Seasonal Abundance of Important Pests of Mango and Their Correlation with Weather Parameters

ABSTRACT

The investigation was carried out at the Instructional Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University (N.A.U.), Navsari, Gujarat, India during 2021-2022. The leaf webber, leafhopper, fruit fly, shoot borer, and thrips were found abundant, whereas the mealybug and stone weevils were very less. The leaf webber population exhibited a significant negative correlation with minimum temperature (r= -0.488*) and evaporation (r=-0.483*). The leafhopper population hada highly significant positive correlation with wind velocity (r= 0.577**) and rainfall (r= 0.823**)and a significant negative correlation with minimum temperature (r=-0.495*) and morning relative humidity (r= -0.414*). Fruit fly population exhibited a highly significant positive correlation with minimum temperature (r= 0.761**), wind velocity (r= 0.646**), and evaporation (r= 0.524**). There was a significant negative correlation of shoot borer population with minimum temperature(r= -0.804**), evening relative humidity(r= -0.467*), and wind velocity (r= -0.437*). Thrips population had a highly significant negative correlation with minimum temperature(r= -0.690**), evening relative humidity (r= -0.879**), wind velocity (r= -0.567**), and rainfall (r= -0.541**) and a significant positive correlation with sunshine hours(r= 0.684**) and maximum temperature(r= 0.438*). Amongnatural enemies, ants, mantids, spiders, and chrysopa were found in the orchard and none of the parasitoids were reported.

Keywords: Mango, natural enemies, pests, seasonal incidence, south Gujarat, weather parameters

1. INTRODUCTION

Mango, *Mangifera indica* (L.), belongs to the family,Anacardiaceae, and is known as the “king of fruits” due to its delicious taste, attractive color, savoring flavor, high nutritive value, and health-promoting qualities[1-3]. It is native to the Indo-Burma region and is the national fruit of India, Pakistan, and the Philippines. Mango fruits contain sugars, protein, carbohydrates, fat, ash, and vitamins. They are highly efficient in stopping bleeding, strengthening the heart, and benefiting the brain[4]. Mango is widely grown in tropical as well as subtropical regions of India. The major mango-producing countries in the world are India, China, Thailand, Pakistan, Mexico, Indonesia, Brazil, Bangladesh, Nigeria,Philippines,and the Vietnam. India ranks first among the world's mango-producing countries accounting for about 50% of the world's mango production and ranks third for the export of mango. The area under mango cultivation in India is 2.29 million hectares with production of 20.44 metric tonnes and productivity of 8.9 metric tonnes per hectare[5]. The major mango-producing states of our country are Andhra Pradesh, Uttar Pradesh, Karnataka, Bihar, Gujarat and Maharashtra.In India, Gujarat ranks eighth in area occupying 1,53,180 ha, and fifth in production with 1.44 million metric tons of production and productivity of 8.11 metric tons per hectare. The mango crop is attacked by about 492 species of insects, 17 species of mites, and 26 species of nematodes at the world level[6]. Of these, 188 species of insects have been reported from India[7]. Among insect pests, fruit flies have been reported to cause major damage in South Gujarat[8-14]. The seasonal abundanceand distribution of the pests depend largely upon the prevailing environmental condition, as the pests multiply tremendously during favorable weather conditions leading to their outbreaks. Environmental factors also influence natural enemy populations such as predators and parasitoids either directly or indirectly[13]. For developing an early warning weather-based system for any pest in a specific agroecosystem, it is necessary to know the seasonal occurrence of pests with prevailing weather parameters. This will help in determining appropriate times for intervention and the application of suitable methods for pest management. Therefore, the investigation was carried out to study the seasonal abundance of important pests and natural enemies of mangoes and their correlation with weather parameters under south Gujarat conditions.

2. MATERIALS AND METHODS

The investigation was conducted at the Instructional Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University (N.A.U.), Navsari, Gujarat, India, 2021-2022. For this study, mango orchards of an area of 2000 m^2 with *var*. Kesar was selected, which was kept free from the insecticidal spray.

The observations of leaf webber and shoot borer were recorded from randomly selected two twigs of about 2.0 m length per tree from four directions *viz*., north, south, east, and west from five trees at fortnightly intervals by visual and inspection count method. In all,a total of 8 twigs per tree were observed, and thus,the total number of observations was forty. After recording observation, the damaged shoot/webbed leaves were removed from the twig. The number of damaged shoot/webbed leaves per twig was recorded.

For the mango hopper, five trees from the orchard were selected and tagged. Observations were recorded by randomly selecting ten inflorescences/growing shoots from each tree at fortnightly intervals. During the off-season, insects were collected using a 30 cm diameter sweep net having a 1.5 mm mesh attached with a 2m long rod. Every fortnight sweeping was done in between 9.00 to 11.00 am and each sample consisted of 10 sweeps. The collected insects were brought from the experimental field to the Post Graduate laboratory to count the mango hopper population per 50 sweeps.Hopper population per ten inflorescences/growing shoots or 10 sweeps were recorded.

Methyl eugenol traps were used for monitoring the fruit fly population. In the orchard, traps were installed @10/ha.The mean number of fruit fly caught per trap were recorded at 15-days intervals.

The population of thrips was recorded from three infested leaves each from four directions *viz*., north, south, east, and west from randomly selected five trees at fortnightly intervals by tapping the leaves on a sheet of white paper, and the numbers of thrips were counted immediately using a magnifying hand lens visually.The total number of thrips per three leaves was recorded.

Five randomly selected mango trees of about the same age and canopy were pin-marked and the number of mealy bug nymphs/female adults present on ten terminal twigs/inflorescences per tree were recorded at fortnightly intervals.The number of nymphs/female adults on ten terminal twigs/inflorescences was recorded.

Mature ten mango fruits were collected from each tree and cut open to check the presence of stone weevils from randomly selected ten trees.The number of infested fruits with grub/adult weevil per tree was recorded.

The data on weather parameters *viz*. maximum and minimum temperature, morning and evening relative humidity, wind speed, rainfall, evaporation, and sunshine hours,*etc*. were obtained from the agro-meteorological observatory, College farm, N.A.U., Navsari. The influence of weather parameters on the population of various insect pests *viz.,* leaf webber, shoot borer, thrips, mealy bug, leafhopper, fruit fly, and stone weevil, *etc*., were worked out using simple correlation and regression analysis.

3. RESULTS AND DISCUSSION

3.1 Seasonal Incidence of Important Pests of Mango

3.1.1 Leaf Webber

The leaf webber incidence started appearing during the 25th SMW with a mean infestation of 0.15 active webs per twig. The incidence increased gradually and reached its peak at 46th SMW with a mean infestation of 2.13 active webs per twig and then started declining to 0.40 active webs per twig during 11th SMW.After the 13th SMW, the larval population almost disappeared from the orchard and no further infestation was noticed till the 23rd SMW in the mango orchard (Table 1 and Fig. 1).

Earlier, Kasar *et al.*[14] reported that the most active period of mango leaf webberwas from August to December. Mallikarjun[15] and Bana *et al.*[16] recorded the incidence of mango leaf webberfrom June to January with its peak during November. Kannan and Rao[17], Gundappa *et al.*[18], and Soumya *et al.*[19] observed the incidence of leaf webberfrom July to December and the peak incidence during October. These findings are similar to the present findings.However, the present findings differ from the findings of Das[20]who reported the peak incidence of mango webberfrom February to April. It might be due to less congeniality of climatic factors, different locations, and weather conditions.

The leaf webber population exhibited a significant negative correlation with minimum temperature (r= -0.488*) and evaporation (-0.483*).Whereas, it hada non-significant negative correlation with the maximum temperature (-0.310), morning relative humidity (r= -0.226), evening relative humidity (r= -0.141), wind velocity (r= -0.393), rainfall (r= -0.252) and sunshine hours (r= -0.171) (Table 2).

Mallikarjun[15] revealed that the population of leaf webberhad a significant negative correlation with minimum temperature, which is similar to the present findings.Kasar *et al.*[14] revealed that atmospheric temperature had a significant negative effect on the leaf webber population.

Table 1. Seasonal abundance of important pests of mango from the 13th to 11th SMW (2021-22)

SMW	Leaf webber (Mean no. of webbed leaves per twig)	Leafhopper(Mean no. of leafhoppers per 10inflorescences/ growing shoots	Fruitfly(Mean no. of fruit fly caught per trap)	Shoot borer (Mean no. of damaged shoots per twig)	Thrips (Mean no. of thrips per 3 leaves)	Mealy bug (Mean no. of nymph/female adults per 10 twigs/ inflorescences	Stone weevil (Mean no. of infested fruit with grub/adult per tree)
13	0	45.80	178.50	0	5.50	0	0
16	0	32.40	208.40	0	4.10	0	0
19	0	15.20	256.90	0	3.25	0	0
21	0	9.20	195.20	0	2.10	0	0
23	0	6.50	171.90	0	1.50	0	0
25	0.15	4.50	183.40	0	0.50	0	0
27	0.20	3.40	199.70	0	0	0	0
29	0.35	3.70	180.70	0	0	0	0
31	0.72	4.80	183.70	0	0	0	0
34	0.75	5.40	185.30	0	0	0	0
36	0.85	5.80	112.60	0	0	0	0
38	1.17	6.20	104.20	0	0	0	0
40	1.47	8.60	100.30	0	0	0	0
42	1.55	24.40	110.00	0.81	2.50	0	0

44	1.97	28.80	108.20	0.86	2.90	0	0
46	2.13	29.80	97.50	0.95	3.20	0	0
48	1.65	33.40	95.80	1.24	3.40	0	0
51	1.50	49.20	86.10	1.34	3.00	0	0
1	1.37	57.60	78.50	0.98	2.50	0	0
3	1.08	66.20	74.20	0.88	3.20	0	0
5	0.75	85.80	77.30	0.70	6.80	0	0
7	0.80	108.60	85.90	0.65	7.95	2.80	0
9	0.60	280.80	99.70	0.44	7.60	2.60	0
11	0.40	253.40	130.90	0	7.45	0	0

Table 2. Correlation coefficient between weather parameters and population of important pests of mango

Insect pests	T_{max} (X_1)	T_{min} (X_2)	RH_{mor}(X_3)	RH_{eve} (X_4)	Wind Velocity (X_5)	Sunshine Hours (X_6)	Rainfall (X_7)	Evaporation (X_8)
Leaf webber	-0.310	-0.488*	-0.226	-0.141	-0.393	-0.171	-0.252	-0.483 *
Leafhop per	0.107	-0.495*	0.414*	-0.117	0.577**	-0.363	0.823**	-0.122
Fruit fly	0.327	0.761**	0.037	0.362	0.646**	0.004	0.232	0.524**
Shoot	-0.263	-0.804**	-0.260	-0.467 *	-0.437*	0.253	-0.356	-0.275

borer								
Thrips	0.438*	-0.690**	-0.396	-0.879**	-0.567**	0.684**	-0.541**	0.336

*Significant at 5 per cent level of significance, **Significant at 1 per cent level of significance

T_{max}= Maximum temperature, T_{min} = Minimum temperature, T_{mor} = Morning relative Humidity, T_{eve} = Evening relative humidity

Table 3. Regression equation of pests in relation to major abiotic factors

Pests	Regression Equation	R2
Leaf webber	Y **=** 7.522 + 0.017 (X_1) - 0.105(X_2) - 0.066 (X_3) + 0.030 (X_4) - 0.106 (X_5) - 0.013 (X_6) -0.009 (X_7) - 0.250 (X_8)	0.872
Leafhopper	Y **=** -477.259 + 12.622 (X_1) + 8.481(X_2) + 4.708 (X_3) - 5.568 (X_4) - 1.823 (X_5) - 3.597 (X_6) + 0.090 (X_7) - 29.467 (X_8)	0.752
Fruit fly	Y **=** 45.658 - 5.302 (X_1) + 7.346(X_2) + 0.426 (X_3) - 0.578 (X_4) + 5.049 (X_5) + 0.010 (X_6) + 0.207 (X_7) + 27.368(X_8)	0.849
Shoot borer	Y **=** 3.924 - 0.002 (X_1) - 0.131(X_2) - 0.022 (X_3) + 0.027 (X_4) + 0.034 (X_5) + 0.065 (X_6) - 0.007 (X_7) - 0.082 (X_8)	0.858
Thrips	Y **=** -8.069 + 0.252 (X_1) + 0.005(X_2) + 0.127 (X_3) - 0.122 (X_4) - 0.076 (X_5) + 0.054 (X_6) + 0.005 (X_7) - 0.168 (X_8)	0.880

Where,Y = Pest Population, X_1 = T_{max}, X_2 = T_{min}, X_3 = T_{mor}, X_4 = T_{eve}, X_5 = Wind velocity, X_6 =Sunshine hours, X_7 = Rainfall, X_8 = Evaporation

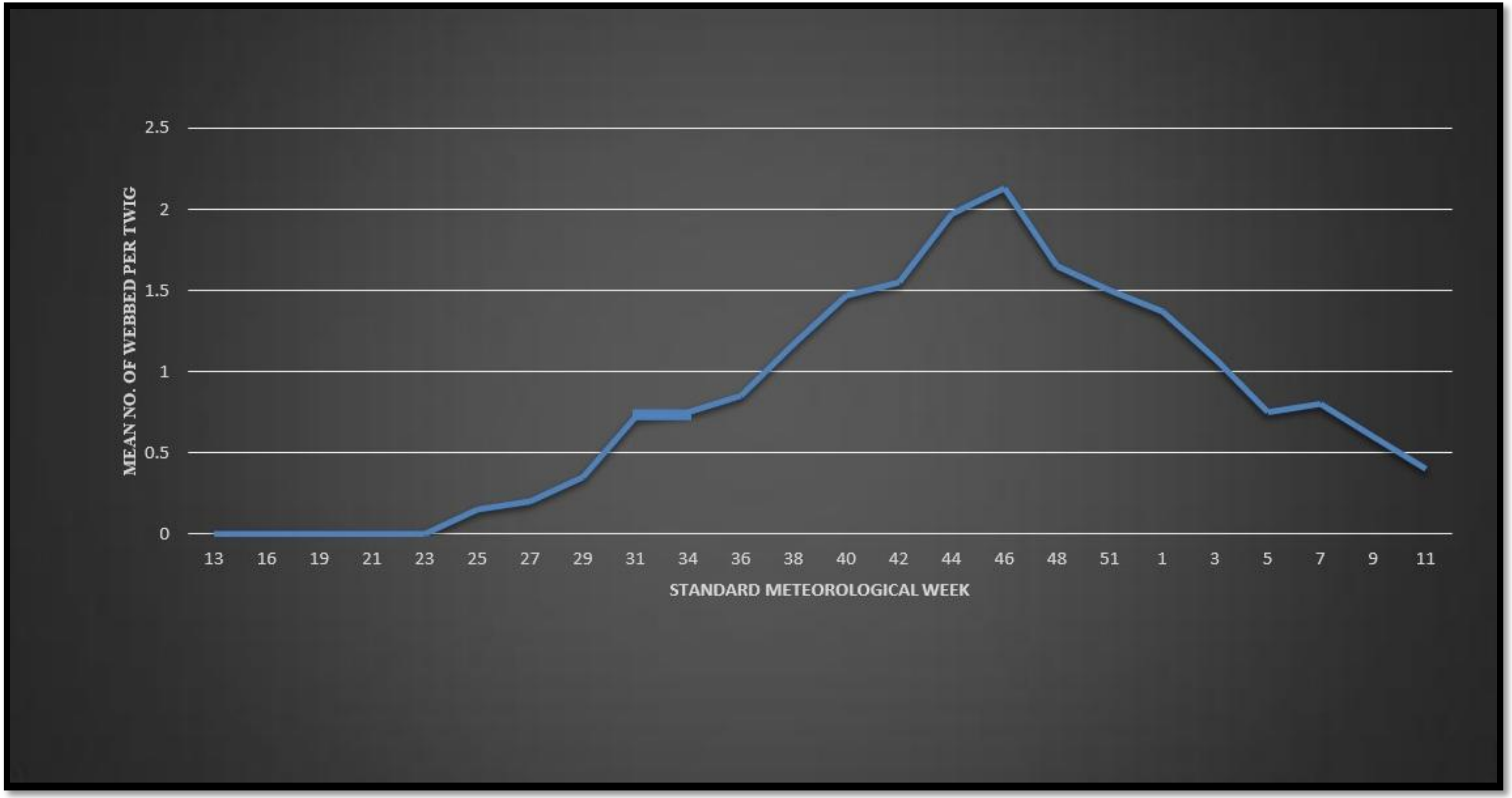

Fig 1. Mean number of webs per twig from the 13th to 11th SMW (2021-22)

3.1.2 Leafhopper

The leafhopper population was observed throughout the year on inflorescence, leaf, and trunk. The minimum population was recorded during the 19^{th} to 38^{th} SMW. The gradual increase in hopper population was observed from 42^{nd} to 9^{th} SMW with the mean number of 24.4 to 280.8 hoppers/ inflorescence. The peak incidence of mango hoppers was recorded during the 9^{th} SMW with a mean number of 280.8 hoppers/ inflorescence (Table 1 and fig. 2).The mango hopper population coincided with the emergence of inflorescence. It was also observed that the population of hoppers migrated from the trunk to the upper canopy as new flush and inflorescence emergence increased and hoppers hid on the trunk during off season.

In the past, Rahman *et al.*[21] showed that the hopper population started increasing in 2^{nd} week of February and reached apeak in 2^{nd} week of March, fluctuating from 6-13 hoppers per panicle till 3^{rd} week of April and decreasing thereafter. Pushpalatha *et al.*[22] recorded the peak incidence of leafhopper in March-April. The rise in temperature during April-July led to anincrease in the population of hoppers. Anant[23] and Bana *et al.*[16] reported that the hopper remained active throughout the year in the cracks and crevices of the mango trunk. Gundappa *et al.*[18] and Chaudhari *et al.*[24] observed that the incidence of mango leafhopperoccurred throughout the year and showed apeak from March to April. These findings are similar to the present findings.On the contrary, Sharma and Tara[25] recorded the peak incidence of mango hoppers from May to June. Then, the hopper population started declining but showed another peak from August to September. Differences might be due to different locations, weather parameters, and per cent infestation in the crop**.**

The leafhopper population exhibited a highly significant positive correlation with wind velocity (r= 0.577**) and rainfall (r= 0.823**). Whereas, it hada significant negative correlation with minimum temperature (r=-0.495*) and morning relative humidity (r= -0.414*). It showed a non-significant positive correlation with maximum temperature (0.107) and a non-significant negative correlation with evening relative humidity (-0.117), sunshine hours (r= -0.363), and evaporation (r=- 0.122) (Table 2).

In the past, Kavitha[26] observed that the population of leafhoppers evinced a significant negative correlation with the minimum temperature, which is similar to the present investigation. On the contrary, Kumar[4] observed that the hopper population hada negative and non-significant correlation with maximum, average temperature and rainfall whereas, it had a positive and non-significant correlation with morning, evening, and average relative humidity, respectively. It might be due to differencesin locations and weather parameters and infestation in crops.

3.1.3 Fruit fly

The population of fruit flieswas observed throughout the year. The population reached its peak at 19th SMW with a mean number of256.9 fruit flies per trap. The lowestpopulation of the fruit fly was observed during the 3rd SMW with a mean number of 74.2 fruit flies per trap. The presence of fruitflies throughout the year might be due to the neighboring orchards of sapota and the polyphagous nature of fruit flies (Table 1 and fig. 3).

Earlier, Jena *et al.*[9] and Jena *et al.*[11] reported that the population of fruit flies, *B. dorsalis* and *B. zonata*, prevailed throughout the year in mango orchards with its peak activity from 14th to 31st SMW which coincided with the fruiting and harvesting period of fruits. Sumathi *et al.*[27] recorded ahigher fruit fly population from April to August and very low in January. Patel *et al.*[28] showed that the fruit fly population was higher from April to July in South Gujarat condition. Amin *et al.*[29] found that fruit fly species were significantly higher from February to May (dry season) as compared to June to September (rainy season). Sarda *et al.*[30] and Jean *et al.*[31] observed the population of fruit fliesfrom March to June and the peak population during the last week of April. These findings are in concurrence with the present findings.

The fruit fly population exhibited a highly significant positive correlation with minimum temperature (r= 0.761**), wind velocity (r= 0.646**), and evaporation (r= 0.524**). The maximum temperature (r= 0.327), morning relative humidity (r= 0.037), evening relative humidity (r= 0.362), sunshine hours (r=0.004), and rainfall (0.232) showed a non-significant positive correlation (Table 2).

Previously, Nboyinee*et al.*[32] observed that the population of fruit flies was positively correlated with temperature but negatively correlated with relative humidity, which is similar to the present findings. Similarly, Nahid[33] found that the daily mean temperature had a significant positive, and light intensity had a non-significant positive correlation with the fruit fly population.

3.1.4 Shoot borer

The infestation of shoot borer first appeared during the 42nd SMW with a mean infestation of 0.81 infected shoots per twig. Further, the incidence gradually increased and reached its peak at 51st SMW with amean population of 1.34 infected shoots per twig, and then onwards started declining and the population of this pest reached zero during 11th SMW (Table 1 and fig. 4).

In the past, Patel *et al*.[28] noticed asevere incidence of shoot borer on new shoots of mango during October-February, which is in close agreement with the present findings. Singh and Kaur[34] observed that mango shoot borers were most abundant from October to November, which also supports the present results.The present findings differ from those of Kaushik[35] who observed that the incidence of shoot borer remained active from March to June, which might be due to different locations, weather parameters, and per cent infestation in the crop.

The shoot borer population exhibited a highly significant negative correlation with minimum temperature (r= -0.804**) anda significant negative correlation with evening relative humidity (r= -0.467*) and wind velocity (r= -0.437*). However, the population exhibited a non-significant negative correlation with maximum temperature (r= -0.263), morning relative humidity (r= -0.260), rainfall (-0.356), and evaporation (r= -0.275) (Table 2).

Previously, Rama Devi and Jha[36] reported that all the abiotic factors had a significant effect on borer infestation but only sunshine hours showeda non-significant effect, which supports the present findings.

3.1.5 Thrips

The population of thrips started appearing during the new flush period from the 42nd to 51st SMW with a mean population of2.5 to 3.0 thrips/three leaves. Further, the population gradually increased and reached its peak at 7th SMW with a mean population of 7.95 thrips/three leaves and then onwards started declining (Table 1 and fig. 5).

Earlier, Pattan[37] observed the highest population of thrips from the last week of February to the first week of March. The thrips incidence was low during the bud stage of mango inflorescence, increased with the initiation of flower opening, and reached the peak in fully opened panicles. Similarly, Patel *et al.*[28] found that thrips incidence was more active during the vegetative (new flush) and flowering cum fruit setting stages (February-March) in South Gujarat condition. The present findings are in line with those of earlier workers.

The thrips population exhibited a highly significant negative correlation with minimum temperature (r= -0.690**), evening relative humidity (r= -0.879**), wind velocity (r= -0.567**), and rainfall (r= - 0.541**). Whereas,it had a highly significant positive correlation with sunshine hours (r= 0.684**). The population exhibited a significant positive correlation with maximum temperature (r= 0.438*). The morning relative humidity (r= -0.396) showed a non-significant negative correlation and evaporation (r= 0.336) showed a non-significant positive correlation with the thrips population(Table 2).

Earlier, Aliakbarpour and Rawi[38] observed that the population of thrips was significantly influenced by temperature and relative humidity. Pattan[37] observed that the mean number of thrips had a negatively significant correlation with minimum temperature. These findings are similar to the present findings.

3.1.6 Mealy bug

The population of mealy bugs was recorded as very low. The incidence of the mealy bug was observed during the 7th to 9th SMW (Table 1).According to Akter *et al*.[39], mealy bugs were most abundant from January to March and gradually decreased from April to July, which differs from the present findings that might be due to different locations and cultural practices.

3.1.7 Stone weevil

The population of stone weevil was recorded as nil (Table 1).These findings are more or less in confirmation with the findings of Patel *et al.*[28] who reported that the overall per cent infestation of stone weevil was found at 0.48 per cent in South Gujarat.

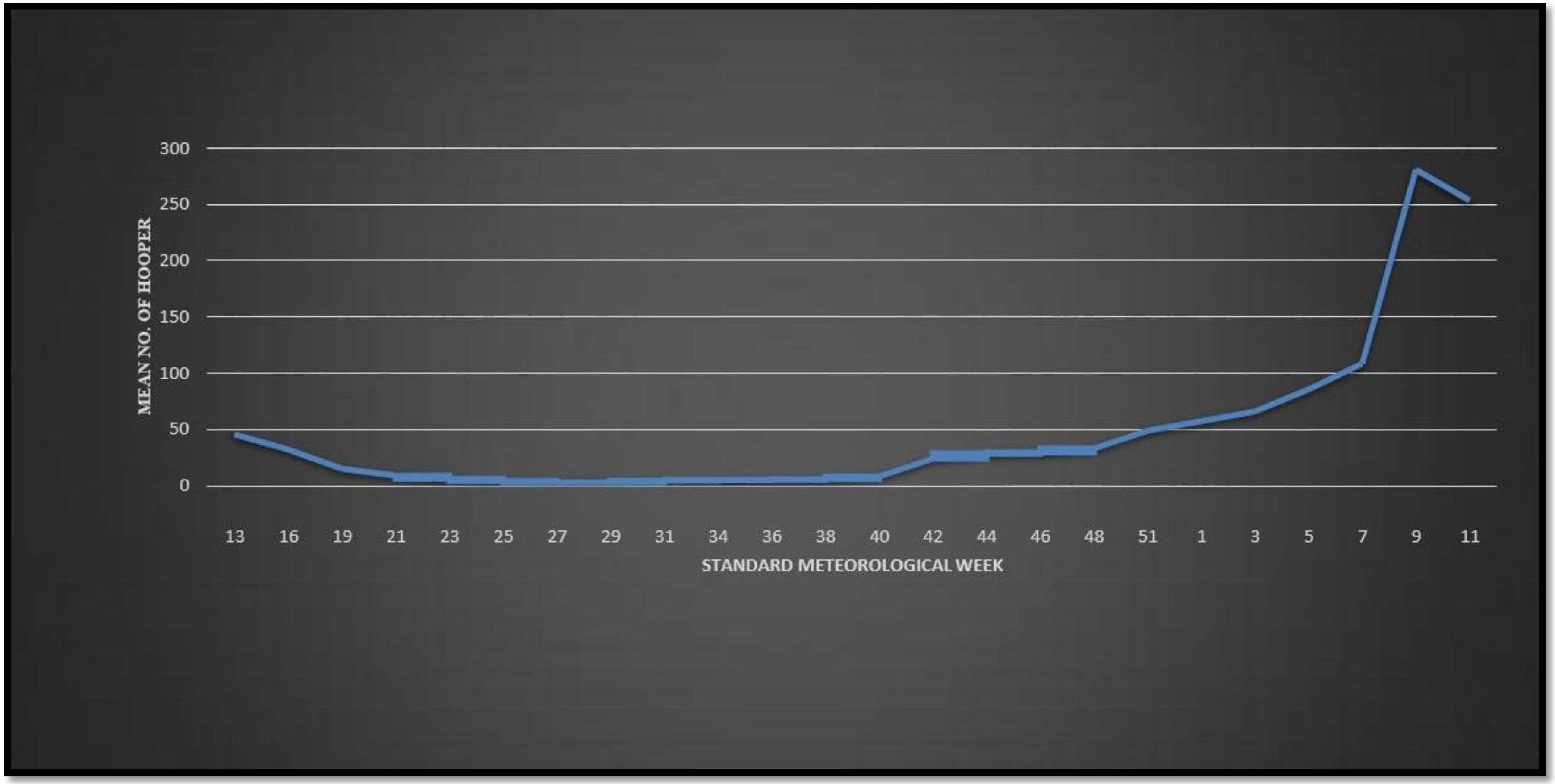

Fig 2. The mean number of mango hopper from the 13th to 11th SMW (2021-22)

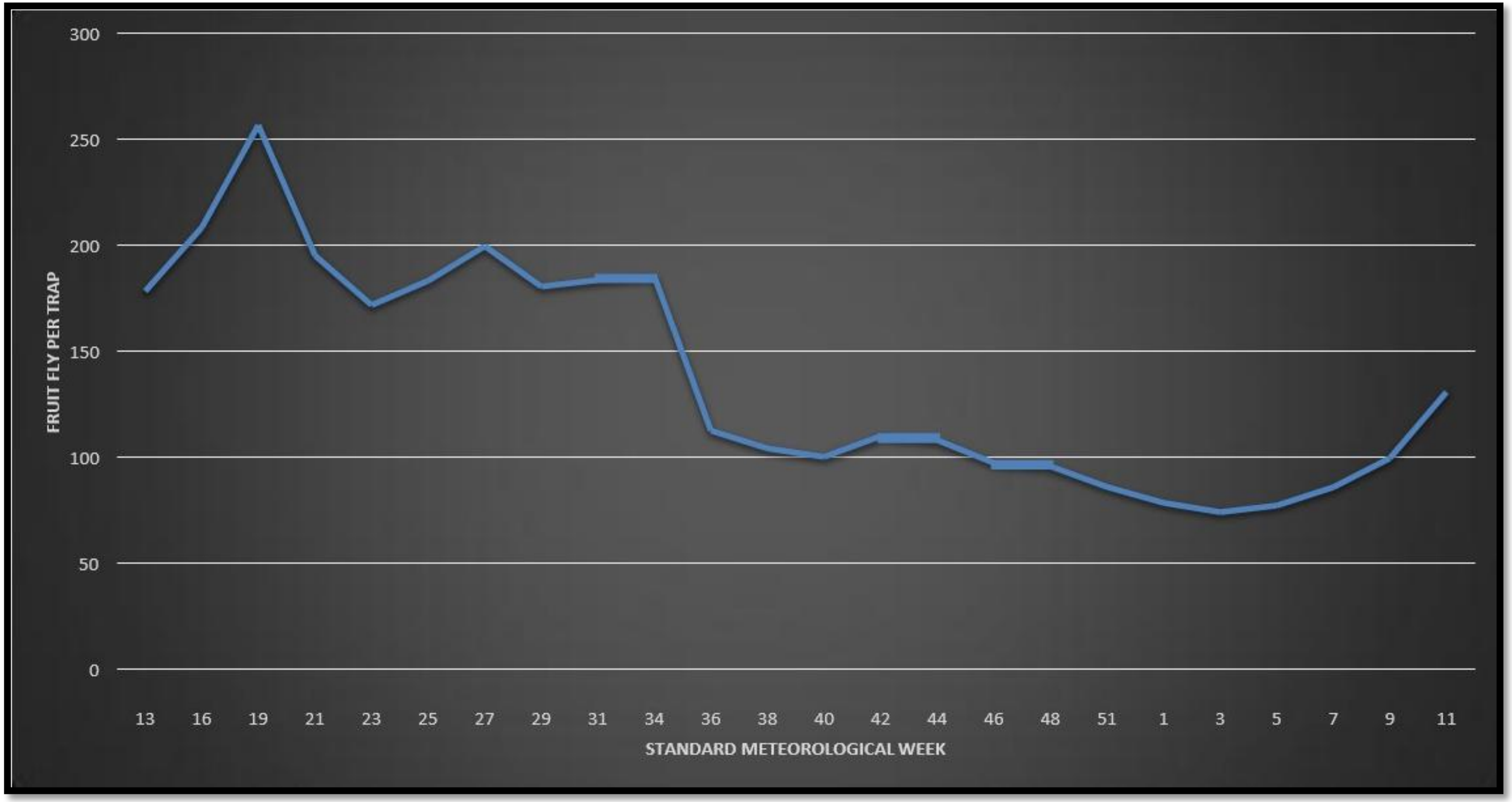

Fig 3. The mean number of fruit fly caught per trap from the 13th to 11th SMW (2021-22)

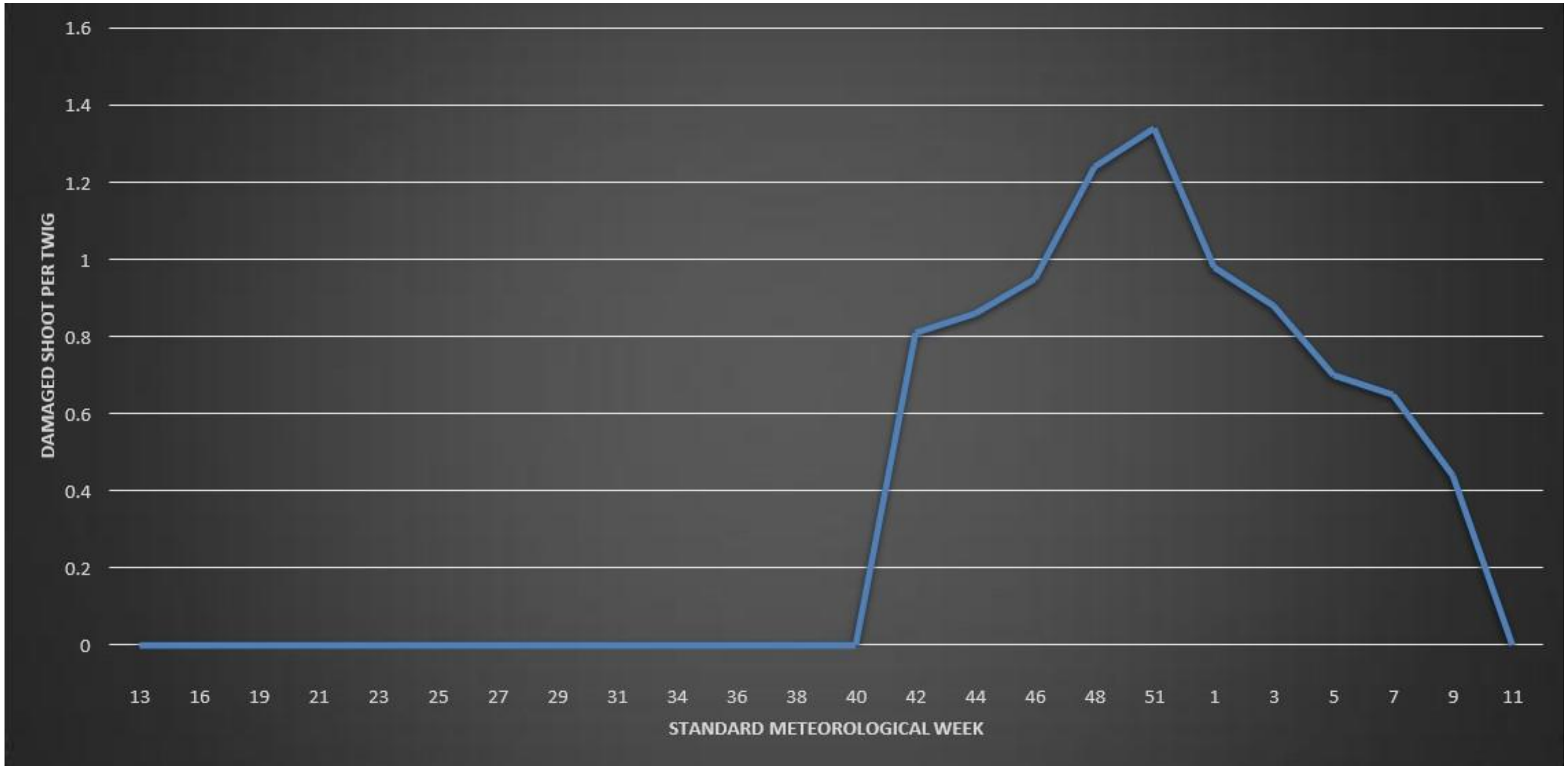

Fig. 4. The mean number of damaged shoots per twig from the 13th to 11th SMW (2021-22)

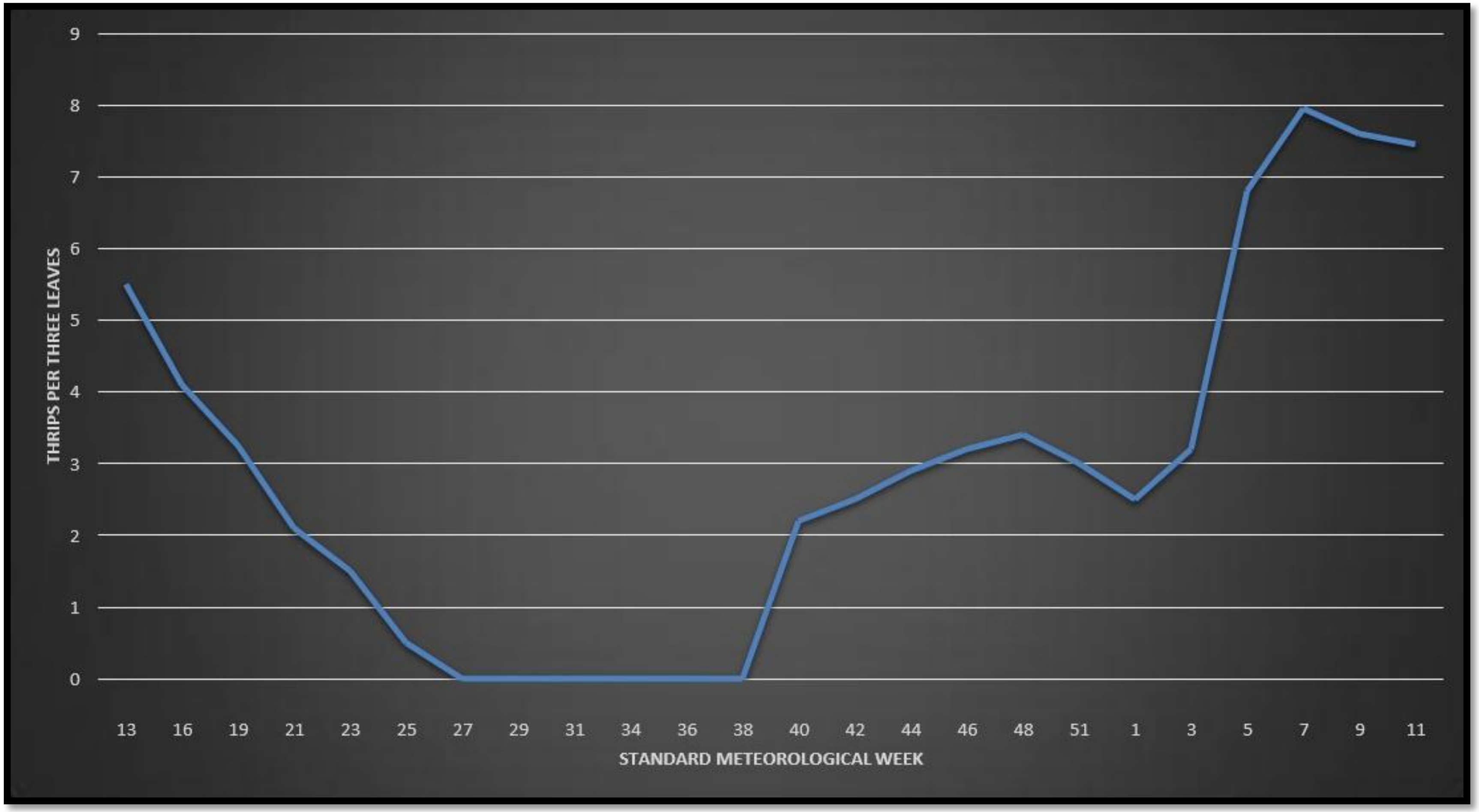

Fig. 5. The mean number of thrips per three leaves from the 13th to 11th SMW (2021-22)

3.2 Seasonal Incidence of Natural Enemies in Mango Orchard

3.2.1 Red ant

The red ant population was observed throughout the year on inflorescence, leaf web, and trunk. The population of red ants was high during the 9th SMW and low during the 23rdto 42nd SMW (Table 4).In the past, Bana *et al.*[16] observed the red ant from February to May with a low population. Anant[23] reported that red ant remained active from October to the fruiting stage of the trees, which isconcurrent with the present findings.

3.2.2. Mantids

The maximum population of mantids was recorded during the 46th SMW. A nil population of mantidswas observed during the 21stto 29th SMW (Table 4).Earlier, Anant[23] recorded the mantid activity from November to April, which is similar to the present findings. Patel *et al.*[28] observed the maximum population of mantids from September to October. It differs from the present findings due to different locations and weather conditions.

3.2.3. Spider

The maximum population of spiders was observed during the 9th SMW. A nil population of spiderswas observed during the 21stto 25th SMW (Table 4).In the past, Anant[23] observed the spider during the fruiting period with a low population which is in close agreement with present findings.

3.2.4. Chrysopa

A higher population of chrysopa was observed during the 5th SMW and nil population was observed during the 13thto 34th SMW (Table 4).Earlier, Anant[23] observed the chrysopa during December to April which is in concurrence with the present findings. More *et al.*[40] recorded the maximum chrysopa population during the first fortnight of November and December.

Table 4. Natural enemies recorded from mango orchard from the 13th to 11th SMW (2021-22)

SMW	Ants/tree	Mantids/tree	Spiders/tree	Chrysopa/tree
13	++	2.2	5.2	0
16	++	2.2	6.1	0
19	++	3.3	5.2	0
21	++	0	0	0
23	+	0	0	0
25	+	0	0	0
27	+	0	4.1	0
29	+	0	6.3	0
31	+	2.4	7.5	0
34	+	1.5	5.2	0
36	+	2.2	5.4	1.2
38	+	1.2	3.2	2.3
40	+	2.4	6.2	2.2
42	+	2.2	5.3	2.3
44	++	5.3	4.2	1.4
46	++	5.5	6.2	1.5
48	+	2.2	4.6	2.2
51	+	1.2	5.4	2.3

1	+	2.2	5.2	3.5
3	+	2.3	6.5	4.3
5	++	1.5	7.5	5.4
7	++	5.4	5.3	1.5
9	+++	5.3	9.7	1.6
11	++	5.2	8.5	1.2

+++=High population, ++=Moderate population, +=Low population, - = Nil Population. For ants/twig (more than 700=+++, between 400 to 700= ++, less than 400= +)

4. CONCLUSION

The leaf webber, leafhopper, fruit fly, shoot borer, and thrips were the major pests causing economic damage, whereas the mealybug and stone weevils were minor pests. The leaf webber population exhibited a significant negative correlation with minimum temperature and evaporation.The leafhopper population exhibited a highly significant positive correlation with wind velocity and rainfall, and a significant negative correlation with minimum temperature and morning relative humidity. Fruit fly population exhibited a highly significant positive correlation with minimum temperature, wind velocity, and evaporation. Shoot borer population exhibited a significant negative correlation with minimum temperature, evening relative humidity, and wind velocity. The thrips population exhibited a highly significant negative correlation with minimum temperature, evening relative humidity, wind velocity, rainfall, and a significant positive correlation with sunshine hours and maximum temperature.Among natural enemies, ants, mantids, spiders, and chrysopa were reported in the orchard and none of the parasitoids were reported during the study period.

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COMPETING INTEREST

No competing interest exists

AUTHOR CONTRIBUTION

SMP. Investigated the research, SHP. supervised the work, MKJ. wrote, reviewed, and edited the manuscript

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