Population dynamics of arthropods on tomato (*Lycopersicum esculentum* l.) in Vindhya plateau region of Madhya Pradesh

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Summary

The field experiment results on “population dynamics of different insect pest and their natural enemies on tomato” showed that the aphid population peaked in the 7th SMW (8.83 aphids/6 leaves) during *Rabi* Season 2021-22. *Amrasca biguttula* population attained its peak (6.33 jassids/ 6 leaves) during the 11th SMW. The first peak of the leaf miner population was observed (4.67 leaf miner/6 leaves) during the 11th SMW and the second during the 16th SMW. The tomato mirid bug had the highest mean population (5.80 bugs/ plant) during the 11th SMW. The damaged fruit borer (*H. armigera*) was first recorded during the 9th SMW and maximum fruit damage was 96 per cent during the 13th SMW. The maximum mean population of ladybird beetle (5.26 lady beetles/ plant) and weaver ant (12.06 Weaver ant/ plant) was recorded during the 11th standard week. The peak population of damselfly (2.20 damselfly/ plant), whitefly (7.83 whitefly/6 leaves) and dragonfly (2.20 dragonflies/plant) were observed during the 10th SMW.

JAE 2023, Vol 17
Received: 15 August 2023
Accepted: 20 September 2023
Published: 30 September 2023
https://doi.org/10.58628/JAE-2317-310

Associated Editor: Dr. SM Haldhar

Keywords: Tomato, pest, population, predators, plant, arthropods, weather, biotic, abiotic, aphid, beetle, wasp, dragonfly

Introduction

Tomato (*Lycopersicum esculentum* Linn), belonging to the family Solanaceae, is a chief vegetable crop cultivated worldwide. The fruits are very rich in minerals, vitamins, vital amino acids, iron and sugar, all of which collectively ensure a healthy and balanced diet. Tomato is grown in about 880.00 thousand ha in India, producing 19.696 thousand metric tons, productivity 24.4 tons/ ha over an area of 0.8085 million hectares. Andhra Pradesh, Tamil Nadu, Karnataka, Chhattisgarh, Madhya Pradesh, Gujarat, Bihar, Odisha, Uttar Pradesh, West Bengal and Maharashtra are the essential tomato-producing states in India. These states make up approximately 90 per cent of the country's overall output (NHB, 2020). Madhya Pradesh an important tomato-growing state, has an area of 100 thousand ha, production of 3.102 million tonnes and productivity of 31.02 tonnes/ha over an area of 0.1 million hectares (Anonymous 2017).

Like many other crops, the production of tomatoes can be adversely affected by various abiotic and biotic factors. Among the biotic factors, pests such as insects, weeds, and diseases pose significant challenges to tomato cultivation. A major limiting factor among biotic factors is pest infestation, which greatly challenges its cultivation in farmer fields by imposing crop quality and quantity deterioration. These factors can lead to reduced yields and impact the quality of the marketable fruit. The insect pests of tomato cause significant economic loss by feeding directly on leaves, stems and fruits and indirectly by transmitting the viral diseases that lead to significant economic loss. Tomato growers are regularly harmed by aphid (*Aphis gossypii*), jassid (*Amrasca bigutulla*), fruit borer (*Helicoverpa armigera*) and whitefly (*Bemisia tabaci*). These pests are polyphagous in nature and are observed throughout the year. The tomato crop is attacked by 41 insect species representing 21 families of class Hexapoda. (Reddy and Kumar, 2004). The primary insect pests responsible for significant economic losses in tomato crops include the American leaf miner, aphid, jassid, whitefly and fruit borer. The fruit borer *Helicoverpa armigera* has been reported to cause yields losses of 14 to 45 per cent of tomato fruit yield in various Indian states (Kurl & Kumar 2010). The tomato pinworm, *Tuta absoluta* (Meyrick) is a recent invasive pest that was first time reported in India in Maharashtra. It has spread eastward and southward at an average rate of 800 km yearly imposing the most severe challenge to tomato cultivation in India (Biondi et al 2018). Under both greenhouse and field conditions, it has the potential to result in a significant reduction of up to 90 per cent in crop yield and fruit quality.

Spiders, the most abundant and ubiquitous animals on la nd, are important part of the agroecosystem's predaceous arthropod community, which helps maintaining ecological balance (Upadhyay et al. 2018). In

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integrated pest management (IPM), biological control using predators of major pest species is an appealing and ecological alternative to pest management (Yang et al. 2017). Tomato mirid bug (*Nesidiocoris* sp.) are omnivorous in Mediterranean agro-ecosystems and help in control small arthropod pests in vegetable crops (Sanchez 2008). In the middle of March, the leaf miner infests the tomato crop (76.67 per cent). The white fly population became prevalent in March onwards while, the fruit borer population started in April onwards (Kharpuse 2005). The fruit borer, a highly destructive pest, poses a significant threat to tomato crops throughout the year, leading to substantial losses in the quality and quantity of the harvest. Fruit borer attack on tomato is estimated to cause a 70 per cent loss in marketable yield (Abbas et al. 2015).

Precise population estimation of pests is crucial for several reasons. Firstly, it helps gauge the severity of pest populations and their impact on crops. Secondly, it aids in evaluating the effectiveness of natural predators in controlling pest populations. Additionally, population estimation assists in assessing crop losses caused by pests, monitoring the emergence of new pests, and making informed decisions regarding appropriate pest control methods. Gaining a thorough understanding of the relationships between insect pest populations, their timing of appearance, and the duration of crop damage during critical growth stages is essential for determining the economic threshold. This information is crucial for devising insect pest management programs tailored to specific agricultural ecosystems. Additionally, it is essential to possess a fundamental understanding regarding the prevalence and geographical spread of pests in correlation to weather conditions. Such knowledge aids in determining the optimal timing for implementing control measures and selecting effective pest control methods. Considering these facts, this study entitled "Population Dynamics of Arthropods on Tomato (*Lycopersicum esculentum* L.) In Vindhya Plateau Region of Madhya Pradesh" was carried out.

Materials and Methods

The current study took place during the Rabi season of 2021-22 at the research farm of the College of Agriculture, Ganjbasoda. A prevalent variety of tomato, OH- 1156 was grown on 24th November 2021 and transplanted on 5th January 2022 with spacing 60 X 45 cm spacing in a 100 m² plot. The crop was cultivated in accordance with all the recommended agronomic practices specific to the region, while no plant protection measures were implemented during the entire crop season. Finally, the crop was harvested on 5th May 2022.

Population dynamics of major insect pests were observed on six leaves per (two lower, two middle, two upper) and natural enemies were noted on 15 randomly selected and tagged plants (canopy). Observations were recorded from transplanting onwards up to maturity of the crop. Whereas, the tomato mirid bug was recorded as 30cm twig/ plant and *H. armigera* population was documented based on a number of damaged fruit/ plants. During each picking, number of healthy and damaged fruit of 5 randomly selected plants was counted and the fruit damage percentage was arrived at using the following formula.

$$\text{Fruit damage}(\%) = \frac{\text{Number of damage fruit}}{\text{Total number of fruit}} \times 100$$

To examine the impact of weather limits, including maximum temperature, minimum temperature, morning relative humidity, and evening relative humidity, on the populations of insect herbivores and their natural predators in tomato plants, a simple correlation coefficient was computed. This analysis aimed to determine the relationships between these weather factors and the abundance of pests and their predators. Weekly meteorological data was collected from the meteorological department itself.

Results and Discussion

Aphis gossypii: The first appearance of aphid in the field was recorded during the 2nd (SMW), which are 1.83/ 6 leaves. The mean of maximum and minimum relative humidity was, 92.4%, 56.0%, respectively minimum and maximum temperature was 8.7̊ C and 22.0̊ C, respectively. The population grew steadily until its peak occurred in the 6th meteorological week (8.5 aphids /6 leaves). The mean of minimum and maximum temperature and evening and morning RH, were 13.3̊ C, 31.4̊ C, and 19.8%, 69.9%, respectively. The incidence of aphid population was recorded from the 2nd to 17th standard meteorological week. The aphid population had a significant negative relationship with maximum (r = -0.502*) and minimum temperatures (r = -0.623**) while, a positive significant correlation was there with morning humidity (r = 0.514*) and positive non-significant with evening RH (r = .090). The findings of present study are corroborated with that of Shakeel et al. (2014), Samadia & Haldhar 2017, 2019 and Dhanda et al. (2020), where the authors mentioned that the pest population has shown a significant negative association between the aphid populace and maximum and minimum temperature.

Amrasca biguttula: The first appearnce of *Amrasca biguttula* was recorded on the 2nd SMW with mean of population 0.16 jassid/ 6 leaves. The mean of minimum and maximum temperature besides evening and morning relative humidity and wind speed during the initial infestation were 8.7̊ C, 22̊ C, 56.0%, 92.4%, and 8 km/ hour, respectively. The peak population of jassid (6.34/ 6 leaves) was recorded at the maturity stage during the 11th metrological week. The mean of minimum in addition to maximum temperature besides evening as well as morning RH were, 20.1̊ C, 37.7̊ C and 15.0%, 36.7%, respectively. A positive non-significant relationship was observed between the jassid population and maximum (r = 0.388) and minimum temperatures (r = 0.242), while, the negative non-significant correlation was there with morning humidity (r = -0.384) and a negative highly significant with evening RH (r = -0.621**). According to Mandloi et al. (2015) and Madhushree (2019). The findings of present study are corroborated with that of Mandloi et al. (2015), Haldhar & Maheshwari 2017 and Madhushree (2019), who found a significant negative relationship between the jassids population and evening RH (r =-0.528).

Bemisia tabaci: The first incidence of whitefly (1.16 whitefly / 6 leaves) was recorded during the 3rd SMW that persisted throughout the cropping season. The peak population of whitefly (7.83 whitefly/6 leaves) was recorded during (the 10th SMW) at a vegetative stage when the mean of maximum and minimum temperature was 37.7° C, 20.1° C and evening and morning RH was 15.05% and 36.7% respectively. Whitefly population had a non-significant negative relationship with the and maximum (r = -0.178) and minimum temperatures (r = -0.382) while, the positive non-significant correlation was there with morning humidity (r = 0.189) and negative non-significant with evening RH (r = -0.191).

Tuta absulata: The leaf miner was first recorded on tomato during the 5th SMW with mean population of 0.33/ 6 leaves. The average minimum and maximum temperature besides evening and morning RH were 9.5° C, 23.9° C and 27.7%, 82.0%, respectively. The peak population (4.67 leaves miner/6 leaves) was observed during the 11th standard week. A positive non-significant relationship was observed between the american leaf miner population and maximum (r = 0.477) and minimum temperatures (r = 0.382), while, negative non-significant correlation was there with morning humidity (r = -0.480) and a negative significant with evening RH (r = -511*). The findings of present study are supported by that of Dhanda et al. (2020), Haldhar et al. 2020 and Selvaraj et al. (2016) who stated a similar significant negative correlation study between leaf miner population and evening RH (r =-0.718). However, it contradicted Chaudhuri and Senapathi (2004), who reported that the peak period of leaf miner was reported at the 8th standard meteorological week.

Nesidiocoris tenuis: The first incidence of tomato mirid bug (0.80 bug/ plant) was recorded during the 5th SMW. The peak population (5.80 bugs/ plant) with during the 11th SMW. The mean temperature (highest and lowest) and RH (morning, evening) were, 37.7° C, 20.1° C and 36.7%, 15.0%, respectively. A positive non-significant relationship was observed between the mirid bug population and maximum (r = 0.483) and minimum temperatures (r = 0.397), while, a negative highly significant correlation was there with morning RH (r = -0.518**) and negative significant with evening RH (r = -511*).

Helicoverpa armigera: The first appearance of fruit borer (*H. armigera)* damage (12% per plant) was recorded between the 9th and incidence up to the 18th SMW. The damaged fruit was first noticed during the 9th SMW. The maximum fruit damage (96 per cent/ plant) was recorded during the 13th SMW at the fruiting stage. The correlation result indicated a positive highly significant development for maximum (r = 0.725**) and minimum temperature (r = 0.677**) while, a negative highly significant result for the morning (r = -0.780**) and evening relative RH (r = -0.626**). The findings of present study are supported by that of Nadaf & Kulkarni (2006) and Kachhawa et al. (2016) and Haldhar & Deshwal 2017, who found a positive, highly significant result for maximum and minimum temperature and a negative, highly significant result for morning and evening RH.

Oecophylla smaragdina: The first appearance of the weaver ant (0.33 weaver ant/ plant) was recorded during the 2nd SMW, which prevailed up to the 18th SMW during the cropping season with a peak of population (12.06 Weaver ant/ plant) at the 11th SMW. A positive significant correlation was detected amid the population of weaver ants and maximum (r = 0.536) and positive non-significant with minimum temperatures (r = 0.416), while, a negative significant correlation was there with morning RH (r = -0.556*) and negative highly significant with evening RH (r = -657**).

Coccicnella septempunctata: The first appearance of ladybird beetle (0.60 beetle) was noticed throughout the 4th standard week which gained its peak (5.06 lady beetle/ plant) during 12th SMW. The correlation studies of beetle showed a positive non-significant relationship with maximum (r = 0.357) and minimum temperature (r = 0.279), whereas, it showed a negative and non-significant (r = -0.382) for morning relative humidity but negative significant correlation (-0.515*) with evening RH.

Neoscona theisi: The first incidence of spider (0.13 spider/ plant) was observed during 3rd SMW and population gained its peak (3.13 spider/ plant) during 12th SMW with mean of maximum and minimum and morning and evening RH were 40.1° C, 22.8° C and 19.3%, 10.6% respectively. A positive non-significant relationship was observed between the spider population and maximum (r = 0.368) and minimum temperatures (r = 0.244) while, the negative non-significant relationship was there with morning humidity (r = -0.380) and negative significant with evening RH (r = -502*).

Sphaerophoria philanthus: The population of syrphid fly prevailed in crop from 4th to 17th SMW with its peak (3.13 syrphid fly / plant) during 13th SMW. At first appearance of syrphid fly (0.13 syrphid fly / plant), the mean of minimum in addition maximum temperature besides evening as well as morning RH 6.8° C, 26.4° C and 49.9%, 88.7%, respectively. There was a significant positive correlation between the population of syrphid flies and the maximum temperature (r = 0.531), and a positive but not statistically significant correlation with the minimum temperature (r = 0.429). However, the syrphid fly population had a significant negative correlation with the morning (r = -0.580*) and the evening relative RH (r = -0.599*).

Mesembrius bengalensis: The first appearance of damselfly (0.06 damselfly / plant) was recorded during the 5th SMW, and the peak population (2.20 damselfly/ plant) was recorded during the 12th SMW with a mean of maximum in addition minimum temperature besides morning also evening RH was 32.2° C, 13.7° C and 56.5%, 22.1% respectively. Damselfly had a positive non-significant relationship with maximum (r = 0.444), minimum (r = 0.336) whereas, negative non-significant correlation (-0.495) per morning relative humidity in addition to negative significant correlation (r = -0.515*) with evening RH. *Delta esuriens***:** The population of dragonfly began to increase steadily with a small fluctuation in number from 5th SMW (0.20

dragonfly/ plant) and gained its peak (2.20 dragonfly/ plant) during 11th SMW, when average minimum in addition, maximum temperature besides evening as well as morning RH were 13.7° C, 32.2̊ C, and 22.1%, 56.5%, respectively. Its population exhibited a positive non-significant relationship with maximum (r = 0.384) and minimum temperature (r = 0.286), whereas, it showed a non-significant negative with morning relative humidity (r = -0.386) and a significant negative correlation (r = -0.509*) with evening RH.

Table 1. Incidence of insect pests on tomato at Ganj-Basoda during *Rabi* 2021-2022

SMW	Date of observation	Mean of population (on 6 leaves)					Larvae/ plant
		Aphid	Jassid	Whitfly	Leaf miner	Mealybug	Fruit borer
1.	09-01-2022	1.83	0.16	0.00	0.00	0.00	0.00
2.	16-01-2022	3.83	0.66	1.16	0.00	0.00	0.00
3.	23-01-2022	5.16	1.83	2.67	0.00	0.00	0.00
4.	31-01-2022	6.33	3.00	3.33	0.3	0.00	0.00
5.	07-02-2022	8.5	2.50	4.16	1.00	0.30	0.60
6.	14-02-2022	8.33	3.16	6.00	1.16	0.92	1.20
7.	21-02-2022	7.5	4.33	5.83	2.66	1.80	1.16
8.	28-02-2022	6.33	4.84	6.33	3.83	3.65	2.20
9.	07-03-2022	7.5	5.16	7.83	4.50	4.80	2.40
10.	14-03-2022	5.83	6.34	6.16	4.66	5.10	3.41
11.	21-03-2022	5.33	5.00	5.00	4.16	6.30	4.60
12.	28-03-2022	4.83	5.16	4.50	3.83	8.86	5.20
13.	04-04-2022	3.33	4.66	3.00	2.66	10.60	4.40
14.	11-04-2022	3.16	4.17	1.83	1.66	12.15	3.20
15.	18-04-2022	1.66	1.83	0.66	2.00	16.85	1.80
16.	25-04-2022	0.33	2.66	0.50	1.83	13.35	1.20
17.	01-05-2022	0.00	1.50	0.16	1.16	11.10	1.0

Table 2. Incidence of natural enemies on tomato at Ganj-Basoda during *Rabi* 2021-2022

SMW	Date of observation	Mean of population/ plant)							
		Red ant	Lady bird beetle	Tomato bug	spider	Syrphid fly	Damselflies	Dragonfly	Ichneumon wasp
1.	09-01-2022	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.	16-01-2022	1.20	0.00	0.00	0.13	0.00	0.00	0.00	0.00
3.	23-01-2022	2.60	0.60	0.00	0.33	0.00	0.00	0.00	0.00
4.	31-01-2022	3.80	1.06	0.80	0.60	0.13	0.06	0.20	0.20
5.	07-02-2022	4.20	1.60	1.66	1.13	0.40	0.13	0.33	1.32
6.	14-02-2022	3.93	2.20	1.93	1.53	0.67	0.54	1.54	1.80
7.	21-02-2022	5.06	3.33	2.20	2.06	0.93	0.86	1.34	1.93
8.	28-02-2022	8.02	3.86	3.26	2.20	1.60	1.06	1.06	2.06
9.	07-03-2022	10.93	4.60	4.66	2.66	1.86	1.40	1.56	3.13
10.	14-03-2022	12.06	4.80	5.80	2.73	2.60	1.53	2.20	3.00
11.	21-03-2022	11.20	5.06	5.40	3.13	3.06	2.20	1.87	2.80
12.	28-03-2022	10.13	4.06	4.40	2.20	3.13	2.13	1.06	3.20
13.	04-04-2022	9.00	3.80	3.20	2.47	2.87	1.80	1.20	1.60
14.	11-04-2022	8.53	2.20	2.00	1.93	2.00	0.73	1.00	1.10
15.	18-04-2022	7.40	2.06	1.80	1.20	0.93	0.33	0.73	0.36
16.	25-04-2022	4.13	1.20	1.67	0.60	0.20	0.21	0.13	0.10
17.	01-05-2022	2.40	0.60	1.33	0.13	0.00	0.00	0.06	0.06

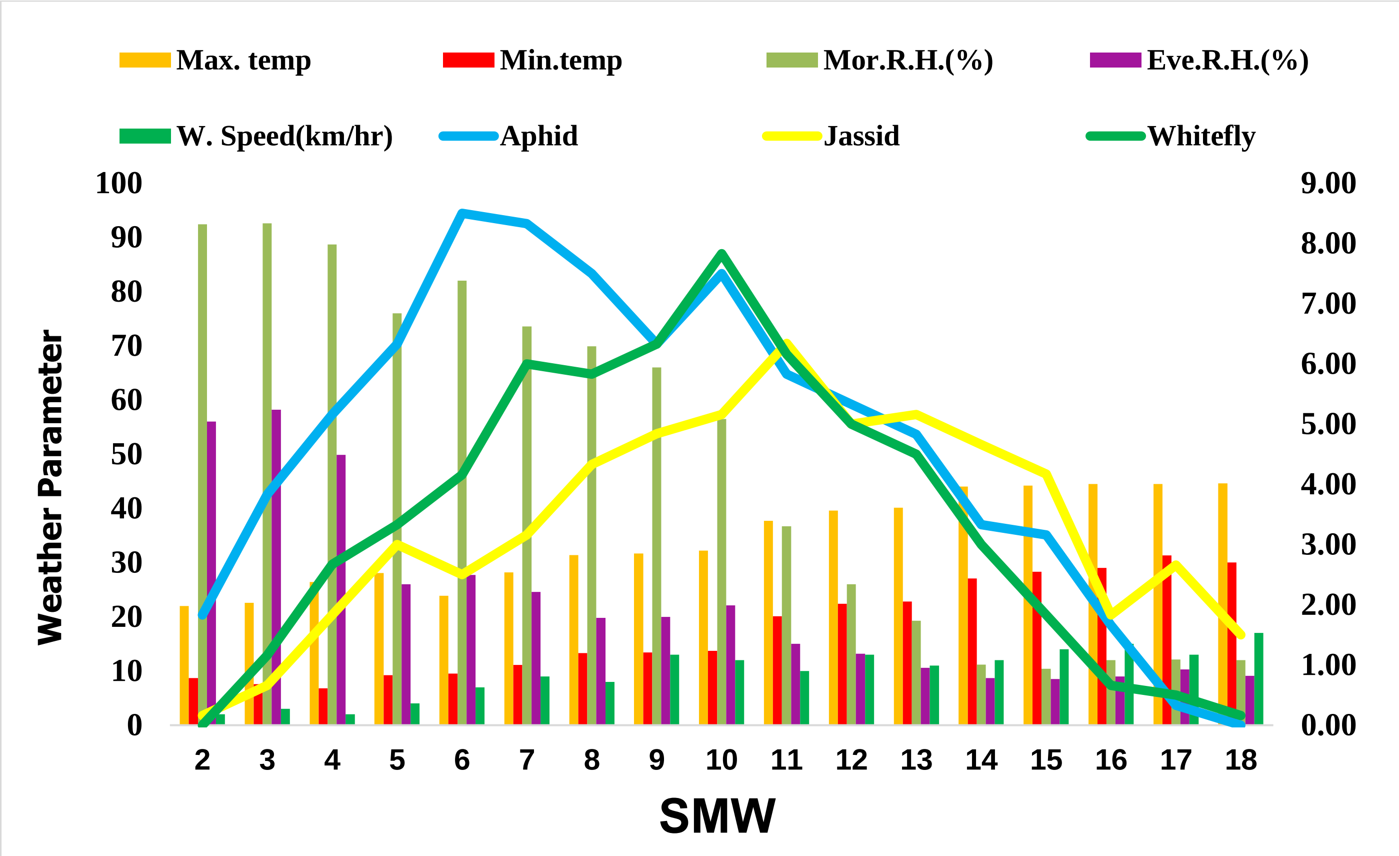


Figure 1. Impacts of weather attributes on the population dynamics of aphid, jassid and whitefly on tomato

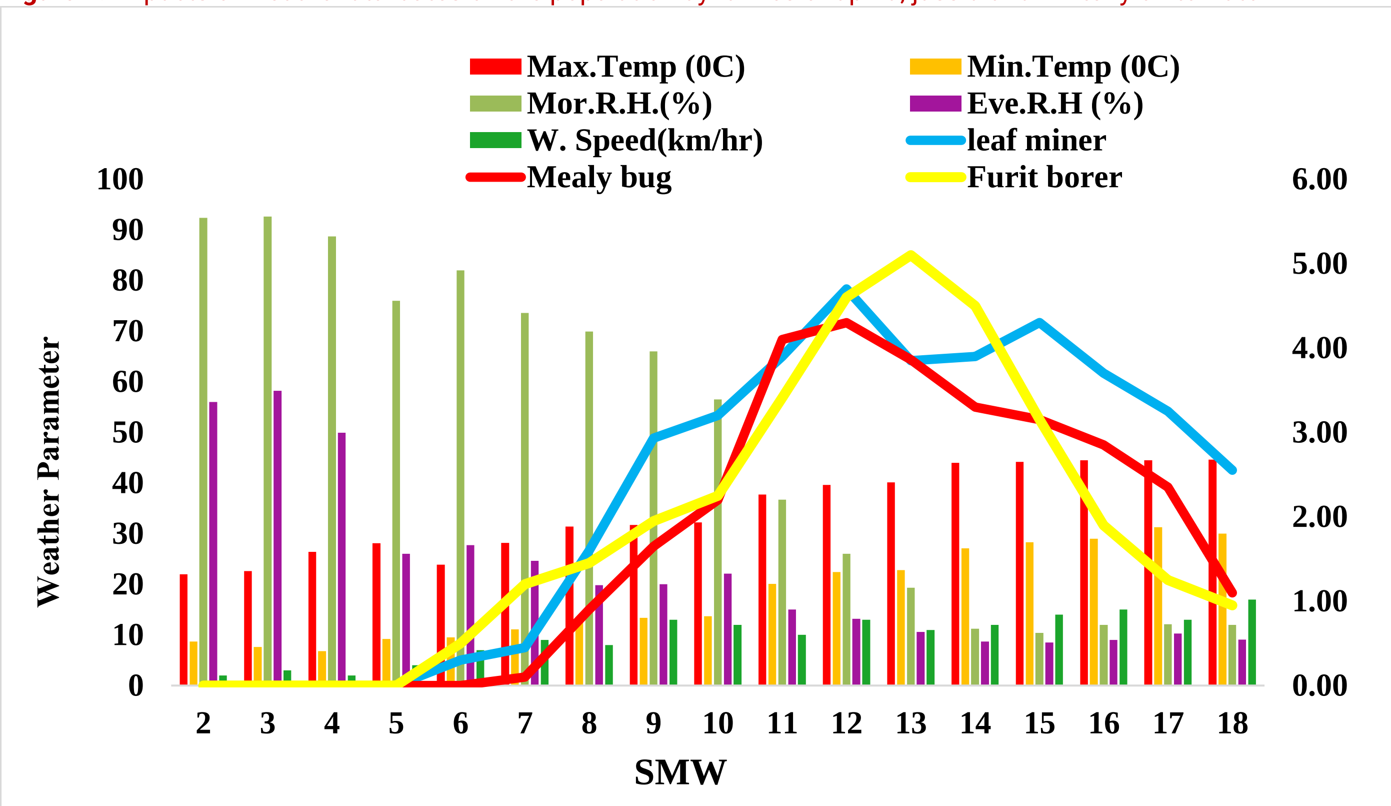


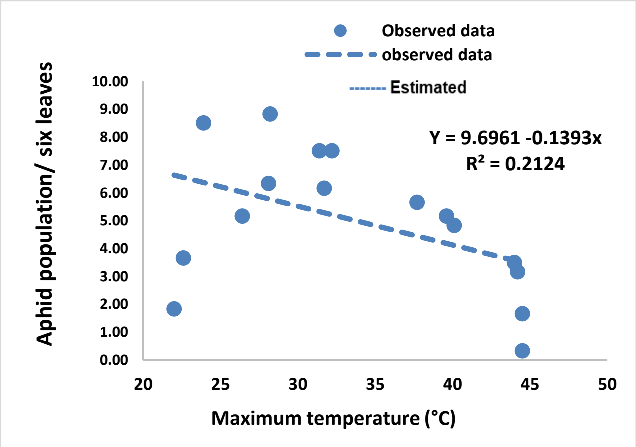
Figure 2. Effect of weather parameters on the population dynamics of leaf miner, mealy bug and fruit borer larvae on tomato

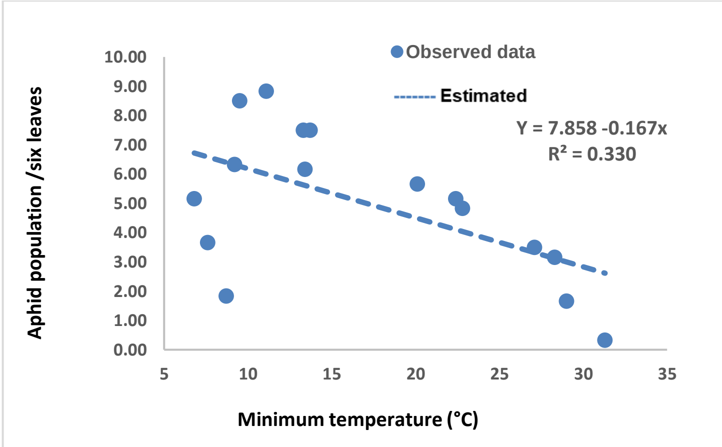
Table 3. Correlation between insect of tomato crop and weather parameters

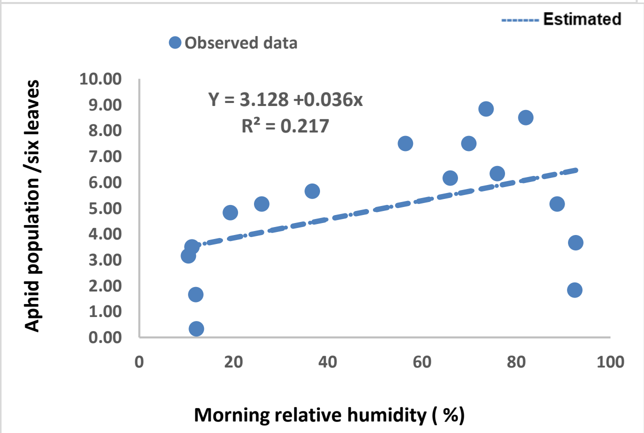
Insects	Temperature (˚C)		Relative humidity (%)	
	Maximum	Minimum	Morning	Evening
Aphid	-0.502*	-0.623**	0.514*	0.090
Jassid	0.388	0.242	-0.384	-0.621**

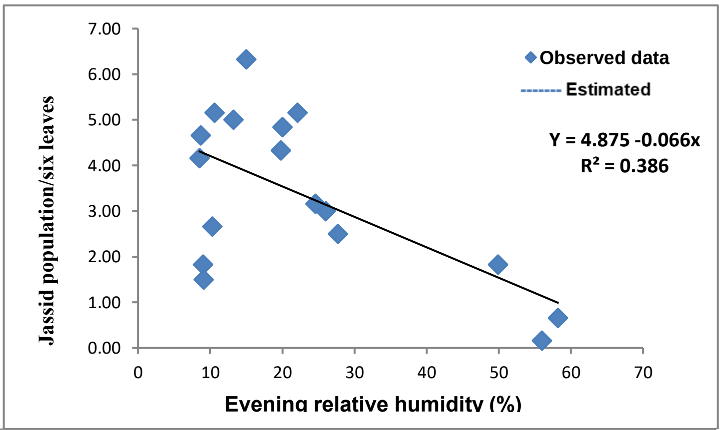
Whitefly	-0.178	-0.382	0.189	-0.191
American leaf miner	0.477	0.382	-0.480	-0.511*
Tomato mirid bug	0.483	0.397	-0.518**	-0.511*
Fruit borer	0.725**	0.667**	-0.780**	-0.626**
Weaver ant	0.536*	0.416	-0.556*	-0.657**
Lady bird beetle	0.357	0.279	-0.382	-0.515*
Spotted weaver spider	0.368	0.244	-0.380	-0.502*
Syrphid fly	0.531*	0.429	-0.580*	-0.599*
Dragon fly	0.384	0.286	-0.386	-0.509*
Damselfly	0.444	0.336	-0.495	-0.515*
Mason wasp	0.174	0.063	-0.208	-0.408

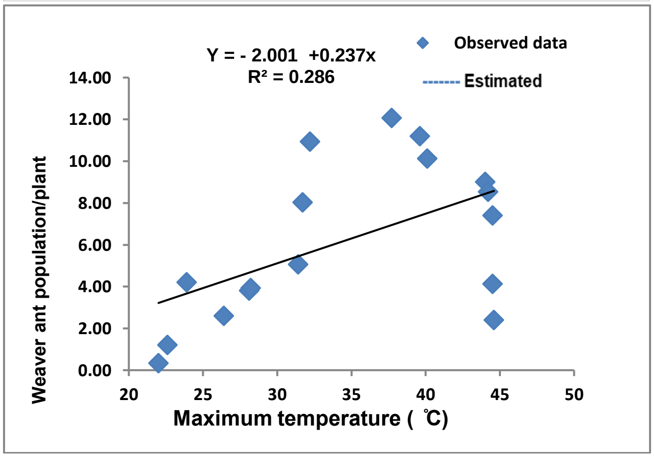
(*): Significant at 5% level, (**): Significant at 1% level

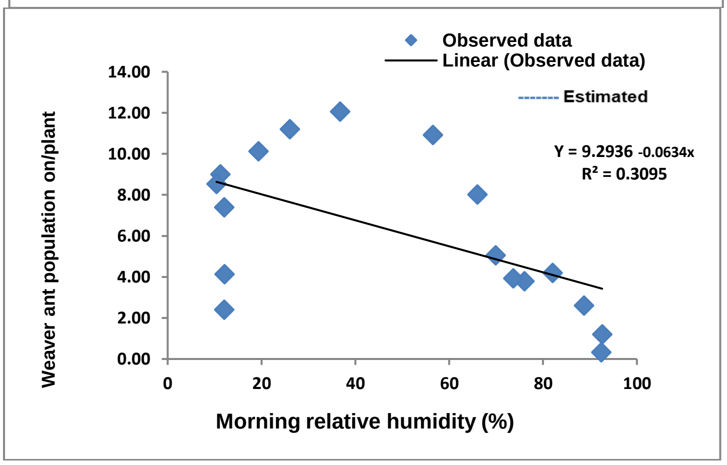












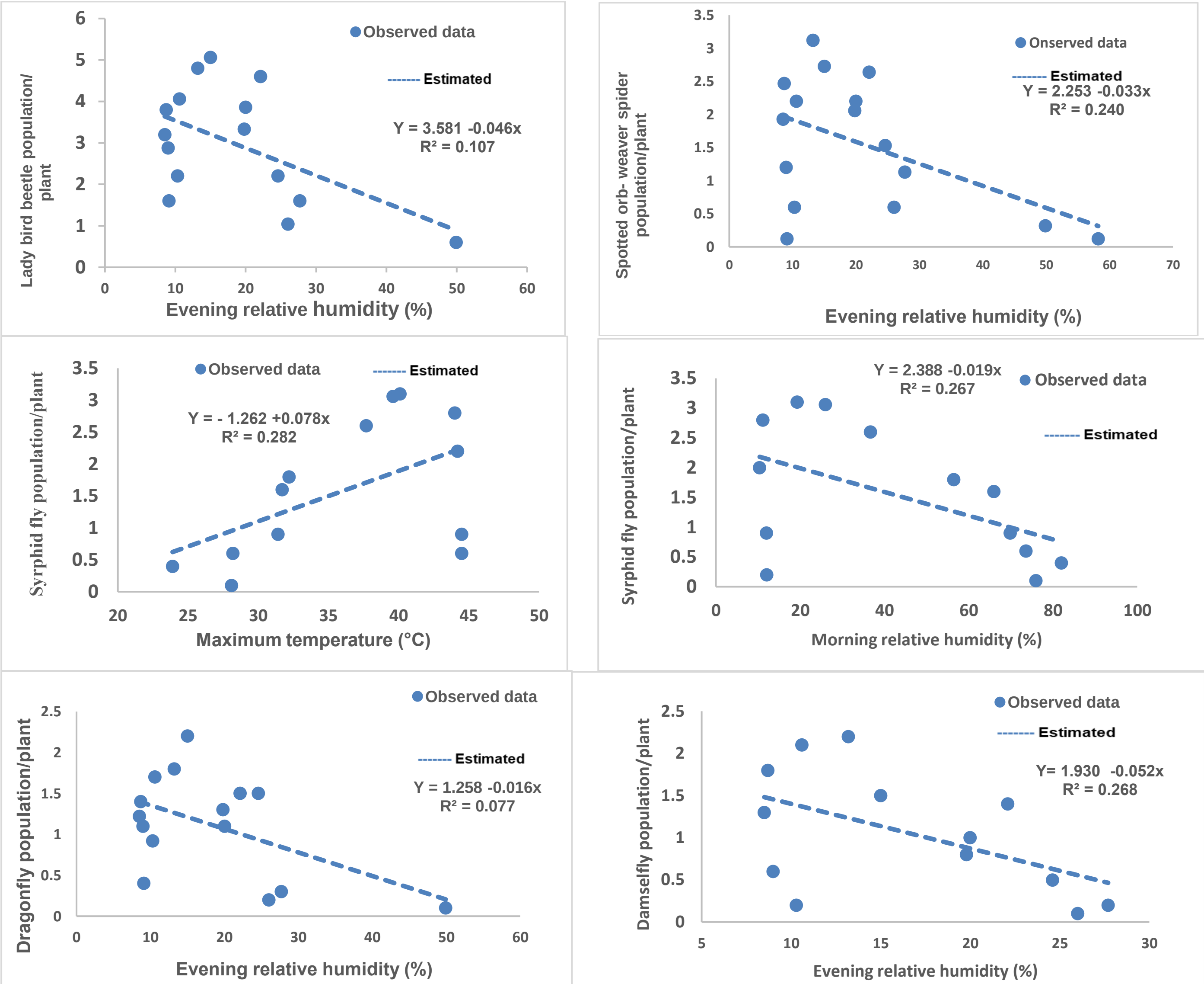


Figure 3. Correlation between insect of tomato crop and weather parameters

Acknowledgement

I am immensely grateful to both the students and teachers at the Department of Entomology, Jawahar Lal Nehru College of Agriculture, for their invaluable support and commendable guidance.

Financial Support

Financial support during M.Sc. and research, was received from the department itself.

Author Contribution Statement

The experiment was carried out and data were collected by Mukesh Netwal, who also wrote the manuscript, with the guidance and supervision of Yogesh Patel, who played a crucial role in conceiving and designing the research. Arvind, Ankit Saini and Mandeep Redhu assisted in data handling and analysis, and they also contributed by providing literature and other essential information for the research. After being thoroughly read, the manuscript received the approval of all the authors.

Conflicts of Interest

Author, hereby declare that he did not have any conflict of interest in any way and with anyone.

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Preferred citation: Netwal M, Patel Y, Arvind, Redhu M and Saini A. 2023. Population dynamics of arthropods on tomato (*Lycopersicum esculentum* l.) in Vindhya plateau region of Madhya Pradesh. *Journal of Agriculture and Ecology*, 17: 58-65; https://doi.org/10.58628/JAE-2317-310