations, reflecting unique ecological niches. Negative correlations, such as those involving *Scirtothrips dorsalis* and *Helicoverpa armigera*, indicate potential competition or differing environmental responses. Understanding these correlations helps optimize management strategies, combining pests with positive correlations or targeting negatively correlated pests separately.

Time series analysis highlighted clear seasonal trends in pest populations, with numbers rising significantly during the Kharif season and falling during the Rabi season. The seasonal indices supported these observations: *Bactrocera cucurbitae* and *Helicoverpa armigera* had indices above 1 in the Kharif season, indicating substantial population growth. Conversely, their indices dropped below 1 in the Rabi season, showing a decline in pest numbers. These results align with findings from Pareek et al. [14] and Mawtham et al. [31], who reported similar seasonal patterns in their research on pest dynamics [43].

5. CONCLUSION

The detailed study of seasonal trends and population changes in insect pests within the Tiruvallur District has unveiled crucial insights into how weather conditions impact these populations. It reveals pronounced seasonal fluctuations, showing that pest numbers are higher and more varied during the Kharif season than in the Rabi season. This highlights the necessity for pest management strategies tailored to the specific seasonal dynamics. Through correlation and regression analyses, the study underscores temperature and humidity as key factors driving pest population changes. This understanding is fundamental for creating predictive models and proactive pest management plans, which are essential for timely and effective control measures to prevent pest outbreaks and reduce crop losses. These findings enrich our understanding of pest ecology in tropical agriculture and provide valuable insights applicable to other regions facing similar issues. The observed seasonal patterns emphasize the importance of ongoing monitoring and adaptive management to tackle the challenges posed by insect pests amid climate variability and agricultural intensification. Additionally, this research offers a thorough framework for comprehending and managing insect pest populations in the Tiruvallur District. The knowledge gained will enhance pest control schedules, improve forecasting accuracy, and ultimately strengthen the resilience and sustainability of agricultural systems in the region.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technologies, including Large Language Models, have been utilized for editing, grammar correction, and improving the clarity of the manuscript. All intellectual content and scientific interpretations are the original work of the author(s)."

Details of the AI usage are given below:

1. CHATGPT 4.0

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Jayakumar K. Analysis of shoreline changes along the coast of Tiruvallur district, Tamil Nadu, India. Journal of Geography and Cartography. 2021;4 (2):12-20.
2. Bebber DP, Holmes T, Gurr SJ. The global spread of crop pests and pathogens. Global Ecology and Biogeography. 2014;23(12):1398-1407.
3. Manosathiyadevan M, Bhuvaneshwari V, Latha R. Impact of insects and pests in loss of crop production: A review. Sustainable Agriculture Towards Food Security. 2017;57-67.
4. Skendžić S, Zovko M, Živković IP, Lešić V, Lemić D. The impact of climate change on agricultural insect pests. Insects. 2021;12 (5):440.
5. Savary S, Bregaglio S, Willocquet L, Gustafson D, Mason D'Croz D, Sparks A, Garrett K. Crop health and its global impacts on the components of food security. Food Security. 2017;9:311-327.
6. Gurr GM, Wratten SD, Landis DA, You M. Habitat management to suppress pest populations: Progress and prospects. Annual Review of Entomology. 2017;62(1):91-109.
7. Lamichhane JR, Barzman M, Booij K, Boonekamp P, Desneux N, Huber L, Messéan A. Robust cropping systems to tackle pests under climate change. A review. Agronomy for Sustainable Development. 2015;35:443-459.
8. Xu Y. Envirotyping for deciphering environmental impacts on crop plants. Theoretical and Applied Genetics. 2016;129:653-673.
9. Tougeron K, Brodeur J, Le Lann C, Van Baaren J. How climate change affects the seasonal ecology of insect parasitoids. Ecological Entomology. 2020; 45(2):167-181.
10. Powell JA, Logan JA. Insect seasonality: Circle map analysis of temperature-driven life cycles. Theoretical Population Biology. 2005;67(3):161-179.
11. Welch KD, Harwood JD. Temporal dynamics of natural enemy–pest interactions in a changing environment. Biological Control. 2014;75: 18-27.
12. Robinet C, Roques A. Direct impacts of recent climate warming on insect populations. Integrative Zoology. 2010;5 (2):132-142.
13. Harvey JA, Heinen R, Gols R, Thakur MP. Climate change-mediated temperature extremes and insects: From outbreaks to breakdowns. Global Change Biology. 2020;26(12):6685-6701.
14. Pareek A, Meena BM, Sharma S, Tetarwal ML, Kalyan RK, Meena BL. Impact of climate change on insect pests and their management strategies. Climate Change and Sustainable Agriculture. 2017;253-286.
15. Filazzola A, Matter SF, MacIvor JS. The direct and indirect effects of extreme climate events on insects. Science of the Total Environment. 2021;769:145161.
16. Roy S, Barooah AK, Ahmed KZ, Baruah RD, Prasad AK, Mukhopadhyay A. Impact of climate change on tea pest status in

northeast India and effective plans for mitigation. Acta Ecologica Sinica. 2020;40(6):432-442.

17. Sarma AK, Damgaard C, Neog P. Retrospection of outbreaks of *Spodoptera mauritia* boisduval in NER India: The solution lies in ecological engineering, not in insecticides. Sustainability. 2021;13 (22):12824.
18. Paschapur A, Subbanna ARNS, Gupta J, Parihar M, Mishra KK. Insect pest scenario in Uttarakhand Himalayas, India, under changing climatic conditions. International Journal of Biometeorology. 2022;66 (7):1445-1460.
19. Mukhtar Y, Shankar U, Wazir ZA. Prospects and challenges of emerging insect pest problems vis-à-vis climate change. Indian Journal of Ecology. 2023; 50(4):1096-1103.
20. Tenguri P, Gawande SP, Kumar R. The outbreak of cotton whitefly Bemisia tabaci Gennadius (Hemiptera: Aleyrodidae) and its management in North India. Journal of Entomological Research. 2023;47(1):21-27.
21. Bhatt B, Karnatak AK. Seasonal incidence of major insect pests of chilli crop and their correlation with abiotic factors. International Journal of Chemical Studies. 2020;8(2):1837-1841.
22. Sujayanand GK, Chandra A, Pandey S, Bhatt S. Seasonal abundance of spotted pod borer, Maruca vitrata Fabricius in early pigeonpea [*Cajanus cajan (L.)* Millsp.] and its management through farmscaping in Uttar Pradesh. Legume Research-An International Journal. 2021;(2):233-239.
23. Pradeep P, Deshmukh SS, Sannathimmappa HG, Kalleshwaraswamy CM, Firake DM. Seasonal activity of *Spodoptera frugiperda* (JE Smith) in maize agroecosystem of South India. Current Science. 2022;123(1):81-86.
24. Anandhi S, Saminathan VR, Yasotha P, Sharavanan PT, Rajanbabu V. Seasonal dynamics and spatial distribution of fall armyworm Spodoptera frugiperda (JE Smith) on Maize (*Zea mays L*.) in Cauvery Delta Zone. Journal of Pharmacognosy and Phytochemistry. 2020;9(4):978-982.
25. Balasubramaniyan M, Mahesh P, Srikanth J, Singaravelu B, Prathap DP, Pothiraja N. Infestation levels of sugarcane shoot borer Chilo infuscatellus in Cauvery delta zone of Tamil Nadu, India. Journal of Sugarcane Research. 2020;10(1).
26. Kumar NV, Yasodha P, Justin CGL. Seasonal incidence of maize fall armyworm Spodoptera Frugiperda (JE Smith) (Noctuidae; Lepidoptera) in Perambalur district of Tamil Nadu, India. Journal of Entomology and Zoology Studies. 2020;8(3):1-4.
27. Manikandan P, Suguna K, Saravanaraman M. Population dynamics of defoliating insect pests of mango in the coastal agroecosystem of Tamil Nadu. Pest Management in Horticultural Ecosystems. 2021;27(2).
28. Selvam K, Shiva N, Manikandan P, Archunan K, Saravanaraman M. Studies on seasonal incidence and diversity of major pests in black gram under rainfed conditions. Journal of Entomological Research. 2022;46(2):300-305.
29. Kanna SS, Premalatha K, Kavitha K, Vijayakumar M, Dheebakaran G, Bhuvaneswari K. Effect of weather parameters on of pests and diseases in groundnut and castor in Salem district of Tamil Nadu, India. International Journal of Environment and Climate Change. 2023;13(10):3652-3659.
30. Pirithiraj U, Soundararajan RP, Justin CGL. Seasonal incidence of major insect pests of jasmine *Jasminum sambac L.* Indian Journal of Entomology. 2023;435-438.
31. Mawtham MM, Justin C, Roseleen S. Seasonal fluctuations and management of sucking insect pests on bitter gourd (*Momordica charantia L*.). Indian Journal of Agricultural Research. 2023;57(1):110-115.
32. Akoijam R, Telem RS, Marangmei L. Insect pest problems and its changing trends on crop losses. Environment and Ecology. 2014;665:74.
33. Rai AB, Halder J, Kodandaram MH. Emerging insect pest problems in vegetable crops and their management in India: An appraisal. Pest Management in Horticultural Ecosystems. 2014;20(2):113-122.
34. Raja M, William SJ, David BV. Population dynamics of key insect pests of cabbage in Tamil Nadu. Indian Journal of Entomology. 2014;76(1):1-7.
35. Rathee M, Dalal P. Emerging insect pests in Indian agriculture. Indian Journal of Entomology. 2018;80(2):267-281.
36. Sankaran Pagalahalli S, Marimuthu M, Mookiah S, Thiyagarajan E,

Kathithachalam A, Gandhi K, Ramasamy S. Evaluation of integrated pest and disease management combinations against major insect pests and diseases of Tomato in Tamil Nadu, India. Horticulturae. 2024;10(7):766.

37. Yi Z, Jinchao F, Dayuan X, Weiguo S, Axmacher JC. A comparison of terrestrial arthropod sampling methods. Journal of Resources and Ecology. 2012;3(2):174-182.
38. McCravy KW. A review of sampling and monitoring methods for beneficial arthropods in agroecosystems. Insects. 2018;9(4):170.
39. Du C, Chen J, Jiang L, Qiao G. High correlation of species diversity patterns between specialist herbivorous insects and their specific hosts. Journal of Biogeography. 2020;47(6):1232-1245.
40. Wenda-Piesik A, Piesik D. Diversity of species and the occurrence and development of a specialized pest population—a review article. Agriculture. 2020;11(1):16.
41. Oakley JL, Bicknell JE. The impacts of tropical agriculture on biodiversity: A meta-analysis. Journal of Applied Ecology. 2022;59(12):3072-3082.
42. Outhwaite CL, McCann P, Newbold T. Agriculture and climate change are reshaping insect biodiversity worldwide. Nature. 2022;605(7908):97-102.
43. Lal J, Swaminathan R, Meena AK, Nagar R. Seasonal incidence of major insect pests of cabbage, Brassica oleracea *Var. capitata L.* Journal of Entomology and Zoology Studies. 2020;8(3):387-391.

Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.mbimph.com/review-history/4015