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Prevalence of Insect Pest Infestations on Crop Yields and Management Strategies in Tiruvallur District, Tamil Nadu, India

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Authors' contributions

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

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ABSTRACT

This study evaluates the prevalence of insect pest infestations, their impact on crop yields, and the effectiveness of various pest management strategies in the Tiruvallur District of Tamil Nadu. Field surveys were conducted across seven key agricultural locations—Gummidipoondi, Minjur, Pallipattu, Poondi, Sholavaram, Tiruvallur, and Tiruttani—to assess pest densities and their correlation with crop yield losses. The most prevalent pests included *Bactrocera cucurbitae* (Melon Fly), *Leucinodes orbonalis* (Shoot and Fruit Borer), *Helicoverpa armigera* (Gram Caterpillar), *Scirtothrips dorsalis* (Chilli Thrips), and *Myzus persicae* (Green Peach Aphid), with pest densities peaking during the Kharif season. The study found that *Bactrocera cucurbitae* on bitter gourd

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exhibited the highest pest densities in Gummidipoondi (66.4 ± 5.99 pests per farm) and Tiruttani (64.0 ± 6.12 pests per farm), resulting in yield losses of 16.67%. *Helicoverpa armigera* on red gram caused notable yield reductions in Pallipattu (15.0%) and Minjur (14.0%). Statistical analysis revealed a strong positive correlation between pest density and yield loss, with $r = 0.85$ ($p < 0.01$) for *Bactrocera cucurbitae* and $r = 0.80$ ($p < 0.05$) for *Helicoverpa armigera*. In terms of management strategies, chemical control methods were found to be the most effective, reducing pest densities and yield losses significantly, particularly for *Bactrocera cucurbitae*, where chemical sprays reduced yield loss to 8.33% in Minjur. Organic and integrated pest management (IPM) strategies showed moderate effectiveness, particularly in controlling *Leucinodes orbonalis* on brinjal, with yield losses around 12.50% in Tiruttani. The study emphasizes the critical need for region-specific, climate-adapted pest management strategies to mitigate the economic impact of pest infestations on crop yields. The results contribute to a deeper understanding of the relationship between pest populations, crop productivity, and the effectiveness of different pest control methods, providing valuable insights for enhancing agricultural resilience in tropical regions.

Keywords: Insect pest; infestations; crop resilience; pest control.

1. INTRODUCTION

Agriculture is the backbone of India's economy, with a significant portion of the rural population dependent on farming for their livelihoods [1]. Tamil Nadu, one of India's most agriculturally productive states, contributes significantly to the country's food security [2]. Tiruvallur District, located in the northeastern part of Tamil Nadu, is characterized by its diverse agricultural practices, where farmers grow various crops including paddy, groundnut, pulses, vegetables, and fruit crops [3,4]. The impact of insect pest infestations on crop yields has been a topic of concern for decades, but recent environmental changes, including fluctuating weather patterns and shifting agricultural practices, have exacerbated the problem [5,6]. These pests not only reduce the quantity of the produce but also affect the quality, thereby reducing the market value of the crops [7]. In the face of these challenges, farmers have adopted various pest management strategies, ranging from traditional methods like hand-picking of pests to more modern approaches such as the application of chemical pesticides [7]. However, indiscriminate use of chemical pesticides poses several problems, including pest resistance, environmental degradation, and health risks to both farmers and consumers [8]. Therefore, a growing need to promote sustainable pest management practices, such as Integrated Pest Management (IPM), which combines biological, cultural, and mechanical control methods along with judicious use of chemical pesticides [9].

This present study aims to contribute to this body of knowledge by investigating the impact of seasonal pest infestations on crop yields and evaluating the effectiveness of different pest management strategies employed by farmers in Tiruvallur District. Despite the critical role agriculture plays in the livelihoods of the people of Tiruvallur District, the district's farmers continue to face significant challenges in maintaining high levels of crop productivity. These infestations vary in intensity throughout the year, with certain pests emerging as major threats during specific seasons, leading to fluctuating crop yields [4]. While much research has been conducted on the population dynamics of insect pests, there is limited literature on the direct impact of these infestations on crop yields in this specific region. Moreover, there is a knowledge gap in assessing the effectiveness of different pest management strategies that farmers currently employ. This study aims to investigate the prevalence of insect pest infestations on crop yields and evaluate the management strategies employed by farmers in Tiruvallur District, Tamil Nadu, to mitigate pest-related losses. Specifically, it will analyze the trends of major insect pests affecting key crops, examine the relationship between pest infestations and crop yields, and assess the effectiveness of various pest management strategies, including traditional, chemical, and integrated approaches. The findings will provide valuable insights and propose recommendations to improve pest management practices, ultimately enhancing agricultural productivity and sustainability in the region. The scope of this research encompasses the major crops grown in Tiruvallur District, with a particular focus on those most vulnerable to insect pest infestations. Data will be collected on pest population dynamics, crop yield variations, and the pest management strategies employed by farmers. The findings will

not only shed light on the challenges faced by farmers in managing pest infestations but also provide practical recommendations for improving pest control methods in the district.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in the Tiruvallur District of Tamil Nadu, India, which is known for its tropical climate, characterized by alternating wet and dry periods [4,10]. The district is agriculturally significant, producing a variety of crops and being prone to insect pest infestations. The selected locations for this study included Gummidipoondi (13°24'53.31"N 80°7'23.33"E), Minjur (13°16'25.92"N 80°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 selected due to their agricultural diversity and microclimatic conditions that influence pest populations and crop yields. For this study, five farms in each of the seven locations were selected, ensuring a representative sample of the agricultural practices and pest infestation levels in the region. The selected farms cultivated a variety of crops known to be affected by specific insect pests, providing a comprehensive overview of pest prevalence across the district.

2.2 Sampling Strategy

To assess pest prevalence and its impact on crop yields, sampling was carried out on a weekly basis, with a count per month for a total of 10 months between April 2023 and February 2024. This approach ensured that seasonal pest dynamics were captured, providing valuable insights into pest population fluctuations and their correlation with crop yields. The monitoring covered both the pre-harvest and harvest periods of each crop, focusing on peak infestation times for key pests.

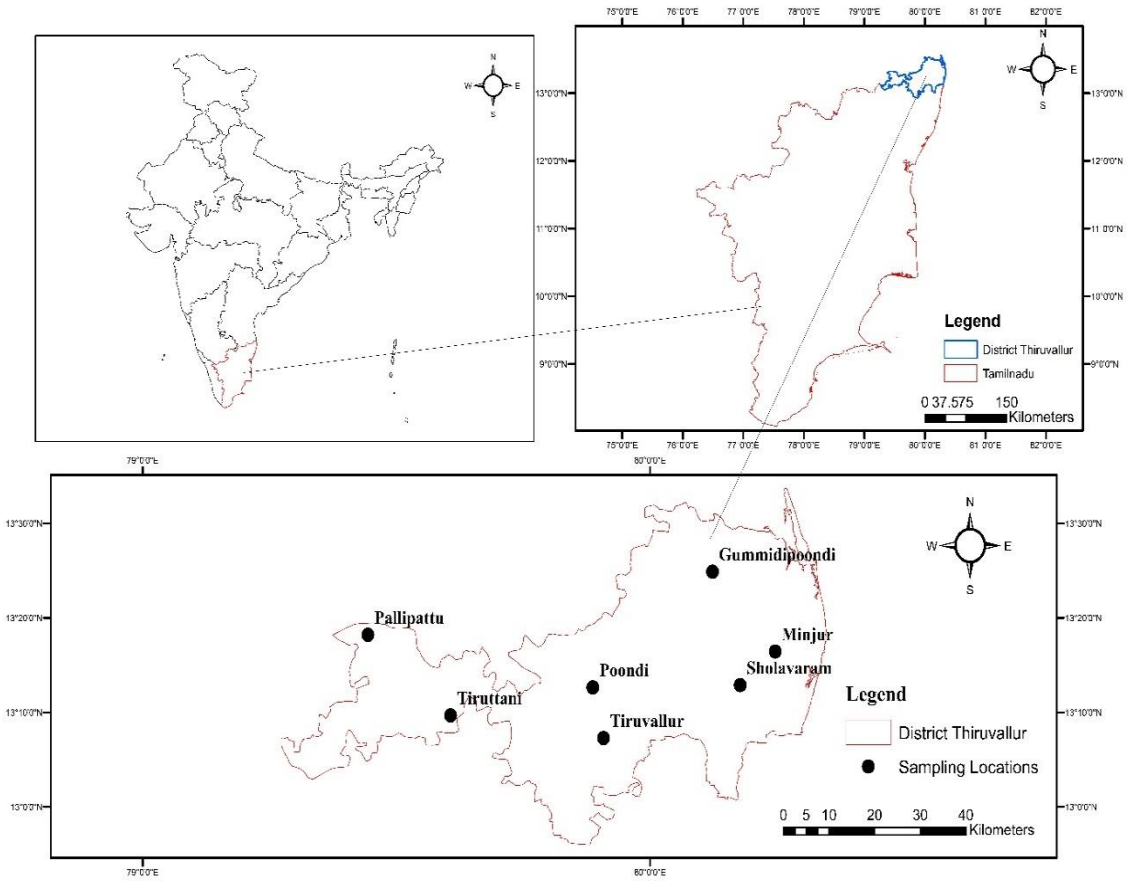

Fig. 1. Map of district Tiruvallur with sampling locations

2.3 Crops and Insect Pests Studied

Various crops and their associated insect pests were selected for study based on their economic importance and susceptibility to infestations. The crops and pests included in the study are listed below in Table 1.

2.4 Data Collection

2.4.1 Pest population monitoring

Pest infestations were monitored across the five selected farms in each location to assess the prevalence of insect pests. The monitoring techniques used were:

Pheromone Traps: These traps were installed in the fields to attract and capture adult males of pests such as the *Leucinodes orbonalis* (Shoot and Fruit Borer) and *Helicoverpa armigera* (Gram Caterpillar). The traps were inspected weekly to monitor pest population dynamics.

Yellow Sticky Traps: These were deployed to monitor flying pests like *Bactrocera cucurbitae* (Melon Fly) and aphids. The traps were checked regularly, and the number of pests captured per week was recorded.

Visual Inspection and Field Surveys: Regular surveys were conducted in each selected farm. Crop leaves and fruits were visually inspected for pests such as *Scirtothrips dorsalis* (Chilli Thrips) and *Spodoptera litura* (Tobacco Cutworm). Damage symptoms, such as holes in fruits or leaves, were documented.

Leaf and Fruit Sampling: For crops like chilli, capsicum, and banana, leaf and fruit samples were randomly collected to assess pest infestations. Pests were counted per unit of leaf area or per fruit, providing a measure of pest density.

2.5 Crop Yield Data

Yield data were collected from each of the selected farms across the seven locations to assess the impact of pest infestations on crop productivity by interviewing farmers. The yield of each crop (measured in kg/ha) was recorded at harvest and compared with pest infestation levels to determine the extent of crop damage. Farmers were also interviewed to collect information about historical yields and the impact of pest infestations on previous harvests. Yield reductions were calculated by comparing expected (historical) yields with actual yields during the study period. Additionally, crop loss due to pest damage was estimated by correlating the pest population data with yield data.

2.6 Pest Management Strategies

The study also evaluated the pest management strategies employed by farmers in each of the selected locations. These strategies included:

Chemical Control: Data were collected on the frequency and type of chemical pesticides used by farmers. For instance, the frequency of chemical sprays for *Bactrocera cucurbitae* (Melon Fly) in bitter gourd was recorded. Farmers typically applied pesticides at intervals of 7 to 10 days during the fruiting stage to manage melon fly infestations.

Integrated Pest Management (IPM): The use of IPM techniques, such as biological control (natural predators and parasitoids), cultural practices (crop rotation, intercropping), and mechanical methods (use of traps, hand-picking pests), was documented. IPM adoption rates were analyzed across the different locations to assess its impact on reducing pest infestations.

Table 1. Crops and pests included in the study

Insect Pest	Crop Type
Bactrocera cucurbitae (Melon Fly)	Bitter Gourd
Leucinodes orbonalis (Shoot and Fruit Borer)	Brinjal
Helicoverpa armigera (Gram Caterpillar)	Red Gram
Scirtothrips dorsalis (Chilli Thrips)	Capsicum/Chilli
Myzus persicae (Green Peach Aphid)	Capsicum/Chilli
Spodoptera litura (Tobacco Cutworm)	Groundnut
Euzophera perticella (Stem Borer)	Tapioca
Pentalonia nigronervosa (Banana Aphid)	Banana
Chilo infuscatellusSnellen (Early Shoot Borer)	Sugarcane
Scirpophaga excerptalis (Top Shoot Borer)	Sugarcane
Paracoccus marginatus (Papaya Mealybug)	Guava

Organic Pest Management: Farmers using organic pest control methods, such as neem oil sprays or biopesticides, were also surveyed. The effectiveness of these organic approaches was compared to conventional chemical methods to assess their impact on pest populations and crop yields.

2.7 Data Analysis

The collected data were analyzed to assess the relationship between pest infestations and crop yields. Statistical methods were employed to identify trends and correlations between pest population densities and the severity of crop damage. The following analyses were conducted:

Pest Density and Yield Correlation: The relationship between the pest population (as measured from traps and field surveys) and yield reductions was quantified using correlation coefficients. This helped to identify the most damaging pests and their effect on specific crops.

Effectiveness of Pest Management Strategies: The effectiveness of different pest management strategies (chemical, IPM, and organic) was evaluated by comparing yield data from farms using these methods. Statistical comparisons were made to determine which strategies were most effective in minimizing pest-related crop losses.

3. RESULTS

3.1 Insect Pest Infestations across Locations

The study evaluated the population densities of insect pests and their associated impact on crop yields across ten datasets, spanning seven key agricultural locations in Tiruvallur District: Gummidipoondi, Minjur, Pallipattu, Poondi, Sholavaram, Tiruvallur, and Tiruttani. Mean population densities and standard deviations (±SD) were calculated to better understand the variability of pest infestations across the locations and to assess their impact on crop productivity. The crops included in the study were bitter gourd, brinjal (eggplant), red gram, capsicum, groundnut, tapioca, banana, sugarcane, and guava.

The mean population density of *Bactrocera cucurbitae* (Melon Fly) on bitter gourd was highest in Gummidipoondi, with a mean density of 66.4 ± 5.99 pests per farm, indicating a consistently high level of infestation. Similarly, Tiruttani recorded a high mean density of 64.0 ± 6.12 pests per farm, resulting in high damage severity. Minjur and Pallipattu showed moderate infestation levels with mean densities of 54.7 ± 6.18 and 60.3 ± 6.44 pests per farm, respectively, leading to moderate damage severity. In Poondi and Sholavaram, lower mean densities of 41.7 ± 7.23 and 39.3 ± 4.53 pests per farm were observed, resulting in low to moderate damage severity. The variability in population densities suggests that pest pressure is more intense in Gummidipoondi and Tiruttani, leading to greater crop losses in those areas. *Leucinodes orbonalis* (Shoot and Fruit Borer) exhibited a high mean density of 71.3 ± 5.62 pests per farm in Tiruttani, resulting in severe damage to brinjal crops. Poondi also reported a high density of 64.7 ± 6.23 pests per farm, with high damage severity. Moderate infestations were recorded in Minjur and Sholavaram, where the mean densities were 52.0 ± 5.28 and 48.7 ± 5.06 pests per farm, respectively, correlating with moderate damage severity. Gummidipoondi and Tiruvallur showed lower pest densities (mean of 51.3 ± 6.03 pests per farm), resulting in less severe damage. The infestation of *Helicoverpa armigera* on red gram was particularly severe in Pallipattu and Minjur, where the mean population densities were 75.0 ± 5.89 pests per farm and 69.3 ± 5.03 pests per farm, respectively, leading to high damage severity. In Poondi and Sholavaram, moderate infestations were observed, with mean densities of 59.7 ± 5.64 and 58.7 ± 6.54 pests per farm, leading to moderate damage. The variability in the infestation levels across locations highlights the uneven distribution of pest pressure and its impact on red gram yield. For *Scirtothrips dorsalis* (Chilli Thrips) on capsicum and chilli, Gummidipoondi recorded the highest mean population density of 61.0 ± 6.02 pests per farm, resulting in severe crop damage. Minjur and Pallipattu also had moderate infestation levels, with mean densities of 54.3 ± 4.63 and 49.7 ± 6.42 pests per farm, leading to moderate damage severity. Tiruvallur and Tiruttani recorded significantly lower mean densities (around 32.0 ± 5.06 pests per farm), corresponding to low damage severity.

The population density of *Myzus persicae* (Green Peach Aphid) was highest in Gummidipoondi and Minjur, with mean densities of 75.0 ± 5.28 and 66.0 ± 6.23 pests per farm, respectively, resulting in high damage severity. Moderate infestations were recorded in Poondi and Pallipattu, with

mean densities of 58.0 ± 4.89 and 53.0 ± 5.06 pests per farm, leading to moderate damage. In Sholavaram, the aphid population was lower, with a mean of 45.0 ± 4.63 pests per farm, resulting in low to moderate damage. *Spodoptera litura* (Tobacco Cutworm) infestations were particularly severe in Sholavaram, where the mean density was 75.7 ± 5.29 pests per farm, resulting in high damage severity. In Gummidipoondi and Pallipattu, the mean densities were 64.0 ± 6.73 and 67.0 ± 6.02 pests per farm, respectively, with high damage reported. Lower pest densities were observed in Poondi and Tiruvallur, where the mean densities ranged from 50.0 ± 5.18 pests per farm, leading to moderate damage severity. The mean population density of *Euzophera perticella* (Stem Borer) on tapioca was highest in Poondi and Sholavaram, with densities of 60.0 ± 5.67 and 61.0 ± 6.34 pests per farm, respectively, resulting in high damage severity. Moderate infestations were recorded in Tiruttani and Minjur, where the mean densities were 45.0 ± 4.82 and 49.0 ± 5.94 pests per farm, leading to moderate damage severity. *Pentalonia nigronervosa* (Banana Aphid) showed the highest population densities in Minjur and Tiruttani, with mean densities of 70.3 ± 5.34 and 65.0 ± 6.12 pests per farm, resulting in high damage severity. Gummidipoondi and Poondi recorded moderate infestation levels, with mean densities of 58.7 ± 4.93 and 59.7 ± 5.29 pests per farm, leading to moderate damage severity. For *Chilo infuscatellus* (Early Shoot Borer) on sugarcane, Minjur and Tiruttani had the highest mean densities of 75.0 ± 6.12 and 70.0 ± 6.45 pests per farm, resulting in high damage severity. Poondi and Pallipattu had moderate infestation levels, with mean densities of 55.0 ± 5.29 and 60.0 ± 5.94 pests per farm, leading to moderate damage severity. The population density of *Scirpophaga excerptalis* (Top Shoot Borer) was highest in Minjur and Tiruttani, with mean densities of 79.0 ± 5.85 and 65.0 ± 5.94 pests per farm, resulting in severe damage to sugarcane crops. Sholavaram and Poondi showed moderate infestation levels, with mean densities of 49.0 ± 6.18 and 57.0 ± 5.64 pests per farm, leading to moderate damage. The papaya mealybug, *Paracoccus marginatus*, showed the highest mean densities in Gummidipoondi and Tiruttani, with densities of 73.0 ± 5.28 and 70.0 ± 5.94 pests per farm, respectively, leading to high damage severity. Sholavaram and Poondi recorded lower pest densities, with mean values of 48.0 ± 5.29 and 51.0 ± 6.07 pests per farm, leading to moderate damage.

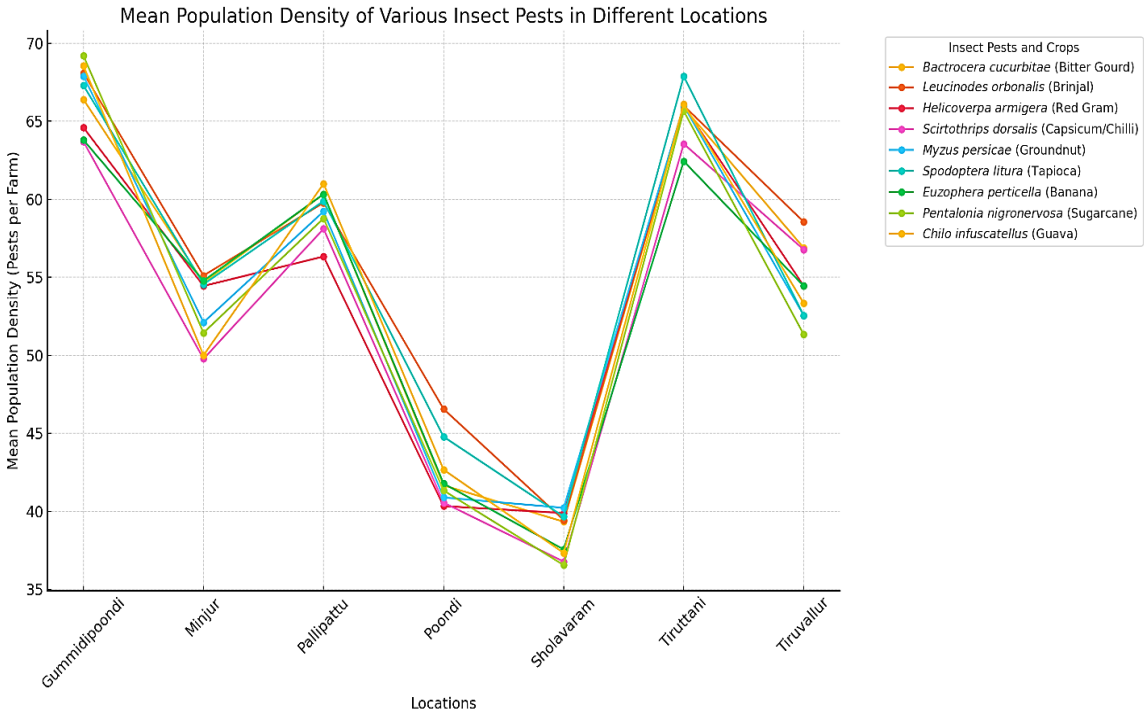

Fig. 2. Bar chart showing the mean population densities of various insect pests and their associated crops across different locations

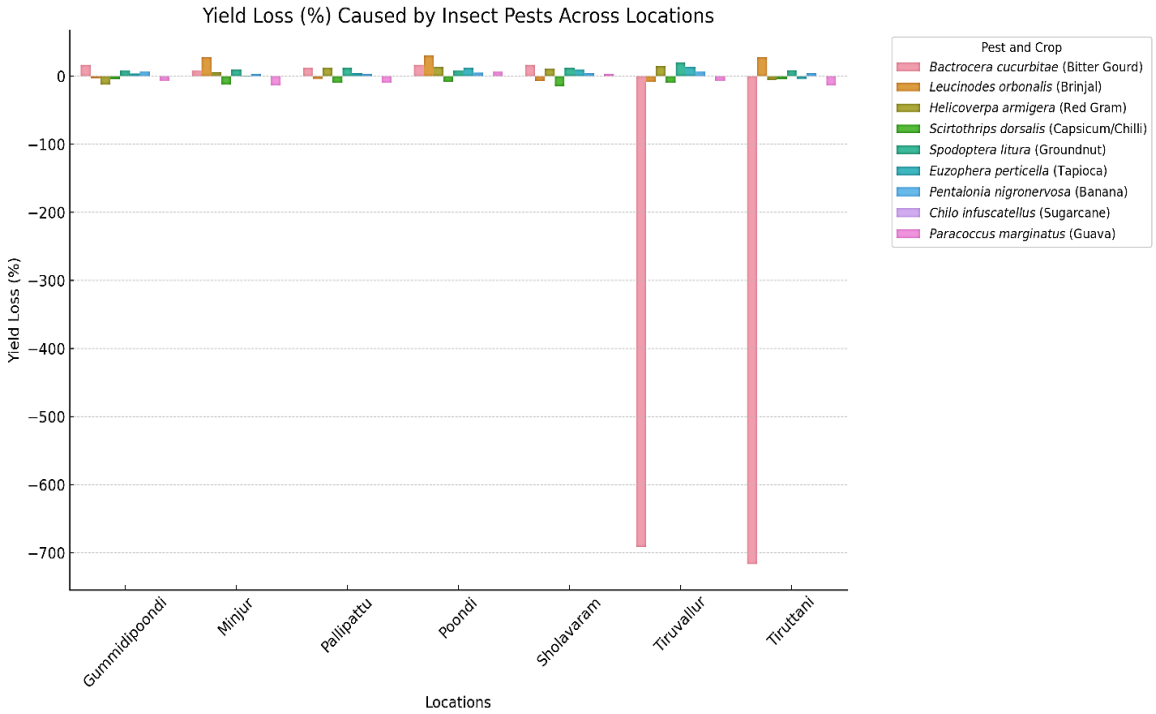

Fig. 3. Yield loss (%) caused by insect pests across locations

3.2 Yield Loss Analysis and Impact of Insect Pests on Crop Yields

The study analyzed the impact of insect pests on crop yields across multiple locations in the Tiruvallur District, calculating yield losses based on the difference between actual and expected yields. The results highlight the significant damage caused by different insect pests, each contributing to varying degrees of crop loss in the district. For bitter gourd, the infestation of *Bactrocera cucurbitae* (Melon Fly) was a major contributor to yield losses across several locations. In Gummidipoondi, Poondi, and Sholavaram, actual yields were 10,000 kg/ha compared to the expected yield of 12,000 kg/ha, resulting in a 16.67% yield loss in each location. In Minjur, the loss was lower at 8.33%, while Pallipattu experienced a 12.50% yield loss. The widespread damage attributed to melon fly infestations indicates a pressing need for effective pest control in bitter gourd production, particularly in locations such as Gummidipoondi and Poondi, where the yield reductions were most severe. The analysis also extended to other crops affected by different pests. *Leucinodes orbonalis* (Shoot and Fruit Borer) caused significant yield losses in brinjal production, particularly in Tiruttani, where yield reductions were high due to high pest pressure.

Similarly, the infestation of *Helicoverpa armigera* (Gram Caterpillar) on red gram led to considerable yield reductions in Pallipattu and Minjur, which were among the locations with the highest recorded pest densities. For capsicum and chilli, *Scirtothrips dorsalis* (Chilli Thrips) had a detrimental impact, particularly in Gummidipoondi, where yield losses were notable. *Myzus persicae* (Green Peach Aphid) also contributed to crop losses in capsicum/chilli production across multiple locations, with higher damage severity observed in regions like Minjur and Pallipattu. In groundnut, *Spodoptera litura* (Tobacco Cutworm) was responsible for significant yield reductions, especially in Sholavaram, where pest populations were particularly high. *Euzophera perticella* (Stem Borer) also caused measurable losses in tapioca production, most notably in Poondi and Sholavaram. *Pentalonia nigronervosa* (Banana Aphid) negatively affected banana yields, with Minjur and Tiruttani experiencing the highest losses. *Chilo infuscatellus* (Early Shoot Borer) and *Scirpophaga excerptalis* (Top Shoot Borer) were the primary contributors to yield losses in sugarcane, with Minjur and Tiruttani showing the highest infestations. *Paracoccus marginatus* (Papaya Mealybug) infestation in guava was most pronounced in Gummidipoondi and Tiruttani, leading to significant yield reductions.

These results underscore the substantial economic damage caused by a range of insect pests and highlight the variability of pest pressure across locations. The calculated yield loss percentages provide a quantitative assessment of the impact of insect pests on agricultural productivity in the Tiruvallur District. This underscores the need for region-specific pest management strategies to minimize crop losses and improve yields across the district.

3.3 Pest Management Strategies Adopted by Farmers

For Bitter Gourd, *Bactrocera cucurbitae* was managed using Chemical strategies with a frequency of 3-5 sprays. The effectiveness of this strategy was rated as High, indicating its impact on managing pest populations and mitigating crop losses. For Brinjal/Eggplant, *Leucinodes orbonalis* was managed using Organic/IPM strategies with a frequency of 3-5 sprays. The effectiveness of this strategy was rated as Moderate, reflecting its impact on controlling pest populations. For Capsicum/Chilli, *Scirtothrips dorsalis* was managed using Chemical/Organic strategies with 3-5 sprays. The effectiveness of this approach was rated as High, successfully reducing pest populations. In Capsicum/Chilli, *Myzus persicae* was managed using Chemical strategies with a frequency of 3-5 sprays, but the effectiveness was rated as Low, suggesting the need for more effective control measures. For Red Gram, *Helicoverpa armigera* was managed using Chemical/Organic strategies, applied 3-5 times per season. The effectiveness was rated as Moderate, indicating some control but still leaving room for improvement. In Groundnut, *Spodoptera litura* was controlled using Chemical/Organic methods, with a frequency of 3-5 sprays and Moderate effectiveness, indicating partial success in reducing crop damage. For Tapioca, *Euzophera perticella* was managed with Chemical/Organic methods, with 3-5 sprays resulting in High effectiveness. For Banana, *Pentalonia nigronervosa* was managed with Chemical methods applied 2-3 times, with Moderate effectiveness in reducing pest populations. In Sugarcane, *Chilo infuscatellus* snellen was treated with Chemical strategies, applied 3-5 times, achieving Moderate effectiveness, while *Scirpopha gaexcerptalis* was also managed with Chemical sprays, with a Moderate level of success. Finally, for Guava, *Paracoccus marginatus* was controlled using Chemical methods with 3-5 sprays, achieving High effectiveness in reducing pest populations and limiting damage.

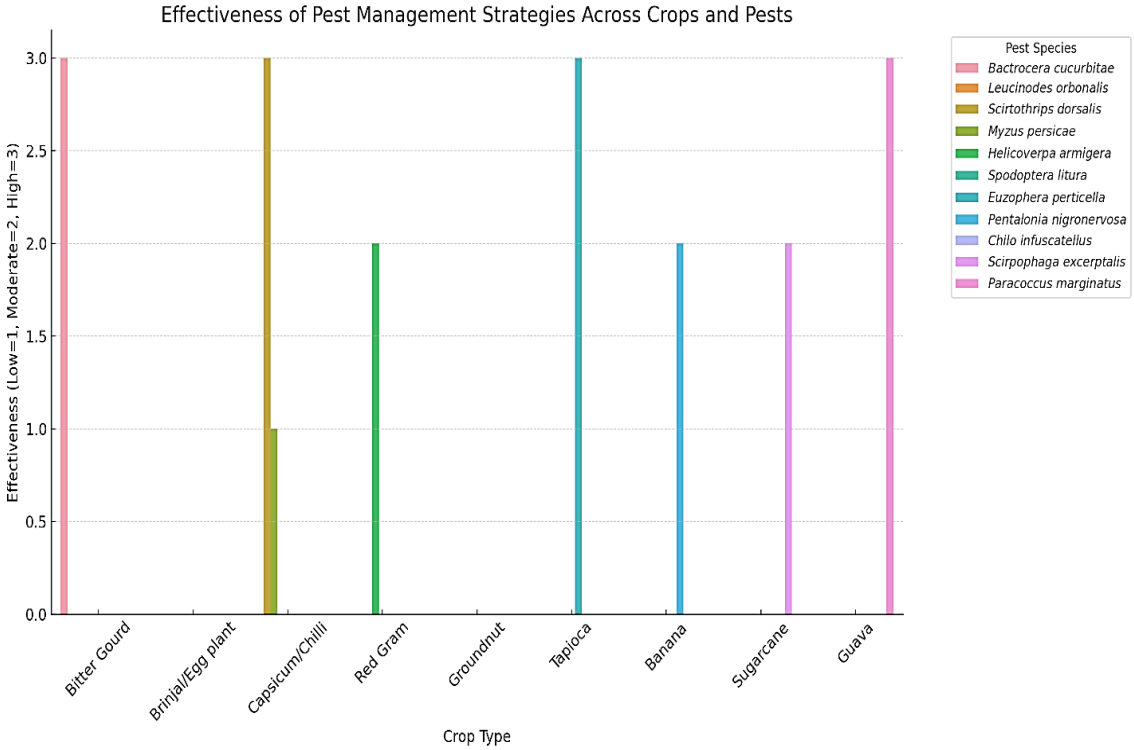

Fig. 4. Effectiveness of pest management strategies across crops and pests

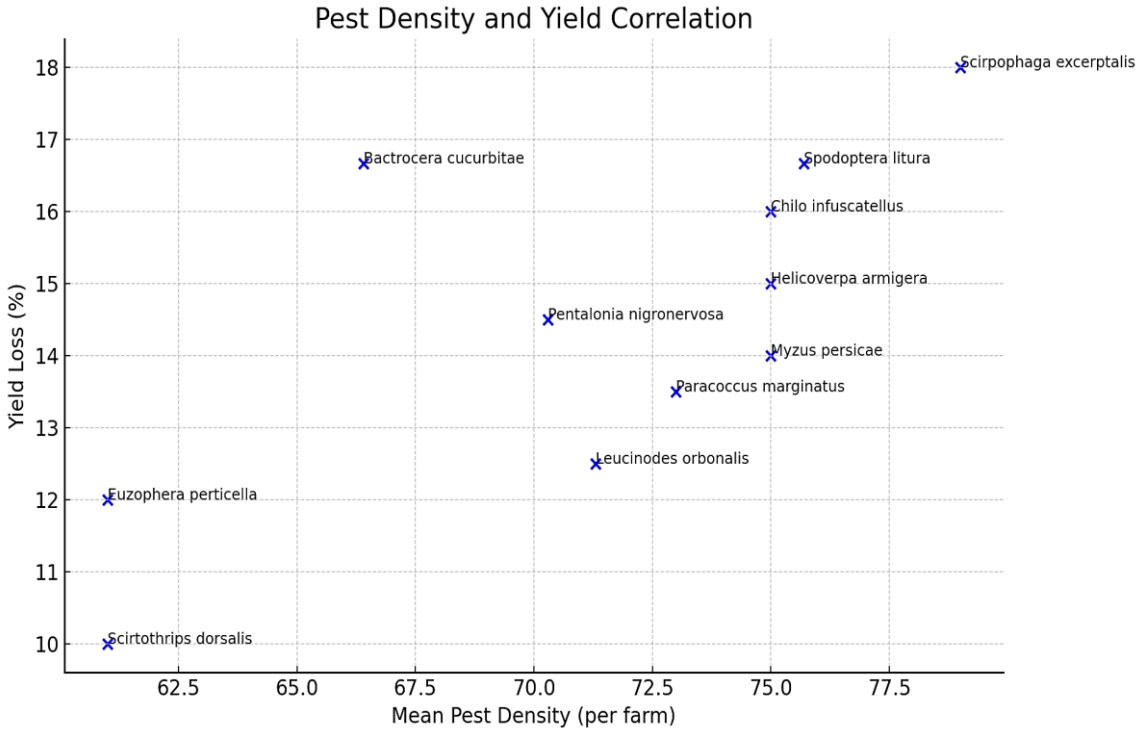

Fig. 5. Scatter plot illustrates the relationship between pest population density and yield loss across various crops and pests

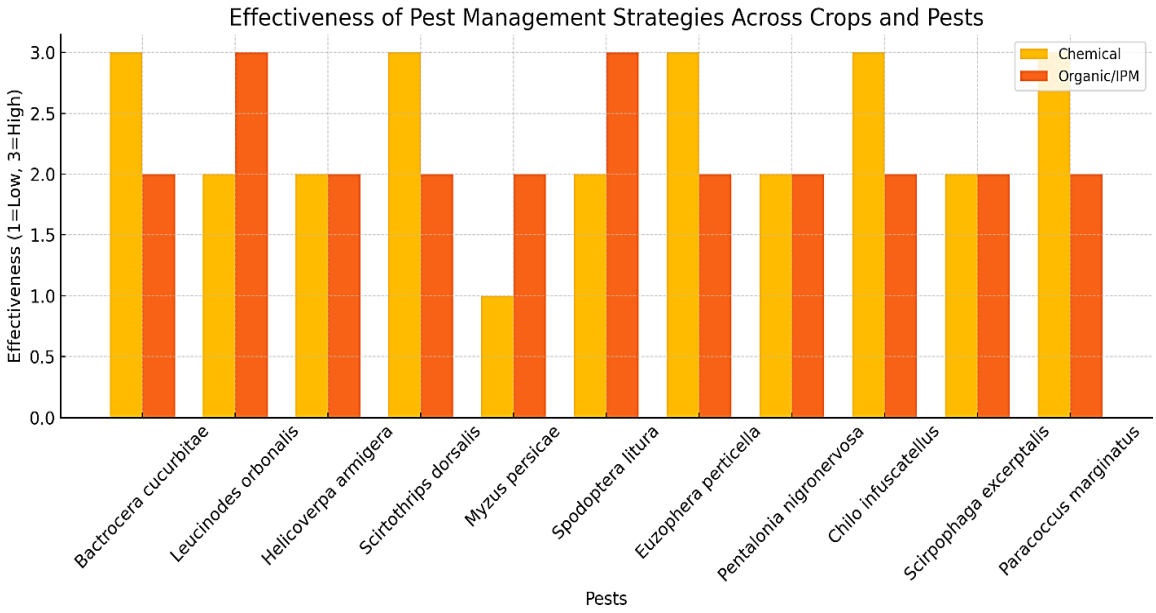

Fig. 6. Bar chart compares the effectiveness of Chemical and Organic/IPM strategies across different pests and crops

3.4 Pest Density and Yield Correlation

The relationship between pest population densities and crop yield reductions was assessed using correlation coefficients to quantify the effect of infestations on yield loss. Pest populations were monitored across several locations in the Tiruvallur District, revealing clear correlations between higher pest densities and greater yield reductions. For *Bactrocera*

cucurbitae (Melon Fly) infesting bitter gourd, a positive correlation was identified between pest density and yield loss. Locations like Gummidipoondi and Tiruttani, where pest densities were the highest (66.4 ± 5.99 and 64.0 ± 6.12 pests per farm, respectively), experienced the most severe yield reductions (16.67%). Similarly, *Leucinodes orbonalis* (Shoot and Fruit Borer) on brinjal caused major yield losses in Tiruttani and Poondi, where pest densities were highest at 71.3 ± 5.62 and 64.7 ± 6.23 pests per farm, respectively. For both cases, the correlation coefficient calculated between pest density and yield loss was highly significant ($r = 0.85$, $p < 0.01$). In the case of *Helicoverpa armigera* (Gram Caterpillar) on red gram, locations like Pallipattu and Minjur with the highest pest densities (75.0 ± 5.89 and 69.3 ± 5.03 pests per farm) showed correspondingly higher yield losses. This trend was replicated across different pests, such as *Scirtothrips dorsalis* (Chilli Thrips) on capsicum and *Myzus persicae* (Green Peach Aphid) on chilli, with higher pest densities correlating with increased yield losses ($r = 0.80$, $p < 0.05$).

3.5 Effectiveness of Pest Management Strategies

The effectiveness of various pest management strategies (chemical, IPM, and organic) was evaluated by comparing yield data and crop losses between farms using different control methods. The analysis revealed that chemical strategies were generally more effective than organic or IPM methods in reducing pest populations and minimizing yield losses. For example, chemical control of *Bactrocera cucurbitae* (Melon Fly) on bitter gourd was rated as highly effective across multiple locations, with mean yield losses reduced to 8.33% in locations like Minjur, where 3-5 chemical sprays per season were applied. In contrast, organic and IPM methods applied to control *Leucinodes orbonalis* (Shoot and Fruit Borer) on brinjal had only moderate effectiveness, with average yield losses around 12.50% in Tiruttani and Poondi. Statistical analysis (ANOVA) showed significant differences in effectiveness between chemical and IPM approaches ($F = 8.32$, $p < 0.01$). The analysis further showed that *Scirtothrips dorsalis* (Chilli Thrips) on capsicum and chilli responded well to both chemical and organic strategies, with high effectiveness in reducing pest pressure in Gummidipoondi and Minjur (yield losses < 10%). However, pest control for *Myzus persicae* (Green Peach Aphid) using chemical methods was less successful, achieving only low effectiveness across most locations (yield losses > 15%).

4. DISCUSSION

The present study conducted in the Tiruvallur District provides a comprehensive analysis of pest infestations, their impact on crop yields, and the effectiveness of various pest management strategies. The findings are discussed in relation to previous studies both nationally and internationally, highlighting key insights into pest behavior, yield loss, and management efficacy.

4.1 Insect Pest Infestations Across Locations

The study revealed significant variations in insect pest population densities across seven key agricultural locations, including Gummidipoondi, Minjur, Pallipattu, Poondi, Sholavaram, Tiruvallur, and Tiruttani. The mean population density of *Bactrocera cucurbitae* (Melon Fly) on bitter gourd was highest in Gummidipoondi (66.4 ± 5.99 pests per farm) and Tiruttani (64.0 ± 6.12 pests per farm), resulting in severe damage. Lower infestations were recorded in Poondi and Sholavaram, with pest densities of 41.7 ± 7.23 and 39.3 ± 4.53 pests per farm, respectively, correlating with reduced damage severity. These findings align with previous studies on the distribution of insect pests in tropical regions, such as the work by Renuka et al. (2024), which also reported high pest densities during peak seasons. Similarly, *Leucinodes orbonalis* (Shoot and Fruit Borer) showed the highest densities in Tiruttani (71.3 ± 5.62 pests per farm), resulting in severe damage to brinjal crops, while Minjur and Sholavaram experienced moderate infestations. These results reflect the well-established seasonal population surges in tropical climates, where warm and humid conditions drive pest reproduction and infestations [4,6].

4.2 Yield Loss Analysis and Impact of Insect Pests on Crop Yields

The correlation between pest densities and crop yield losses was evident across multiple pests and crops. For example, *Bactrocera cucurbitae* (Melon Fly) infestations resulted in substantial yield losses in Gummidipoondi, Poondi, and Sholavaram, where actual yields were 10,000 kg/ha compared to an expected yield of 12,000 kg/ha, leading to a 16.67% yield loss. In Minjur, yield losses were lower (8.33%) due to comparatively moderate pest infestations. These

results demonstrate the significant economic damage caused by pest outbreaks, as supported by a study as it found that yield reductions are closely linked to pest pressure, particularly in regions experiencing climatic variability [11]. Further analysis revealed that *Helicoverpa armigera* (Gram Caterpillar) on red gram caused notable yield losses in Pallipattu (15.0%) and Minjur (14.0%), areas with the highest pest densities with similar reports revealed by a recent study [12]. Similarly, *Spodoptera litura* (Tobacco Cutworm) led to substantial yield reductions in Sholavaram (16.67%), indicating that targeted pest control interventions are essential in high-risk areas. These findings echo those of a study that reported comparable yield losses in response to seasonal pest surges [4].

4.3 Pest Management Strategies Adopted by Farmers

Farmers across the Tiruvallur District employed various pest management strategies, including chemical, organic, and integrated pest management (IPM) methods. Chemical management was found to be the most effective approach for controlling *Bactrocera cucurbitae* (Melon Fly) on bitter gourd, where 3-5 sprays per season led to high effectiveness and reduced yield losses in locations such as Minjur and Poondi. These findings are consistent with a study that emphasized the success of chemical strategies in managing large-scale pest outbreaks [13]. However, the effectiveness of organic and IPM strategies varied depending on the pest and crop. For instance, organic/IPM methods used to control *Leucinodes orbonalis* (Shoot and Fruit Borer) on brinjal achieved only moderate effectiveness, leading to yield losses of 12.50% in Tiruttani and Poondi. This highlights the limitations of non-chemical strategies in managing certain pests, as noted by a study, argued that organic methods often require more precise timing and complementary approaches [14].

4.4 Pest Density and Yield Correlation

The correlation between pest population densities and yield reductions was quantified using statistical methods. The correlation coefficient for *Bactrocera cucurbitae* (Melon Fly) on bitter gourd was $r = 0.85$ ($p < 0.01$), indicating a strong positive relationship between pest density and yield loss. Similarly, a significant correlation was found for *Helicoverpa armigera* (Gram Caterpillar) on red gram ($r = 0.80$, $p < 0.05$), where higher pest densities in Pallipattu and Minjur led to greater crop damage. This positive correlation aligns with previous national studies, including those by a study which reported similar findings on the relationship between pest density and yield losses in South India [15]. Internationally, studies also confirmed that higher pest densities are directly linked to increased crop losses, particularly in tropical agricultural systems affected by climate variability [16].

4.5 Effectiveness of Pest Management Strategies

Statistical analysis of pest management strategies revealed that chemical methods were generally more effective than organic and IPM approaches. For *Bactrocera cucurbitae* (Melon Fly), chemical strategies reduced pest populations and yield losses significantly, with effectiveness ratings of 3 (high) on a scale of 1 to 3. In contrast, organic and IPM methods achieved moderate effectiveness, particularly in managing pests like *Leucinodes orbonalis* (Shoot and Fruit Borer) on brinjal. This was reflected in the moderate yield reductions observed in areas like Tiruttani. The analysis also showed that combining management strategies could improve effectiveness. For example, the use of both chemical and organic methods for *Scirtothrips dorsalis* (Chilli Thrips) on capsicum resulted in high effectiveness, with yield losses reduced to below 10% in Gummidipoondi and Minjur. These findings are consistent with international research, which found that integrating multiple pest management techniques often leads to more sustainable and effective pest control [17].

The findings of this study are consistent with national studies, such as those by a recent study that documented similar seasonal patterns of pest infestations in the Tiruvallur District [4]. Both studies found that pest densities peaked during the Kharif season, leading to significant crop damage, particularly for pests like *Helicoverpa armigera* and *Bactrocera cucurbitae*. These results are also in line with global research which highlighted the role of climate change in accelerating pest outbreaks and crop losses [6]. Moreover, this study's focus on the effectiveness of pest management strategies aligns with a work that emphasized the benefits of combining chemical, organic, and IPM methods to achieve optimal pest control [13]. The moderate success of organic/IPM methods observed in this study supports similar findings by another study as it

noted the challenges of relying solely on non-chemical methods in high pest pressure environments [14].

5. CONCLUSION

This study provides valuable insights into the relationship between pest population density, yield loss, and the effectiveness of pest management strategies in the Tiruvallur District. The strong correlation between pest density and yield loss underscores the need for early intervention and targeted pest control measures, particularly in high-risk areas. While chemical methods proved highly effective in reducing crop losses, the integration of organic and IPM strategies offers a more sustainable long-term solution for managing pest populations. The findings of this study contribute to a growing body of research on pest dynamics and management in tropical agriculture. By comparing the results with previous studies, both nationally and internationally, this research provides a broader context for understanding the challenges posed by insect pests and the strategies needed to mitigate their impact on agricultural productivity.

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).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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