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Population Dynamics and Environmental Correlates of Insect Pests in Watermelon, *Citrullus lanatus* (T.)

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Authors' contributions

This work was carried out in collaboration among all authors. Author HVM executed field/lab experiments and collected the data. Authors KP, ABR and CT analyzed and interpreted the data. Authors KP, ABR and Priyanka prepared the draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted in Kandavara village, Chikkaballapur district, during 2021, investigated the insect pest complex affecting watermelon, *Citrullus lanatus* (T) following standard crop management practices but without any insecticidal interventions to assess the natural occurrence of

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insect pests. Weekly observations were made from February to April (2021) employing various sampling methods to monitor key pests, including leaf miners, thrips, whiteflies, fruit flies, leaf-eating caterpillars, and pumpkin beetles. The study revealed that leaf miners, *Liriomyza trifolii* (Frick) were the first to appear, peaking in the 11th Standard Meteorological Week (SMW) with 6.45 leaf mines per five leaves. Thrips, *Thrips palmi* Karny and whiteflies, *Bemisia tabaci* (Gennadius) emerged during the vegetative stage, showing a significant positive correlation with maximum temperature. Fruit flies, *Zeugodacus cucurbitae* (Coquillett) caused the most significant damage during the fruiting stage, with a peak incidence of 14.92 per cent in the 15th SMW. The study highlighted that higher temperature had a positive correlation with pest populations, while rainfall had a negative correlation reducing the pest activity. These findings emphasize the importance of precise timing in pest management interventions to minimize crop losses and enhance the sustainability and productivity of watermelon cultivation in India.

Keywords: Cucurbits; pest complex; population dynamics; watermelon.

1. INTRODUCTION

Watermelon, *Citrullus lanatus* (T.), a popular summer crop in India, belongs to the Cucurbitaceae family and is widely cultivated for its refreshing and nutritious nature. Originating from Africa's Kalahari Desert, watermelon has become a staple crop in tropical and subtropical regions across the globe. The fruit is considered one of the most important commercial crops in India, occupying about 1.16 lakh ha of land and producing approximately 31.5 lakh metric tonnes annually [1]. The crop is cultivated across various states, including Uttar Pradesh, Andhra Pradesh, Tamil Nadu, West Bengal, Madhya Pradesh, and Karnataka [2]. Karnataka, in particular, is a significant producer, with commercial cultivation taking place in districts like Kolar, Mandya, Chamarajnagar, Mysuru, Haveri, Belgaum, Bagalkot, and Koppal, covering an area of roughly 475505.6 ha and yielding about 38,855,000 tonnes [3].

Despite the increasing popularity and economic importance of watermelon cultivation in India, the crop faces significant challenges from various insect pests. These pests attack the crop from its early stages through to fruit maturity, causing substantial yield losses. The major insect pests affecting watermelon include thrips, *Thrips palmi Karny*, leaf miners, *Liriomyza trifolii (Frick)*, whiteflies, *Bemisia tabaci* (Gennadius), fruit flies, *Zeugodacus cucurbitae* (Coquillett), pumpkin beetles, *Raphidopalpa foveicollis* (Lucas), aphids, *Aphis gossypii* Glover, leaf-eating caterpillars, *Diaphania indica* (Saunders) and red spider mites, *Tetranychus urticae* C. L. Koch.

The American serpentine leaf miner, *L. trifolii,* significant pest species, particularly during the early stages of watermelon cultivation. This polyphagous pest creates serpentine mines on the upper surface of leaves by feeding on the mesophyll tissues while leaving the epidermis intact. Severe infestations can lead to a loss of chlorophyll, causing desiccation and drying of the leaves [4]. The leaf damage caused by this pest on watermelon can reach up to 37 per cent, resulting in significant yield loss [5].

Melon thrips (*T. palmi*) is another destructive pest of watermelon causing direct damage by feeding on plant tissues and acting as vectors for various plant Tospoviruses, including watermelon silvery mottle virus and groundnut bud necrosis. Depending on the variety or hybrid and the time of sowing, thrips can cause yield losses ranging from 60 to 100 percent [6].

Whiteflies, particularly *B. tabaci,* an extremely polyphagous pest of watermelon with over 600 host plants globally, including solanaceous crops, legumes, cucurbits, and okra. The *B. tabaci* is known for its direct feeding damage as well as its role as a carrier for over 100 plant viruses. These viruses can severely impact watermelon crops, leading to reduced yields and poor fruit quality [7-8].

Fruit flies, particularly *Z. cucurbitae* and *Bactrocera tau* Walker, are major pests of cucurbit crops, including watermelon. These pests are considered one of the 10 agriculturally important insect pests in India [9]. Female fruit flies use their sharp ovipositors to puncture the fruit's skin and lay eggs beneath the surface [10]. The resulting maggots feed on the fruit pulp, creating galleries and leading to secondary infections that cause fruit rot [11]. In India, fruit flies can cause partial or total damage to 50 per cent of cucurbits [12], with watermelon experiencing damage rates as high as 28.55 per cent.

The cucumber moth or leaf-eating caterpillar (*D. indica*) is a destructive pest that attacks a wide range of crops, including watermelon [13]. The larvae feed on the flowers, leaves, and fruits of host plants, leading to significant damage. *D. indica* was first reported in India on cotton leaves but has since become a major pest of cucurbits.

The pumpkin beetle (*R. foveicollis*) is a serious foliar pest that poses a significant threat to watermelon crops [14], especially during the cotyledon stage. The beetles feed voraciously on tender leaves, creating irregular holes and giving the leaves a net-like appearance. The first generation of beetles is particularly injurious, causing considerable damage to young plants [15].

The attack of insect pests on watermelon, from the primordial stage to maturity, leads to a significant reduction in crop yield and productivity. This, in turn, has serious implications for the livelihoods of farmers who rely on watermelon cultivation for income generation. To combat these pests, farmers often resort to pesticide treatments [16] However, the effectiveness of many pesticides is limited, and frequent spraying can lead to the development of resistance among pests, making them even harder to control.

Effective pest management strategies are essential to protect watermelon crops and ensure the continued success of this important summer fruit. The study of the insect pest complex on watermelon is crucial in developing sustainable agricultural practices that can mitigate the impact of these pests and enhance the productivity and profitability of watermelon cultivation in India.

2. MATERIALS AND METHODS

2.1 Study Site and Crop Management

The study was conducted in Kandavara village (13.41482º N, 77.71791º E), Chikkaballapur taluk, Chikkaballapur district during the year 2021, where watermelon was cultivated with a spacing of 1.5 meters between rows and 1 meter between plants (1.5m x 1m). The recommended package of practices of the University of Agricultural Sciences (UAS), Bengaluru were followed and the insect pest complex of watermelon was studies periodically.

2.2 Insect Collection and Sampling Procedures

Insect pests were recorded using various sampling methods, including sweep nets, vials, and suction devices. Observations were conducted weekly from February 5, 2021 (6th Standard Meteorological Week) to April 9, 2021 (15th Standard Meteorological Week), focusing on 30 randomly selected plants.

2.2.1 Leaf miner

Leaf miners (*L. trifolii*) were monitored by counting live mines on leaves of tagged plants. Initially, observations were made on two leaves per plant for the first week after transplanting. Subsequently, observations were expanded to five leaves per plant, with data collected weekly from 30 randomly selected plants.

2.2.2 Thrips

Thrips populations were assessed using the beating method. Thrips nymphs and adults were counted by gently tapping plant tips onto a stiff black paper board (30 cm x 30 cm). Observations began with one vine per plant and progressed to four vines per plant in each direction during later growth stages. Thirty plants were sampled for this method.

2.2.3 Whitefly

Whiteflies (*B. tabaci*) were recorded by examining both nymphs and adults on 30 randomly selected and tagged plants. Initially, one vine per plant was assessed, and later, observations included four vines per plant, with five tender leaves per vine.

2.2.4 Fruit fly

Fruit fly incidence was studied by recording ovipositional punctures on fruits from 30 randomly selected tagged plants. The percentage of fruit damage was calculated as follows:

$$\text{Per cent fruit damage} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits observed}} \text{X100}$$

2.2.5 Leaf-eating caterpillar

Observations for leaf-eating caterpillars (*D. indica*) involved recording the number of larvae and adults on 30 randomly selected tagged plants.

2.2.6 Pumpkin beetle

The population of pumpkin beetles (*R. foveicollis*) was assessed by counting both grubs and adults on 30 randomly selected tagged plants.

2.3 Preservation and Identification

Collected insects were transferred to the lab, where they were placed in killing bottles with ethyl acetate-soaked cotton. After labeling and pinning, specimens were dried and stored in insect boxes with naphthalene balls to prevent infestations. Each specimen was labeled with details such as host plant, location, and collection date. Under a binocular microscope, specimens were examined and identified at the Department of Entomology, UAS, Bangalore.

2.4 Meteorological Parameters

Data on meteorological parameters, including temperature (maximum and minimum), relative humidity (morning and evening), and rainfall, were obtained from the official website of the University of Agricultural Sciences, GKVK, Bengaluru [17].

2.5 Statistical Analysis

Population dynamics data and correlations between weather parameters and pest populations were analyzed using SPSS software (Version 16.0). Figures were generated using Tableau Desktop Software.

3. RESULTS AND DISCUSSION

The study conducted from February to April 2021 on watermelon cultivation provided comprehensive insights into the seasonal dynamics of major insect pests and their interactions with abiotic factors. The results on insect pest complex recorded on watermelon, and fluctuations in the incidence of various pests and the impact of abiotic factors on their population are presented in Table 1 and Figs. (1-3) respectively.

3.1 Leaf Miner (*L. trifolii*)

The first pest to attack was the leaf miner (*L. trifolii*) appearing four days post-transplant during the seedling stage. Its population peaked in the 11th Standard Meteorological Week (SMW), i.e., first fortnight of March with 6.45 leaf mines per five leaves, averaging 3.89 mines throughout the cropping period. The correlation of watermelon pests with abiotic factors revealed distinct patterns for each species. The leaf miner (*L. trifolii*) showed a non-significant positive correlation with maximum (r = 0.42) and minimum temperatures (r = 0.27) but had a significant negative correlation with evening relative humidity (r = -0.68, p<0.05).

3.2 Red pumpkin beetle (*R. foveicollis*)

The red pumpkin beetle (*R. foveicollis*), was observed from the vegetative stage, starting in the 7th SMW (first fortnight of February). Its population peaked in the 8th SMW (second fortnight of February) at 0.83 beetles per five plants, before gradually declining and ceasing by the 11th SMW (first fortnight of March). The red pumpkin beetle (*R. foveicollis*) exhibited a non-significant negative correlation with maximum (r = -0.52) and minimum temperatures (r = -0.48), and a non-significant positive correlation with evening relative humidity (r = 0.25) and rainfall (r = 0.49).

3.3 Sucking Pests (Thrips, *T. palmi* and whitefly*, B. tabaci*)

The *T. palmi* emerged during the vegetative stage in the 8th SMW (second fortnight of February) with an initial mean population of 4.6, peaking in the 11th SMW (first fortnight of March) at 17.73 thrips per five leaves, making it a major pest throughout the season. Simultaneously*, B. tabaci* was first recorded in the 8th SMW (second fortnight of February), with a peak incidence of 8.21 whiteflies per five leaves in the 12th SMW (second fortnight of March), with an average population of 3.67 during the season. Thrips, (*T. palmi*) had a highly significant positive correlation with maximum temperature (r = 0.85, p<0.01) and a positive correlation with minimum temperature (r = 0.75; p< 0.05), while showing a significant negative correlation with evening relative humidity (r = -0.71). Whitefly (*B. tabaci*) showed a highly significant positive correlation with maximum temperature (r = 0.78, p<0.01) and a significant positive correlation with minimum temperature (r = 0.66, p<0.05), alongside non-significant negative correlations with relative humidity and rainfall.

3.4 Leaf-eating Caterpillar (*D. indica*)

The leaf-eating caterpillar (*D. indica*) was first noted during the flowering stage in the 10th SMW (first fortnight of March), with its highest population in the 13th SMW (First fortnight of April) at 0.80 caterpillars per five plants. The leaf-eating caterpillar (*D. indica*) had a significant positive correlation with maximum temperature (r = 0.70) and a highly significant positive correlation with minimum temperature (r = 0.80, p<0.01), with non-significant negative correlations with relative humidity and rainfall.

3.5 Fruit Fly (*Z. cucurbitae*)

The fruit fly (*Z. cucurbitae*) was recorded during the fruiting stage, causing fruit damage first observed in the 11th SMW (first fortnight of March) at 4.24 per cent, with the highest damage at 14.92 per cent in the 15th SMW (first fortnight of April), averaging 4.91 per cent damage throughout the cropping period. Finally, the fruit fly (*Z. cucurbitae*) demonstrated a highly significant positive correlation with maximum temperature (r = 0.81, p<0.01) and a significant positive correlation with minimum temperature (r = 0.76, p<0.05), while showing non-significant negative correlations with evening relative humidity (r = -0.26) and rainfall (r = -0.18) (Fig. 2). These findings emphasize the crucial role of temperature in pest dynamics, with varying effects of humidity and rainfall across different pests. These observations highlight the critical points of pest incidence, informing targeted pest management strategies in watermelon cultivation.

The study on pest incidence in watermelon cultivation provides valuable insights into the timing and management of key pests, which is crucial for effective integrated pest management (IPM) strategies. The leaf miner (*L. trifolii*), was the first pest to appear, emerging just four days after transplanting and peaking in the 11th Standard Meteorological Week (SMW). This early colonization aligns with Rauf et al. [18], who noted that *Liriomyza* species typically target young cucurbit crops early in the growing season [19]. *T. palmi* and *B. tabaci* emerged during the vegetative stage, aligning with Barbosa et al. [20] and Oliveira et al. [21], who observed increased populations during the mid-vegetative to flowering stages. The fruit fly (*Z. cucurbitae*) was a significant pest during the fruiting stage, and Wazir et al. [22] too highlighted it as a major threat during fruiting. These findings emphasize the need for targeted pest control measures aligned with the critical periods of pest activity to minimize crop losses and enhance management practices.

Moreover, the study highlights the significant influence of environmental factors, particularly temperature and rainfall, on pest populations. The population of sucking pests, including thrips and whiteflies, increased during periods of high temperatures in March, reflecting findings by Bhattacharyya et al. [23] and Divya et al. [24], who noted that high temperatures favor the proliferation of these pests. However, the populations of these pests decreased during rainy periods, a trend corroborated by Barbosa et al. [20], who observed higher populations of thrips in watermelon crops during the dry season compared to the rainy season. Rainfall impacts pest populations both directly and indirectly. Directly, rainfall can physically dislodge and wash pests like thrips and whiteflies off plants, as noted by Semeão et al. [25]. Indirectly, the increased humidity associated with rainfall can promote the growth of entomopathogenic fungi, which can further reduce pest populations by increasing mortality rates, as discussed by Augustyniuk-Kram and Kram [26]. Aishwarya et al. [27] found a positive correlation between temperature and thrips populations and a negative correlation between thrips and both relative humidity and rainfall, similar to the findings of the current study. Similarly, the fruit fly population was positively correlated with higher temperatures and decreased during rainy periods, aligning with the findings of Nehra et al. [28] and Saha et al. [29]. These environmental factors must be considered when developing IPM strategies. By understanding how temperature and rainfall influence pest behavior, growers can better time their interventions, applying controls when pests are most vulnerable, and potentially reducing the need for chemical treatments. This approach not only enhances the sustainability of watermelon cultivation but also helps improve crop yields and reduce environmental impact.

Table 1. List of insect pest complex recorded on watermelon, *Citrillus lanatus* (T.) during February to April (summer) 2021

Sl. No.	Common name	Scientific name	Family	Order	Period of occurrence	Pest status
1	Leaf miner	*Liriomyza trifolii* (Frick)	Agromyzidae	Diptera	Seedling stage to harvesting stage	Major
2	Red pumpkin beetle	*Raphidopalpa foveicollis* (Lucas)	Chrysomelidae	Coleoptera	Vegetative stage	Minor
3	Thrips	*Thrips palmi* Karny	Thripidae	Thysanoptera	Vegetative stage to Harvesting stage	Major
4	Whitefly	*Bemisia tabaci* (Gennadius)	Aleyrodidae	Hemiptera	Vegetative to Harvesting	Major
5	Leaf eating caterpillar	*Diaphania indica* (Saunders)	Crambidae	Lepidoptera	Flowering stage	Minor
6	Fruit fly	*Zeugodacus cucurbitae* (Coquillett)	Tephritidae	Diptera	Fruit setting stage to Harvesting stage	Major

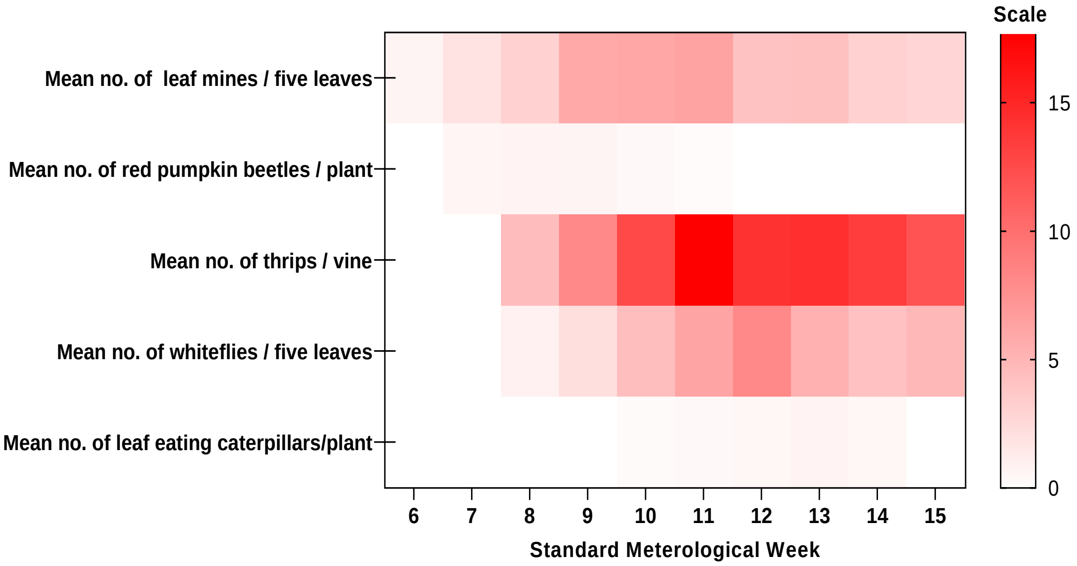

Fig. 1. Population dynamics of major insect pests of watermelon, *Citrullus lanatus* (T.) during 2021

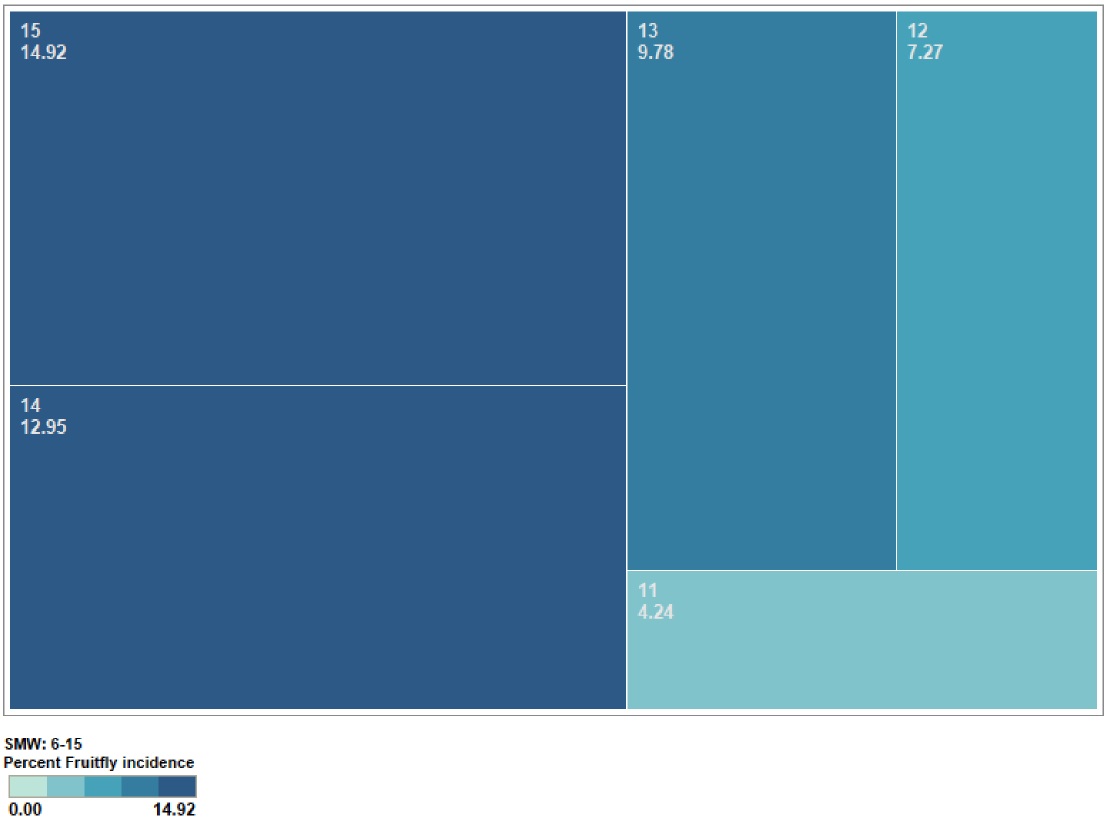

Fig. 2. Per cent fruit fly (*Zeugodacus cucurbitae)* incidence in watermelon, *Citrullus lanatus* (T.) during 2021

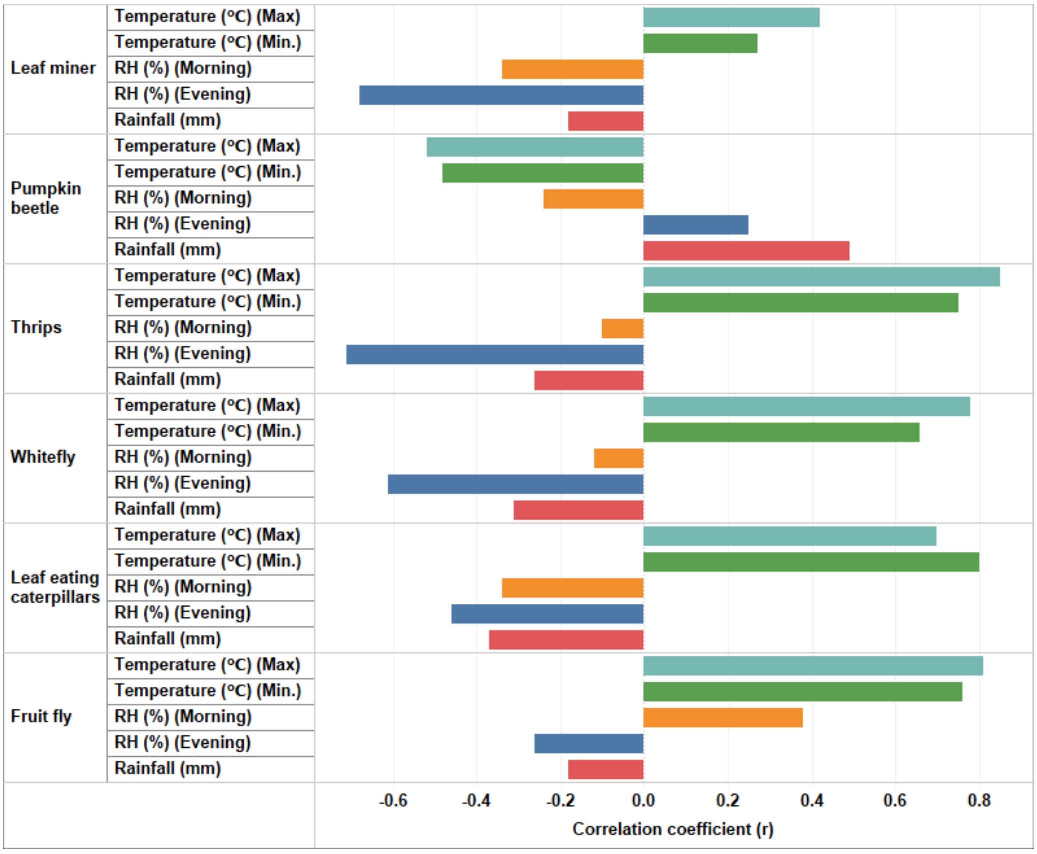

Fig. 3. Correlation coefficient (r) of major pests of watermelon, *Citrullus lanatus* (T.) (T.) with abiotic factors

4. CONCLUSION

This study highlights the intricate relationship between pest dynamics and environmental factors in watermelon cultivation. The findings emphasize the importance of temperature as a key driver of pest populations and underscore the impact of rainfall in moderating pest incidence. Effective IPM strategies should integrate this knowledge by timing interventions to coincide with periods of high pest activity and adverse weather conditions. By adopting such targeted approaches, growers can reduce reliance on chemical controls, and promote sustainable farming practices. This approach not only enhances crop yields but also supports environmental stewardship and reduces the ecological footprint of agricultural practices.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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