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Seasonal Incidence of Different Insect Pests and Their Natural Enemies in Tomato Ecosystem

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Abstract

A field investigation was carried out to analyze the seasonal incidence of different insect pests and their natural enemies in tomato ecosystem along with their correlation with weather parameters from December, 2020 to April, 2021. A total number of 10 insect pests and 11 natural enemies were documented throughout the season. Among those insect pests recorded, tomato fruit borer, *Helicoverpa armigera* was the major one (49.91% relative abundance) followed by aphid, *Aphis gossypii* (18.62%), serpentine leaf miner, *Liriomyza trifolii* (16.20%) and whitefly, *Bemisia tabaci* (7.33%). Among the natural enemies, coccinellids were found abundantly and *Coccinella transversalis* recorded the highest relative abundance of 26.77% followed by *Cheilomenes propinqua* (10.23%), *Cheilomenes sexmaculata* (10.23%) and *Coccinella septempunctata* (9.44%). The findings of the experiment indicated that the maximum population of *Helicoverpa armigera* and *L. trifolii* was observed on the 10th SMW. While in case of *A. gossypii* it was observed on the 7th SMW respectively. The correlation between insect infestations and meteorological conditions demonstrated that the min temp. showed notable positive correlation with *H. armigera* and *Aphis gossypii* population and considerable negative correlation with *L. trifolii*. The max temp. showed noteworthy negative correlation with *L. trifolii* and *Aphis gossypii*. The morning relative humidity was found to possess significant positive correlation with *L. trifolii* and negative correlation with *H. armigera*. The evening relative humidity showed negative correlation with *L. trifolii* and *Aphis gossypii*. The study's findings provide a clear picture of the level of harm caused by insect pests in addition to helping us anticipate the seasonal occurrence of these pests for the purposes of pest monitoring and management.

Keywords: *Aphis gossypii, Helicoverpa armigera*, *Liriomyza trifolii*, Natural enemies, Seasonal incidence

Introduction

Tomatoes rank second among the most significant vegetables farmed worldwide for their high nutritional content and widespread consumption. The cultivated tomato (*Lycopersicon esculentum* Mill.) is a genetically enhanced species that is a member of the genus *Solanum* belonging to the nightshade family (Solanaceae). It can be grown outdoors, in greenhouses, or in net houses all over the globe.

Tomatoes contain a number of vitamins, minerals and secondary metabolites (Luthria *et al.*, 2006). A hundred grams of fresh tomatoes can fulfill daily requirement of more than 46% of Potassium, 8% of vitamin C and 3.4% each of vitamin A and C (Gebhardt and Thomas, 2002; Canene-Adams *et al.*, 2005). The tomato is also a good source of antioxidants and a number of minerals, including Fe, P, Mn and K. Lycopene, the first antioxidant compound, imparting red colour to the tomatoes has been known to lower the risk of numerous malignancies, including those of the stomach, lungs and prostate. Because of its unique nutritious content,

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tomato is regarded as a protective food.

In terms of global production, India ranks second to China both in terms of area and output, contributing 11% to global tomato production (Anonymous, 2021). In India, 20300 thousand MT of tomatoes are produced annually on 778 acres of land. The highest tomato producing state is Andhra Pradesh followed by Madhya Pradesh and Karnataka. Assam occupies 18.79 thousand ha under tomato production with 430.83 thousand tonnes of tomato production (Anonymous, 2022).

Although it is a crop that is relatively simple to grow, there are a number of limitations that significantly lower the output of tomatoes. Insect pests are among the most significant recognised factors since they affect crop quality and production in addition to productivity. Numerous pests, including jassids, aphids, tobacco caterpillars, leaf miners, flea beetles and fruit borers, attack tomatoes (Sajjad *et al*., 2011). The primary insect pests of tomato includes whitefly (*Bemisia tabaci*), thrips (*Thrips tabaci*, *Frankliniella* sp.), aphid (*Myzus persicae* and *Aphis gossypii*), mealybugs (*Maconellicocus* sp., *Phenacoccus solenopsis*), mites (*Tetranychus* spp.), tobacco caterpillar (*Spodoptera litura*), leaf miner (*Liriomyza trifolii*) and fruit borer (*H. armigera*) among which *H. armigera* is the major one and alone causes 22-38% of crop loss (Dhandapani *et al*., 2003; Kuldeep, 2013). Under extreme circumstances, yield loss can range from 72.19 to 77.79% (Aheer *et al*., 1998).

The insect pest scenario is constantly changed by the changing climatic conditions as well as the insecticidal pressure on the environment. Information on seasonal incidence of insect pest and natural enemies in a crop ecosystem will provide insight and help to formulate effective timely Integrated Pest Management strategies for keeping these insect pests under ETL.

Materials and Methods

Location of Work and Experiment Details

Field studies were carried out at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat, located at 94°12' E Longitude and 24°47' N Latitude, with an altitude of 86.8 m above mean sea level. Susceptible tomato variety 'Pusa Ruby' was transplanted on 03.12.2020 in randomized block design with 8 treatments 43 replications and plot size of 3 m × 2.5 m and 75 cm × 60 cm spacing. The plants were cultivated in accordance with the suggested agronomic procedures mentioned in the package of practices for horticultural crops of Assam, 2019. The space between the plots was kept at 0.5 m.

Estimation of Relative Abundance

To observe the appearance of various insect pests and natural enemies, weekly monitoring was done from 2 WAS till the last harvest stage. Visual observation of arthropods species on tomato plants were counted by visual searching and using sweep net. A random sampling taking 5 plants from each plot was done. Ten leaves were randomly chosen on each plant from the bottom, middle and top of the canopy and examined thoroughly. The relative abundance of various insect pests of tomato was worked out using the following formula and expressed in percentage.

$$\text{Relative abundance of species} = \frac{\text{No. of individuals per species}}{\text{Total no. of indivisuals}} \times 100$$

Correlation with Weather Parameters

Weekly data of weather parameters from December, 2020 to April, 2021 was collected from the Department of Agro-Meteorology, AAU, Jorhat. Maximum temperature, minimum temperature, morning and evening relative humidity, rainy days, rainfall and basic sunshine hours were taken into consideration for finding the multiple regressions. The analysis was done using IBM SPSS Statistics 21.0.

Results and Discussion

Relative Abundance of Major Insect Pests and Natural Enemies of Tomato

Globally, tomatoes (*Solanum lycopersicum* L.) are one of the most extensively farmed vegetable crops. Among the biotic factors affecting tomato crop, insect pests devour the crop at various phases of growth from the period of germination till harvest. To know the estimation of insect pests and their natural enemies, weekly observations from 15 days after germination till the last harvest stage were recorded. The total number of insects and percent relative abundance were calculated and presented in table 1 and table 2. A total of 10 insect pests were documented among which tomato fruit borer, *Helicoverpa armigera* recorded the highest relative abundance of 49.91% followed by aphid, *Aphis gossypii* (18.62%), serpentine leaf miner, *Liriomyza trifolii* (16.20%) and whitefly, *Bemisia tabaci* (7.33%). The other insect pests recorded were *Agrotis ipsilon* (3.77%), *Trichoplusia ni* (0.95%), *Monolepta signata* (1.41%), *Trilophidia annulate* (0.48%), *Bactrocera cucurbitae* (0.084%) and *Epilachna vigintioctopunctata* (1.20%). Different insect pests found in various crop stages has been recorded and it was found that tomato fruit borer, *Helicoverpa armigera* appeared during fruiting stage and devoured the fruits till the harvesting stage. *Liriomyza trifolii* was found mostly from the vegetative stage till the fruiting stage; whereas *Aphis gossypii* was found to occur from the vegetative stage till the harvesting stage. During the observation, 11 numbers of both predators and parasitoids were recorded. Among them, coccinellids were found abundantly and *Coccinella transversalis* recorded the highest relative abundance of 26.77% followed by *Cheilomenes propinqua* (10.23%), *Cheilomenes sexmaculata* (10.23%) and *Coccinella septempunctata* (9.44%). The other natural enemies recorded during the study period were *Micraspis discolor* (8.66%), *Brumoides suturalis* (7.08%), *Platycnemis pennipes* (7.08%), unidentified damselfly (7.87%), *Cotesia* sp. (5.51%), long legged fly (3.93%) and *Apiomerus crassipes* (3.14%). Total 4720 and 127 numbers of various insect pests and natural enemies were collected during both the crop seasons (Figure 2-9).

Similar results were reported by Chaudhuri *et al.* (2001), Kaushik *et al.* (2023), Salam *et al.* (2023), who observed aphid (*Aphis gossypii*), whitefly (*Bemisia tabaci*), leaf miner (*Liriomyza trifolii*), tingid bug (*Urentius hystricellus*) and fruit borer *(Helicoverpa armigera)* as the most important insect pests of tomato crop. *Helicoverpa armigera* was identified by Rudenko *et al.* (2001) as the main insect pest of tomato fruits. The results of Umeh *et al.* (2002), who stated that the main insects attacking tomatoes in Nigerian tomato-growing regions were the fruit borer, *Helicoverpa armigera*; the whitefly, *Bemisia tabaci*; and many aphids of different species, primarily *Aphis gossypii*, corroborated the current findings. Kaur *et al*. (2010) observed that whiteflies (*Bemisia tabaci* Genn.) were present and that the incidence of leaf miners (*Liriomyza trifolii* Burgess) was low. During the vegetative stage, the occurrence of aphid (*Aphis gossypii*) was very less; whereas whitefly population was negligible which corroborated with our present results. Singh (2017) recorded similar natural enemies (*Coccinella septumpunctata*, dragonfly, mantids, red ants and spiders) dominating tomato ecosystem which was in tune with our findings.

Seasonal Incidence of Major Insect Pests of Tomato

The data were collected from December, 2020 to April, 2021 to observe the seasonal incidence of the most important insect pests on tomato. These results have been presented in table 3, figure 1. During the study period (2020-21), *Helicoverpa armigera* first appeared on 2nd SMW (0.67 larvae plant^{-1}) and the population was found to increase gradually. The maximum population was observed in the 10th SMW with a population of 5.33 no. of larvae plant^{-1} which was similar with the results recorded by Kaushik *et al.* (2023). At the 51st SMW, they noticed the first fruit borer occurrence. After that, the population grew and peaked at the 10th SMW. Our findings also aligned with those of Wade *et al.* (2020), who noted the fruit borer's first incidence on the 5th SMW; Reddy and Kumar (2004), who noted the highest incidence of *Helicoverpa armigera* from March to April; Kharpuse and Bajpai (2006), who reported a fruit borer population during the 3rd week of February during *Rabi*, 2004-2005; Reddy *et al.* (2009) and Pandey *et al.* (2012), who also noted the fruit borer's peak population in March.

The leaf miner, *L. trifolii* incidence first occurred on 52nd SMW with initial population of 14.69 mines leaf^{-1} and increasing trend was observed up to 10th SMW. Highest numbers of mined leaves plant^{-1} were noticed on 10th SMW (March)

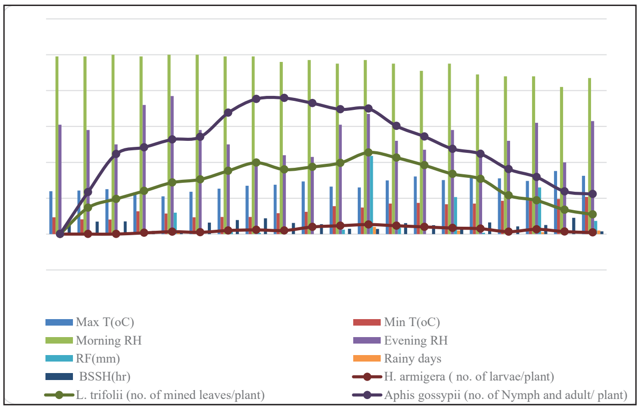

Figure 1: Incidence of insect pests on tomato during 2020-21

i.e., 40.17 mined leaves plant^{-1}. Whereas, the incidence of number of live mines was decreased from 11th SMW onwards and reached 10.07 mined leaves plant^{-1} by the end of 18th SMW (May). According to Reddy and Kumar (2005), the population of *Liriomyza trifolii* declined in November and December as a result of natural parasitization, corroborated by the current findings. The peak population of the parasite was recorded in March-April, coinciding with the vegetative and reproductive stages of the crop. Our results matched with the findings of Nitin *et al.* (2017), who recorded maximum density of leaf miner during March-April and during October to November the infestation was not found beyond 25 larvae plant^{-1}. Kachave *et al.* (2020) also found leaf miner occurence at 32nd SMW (vegetative stage of the crop) which corroborated with our finding and but peak population was observed in the 41st SMW (fruiting stage of the crop) which didn't match with our finding.

In case of *Aphis gossypii*, the population gradually increased from the day of its first appearance (52nd SMW) and reached the peak population of 39.87 nos. of nymph and adults per plant at 7th SMW during 2020-21. Kaushik *et al.* (2023) also reported similar results where they observed the aphid population first at 48th SMW and peak population at 7th SMW.

a) Leaf infestation by *Helicoverpa armigera* (Hubner) larva

b) Fruit damage by *H. armigera* (Hubner)

Figure 2: Different damage symptoms caused by *H. armigera* (Hubner)

(a) *Liriomyza trifolii* larvae b) Infestation by *L. trifolii*

Figure 3: Infestation of tomato leaves by *Liriomyza trifolii*

a) Nymph and adult of *A. gossypii*

b) Winged adult of *A. gossypii*

Figure 4: Infestation of tomato leaves by *Aphis gossypii*

Figure 5: *Trichoplusia ni* (Hubner)

Figure 6: *Agrotis ipsilon* (Hufnagel)

Figure 7: *Bemisia tabaci*

a) *Epilachna vigintioctopunctata* Fabricius

b) Winged adult of *A. gossypii*

c) Bactroceracucurbitae Coquillett

d) *Trilophidia annulate* (Thunberg)

Figure 8: Minor insect-pest recorded in tomato crop

a) Larvae of Coccinellid Beetle

b) *Cheilomenes propinqua* (Mulsant)

c) *Coccinella septumpunctata* (Linnaeus)

d) *Cheilomenes sexmaculata* (Fabricius)

e) *Coccinella transversalis* (Fabricius)

f) *Brumoides suturalis* (Fabricius)

g) *Cotesia* sp.

h) *Apiomerus crassipes* (Fabricius)

i) *Platycnemis pennipes*

j) Unidentified

k) *Micraspis discolor* (Fabricius)

l) Long legged fly

m) Unidentified dipteran

Figure 9: Natural enemies recorded in tomato crop

Similar work conducted by Wade *et al.* (2020) recorded aphid and leaf miner during 2nd SMW. Moreover, in 7th and 12th SMW leaf miner infestations (40.02%) were observed. The highest peak of aphid was found on the 7th SMW. The highest leaf miner infestation was recorded on 12th SMW. They also recorded increasing trend of leaf miner infestation after its first appearance. All these findings recorded by them were same with the findings of the present investigation. Our findings were nearly exactly in line with Waluniba and Ao's (2014) observations of the incidence of various pests on different sowing dates, including whitefly (*Bemisia tabaci*) at 4th, 7th and 9th; serpentine leaf miner (*Liriomyza trifolii*) at 4th, 7th and 9th and fruit borer (*Helicoverpa armigera*) at 9th, 11th and 13th standard week.

Multiple Regressions of Different Meteorological Parameters on Major Insect Pests

The multiple regression analysis was conducted to see the

Table 1: Relative abundance of different insect pests of tomato

Common name	Scientific Name	Family	Order	Time of observation	No. of insects	Relative abundance (%)
Tomato fruit borer	*Helicoverpa armigera*	Noctuidae	Lepidoptera	Flowering - harvesting stage	2356	49.91
Serpentine leaf miner	*Liriomyza trifolii*	Agromyzidae	Diptera	Vegetative - fruiting stage	765	16.20
Aphid	*Aphis gossypii*	Aphididae	Hemiptera	Vegetative - fruiting stage	879	18.62
Whitefly	*Bemisia tabaci*	Aleyrodidae	Hemiptera	Vegetative stage - harvest stage	346	7.33
Cut worm	*Agrotis ipsilon*	Noctuidae	Lepidoptera	Seedling stage	178	3.77
Cabbage looper	*Trichoplusia ni*	Noctuidae	Lepidoptera	Fruiting stage	45	0.95
Leaf beetle	*Monolepta signata*	Chrysomelidae	Coleoptera	Seedling - maturity stage	67	1.41
Grasshopper	*Trilophidia annulate*	Acrididae	Orthoptera	Vegetative stage - harvest stage	23	0.48
Fruit fly	*Bactrocera cucurbitae*	Tephritidae	Diptera	Fruiting stage	4.00	0.084
Hadda beetle	*Epilachna vigintioctopunctata*	Coccinellidae	Coleoptera	Vegetative - harvest stage	57.00	1.20
Total					4720	99.96

Table 2: Relative abundance of natural enemies of tomato

Common Name	Scientific Name	Family	Order	Time of observation	No. of insects	Relative abundance (%)
Transverse ladybird	*Coccinella transversalis*	Coccinellidae	Coleoptera	Vegetative - harvest stage	34	26.77
Ladybird beetle	*Cheilomenes propinqua*	Coccinellidae	Coleoptera	Vegetative - harvest stage	13	10.23
Ladybird beetle	*Micraspis discolor*	Coccinellidae	Coleoptera	Vegetative - harvest stage	11	8.66
Ladybird beetle	*Coccinella septempunctata*	Coccinellidae	Coleoptera	Vegetative - harvest stage	12	9.44
Ladybird beetle	*Cheilomenes sexmaculata*	Coccinellidae	Coleoptera	Late vegetative - harvest stage	13	10.23
Ladybird beetle	*Brumoides suturalis*	Coccinellidae	Coleoptera	Late vegetative - harvest stage	9	7.08
Damselfly	*Platycnemis pennipes*	Platycnemididae	Odonta	Vegetative - harvest stage	9	7.08
Damselfly	Unidentified	-	Odonata	Vegetative - harvest stage	10	7.87
Cotesia wasp	*Cotesia sp.*	Braconidae	Hymenoptera	Vegetative - harvest stage	7	5.51
Long legged fly	Unidentified	Dolichopopidae	Diptera	Vegetative - harvest stage	5	3.93
Assassin bug	*Apiomerus crassipes*	Reduviidae	Hemiptera	Vegetative - harvest stage	4	3.14
Total					127	99.94

relation between different meteorological parameters and the major insect pests recorded and have been depicted in table 4. During the study period, the correlation analysis showed significant positive correlation between *H. armigera* populations with min temp. (r = 0.408) and major negative correlation with morning relative humidity (r = -0.130). However, it was found to be positive non-significant correlation with max temp, rainfall and rainy days, while evening relative humidity and bright sunshine hours showed non-significant negative correlation. From the multiple regression equation *i.e.*,

$$Y_1 = -27.789 - 0.533X_1 + 1.009X_2 + 0.459X_3 - 0.233X_4 + 0.068X_5 - 0.080X_6 - 0.056X_7\ (100R^2 = 82.50)$$

It was observed that $R^2 = 82.50$; which indicated that weather parameters together were responsible for 82.50% fluctuation in the *H. armigera* population in 2020-21. The results of the present study were in similar trend with the previous study conducted by Wade *et al.* (2020) who reported fruit borer had non-significant positive relation with maximum temperature (r = 0.314), positive non-significant correlation (r = 0.450) with minimum temperature and non-significant negative correlation (r = - 0.484) of maximum relative humidity. However, fruit borer population recorded positive non-significant correlation with evening relative humidity (r = 0.407). The reason behind the variations with our study might be due to different weather conditions and variation of rainfall intensity. Another finding stated that the population of fruit borer had a non-significant positive connection with maximum temperature (r = 0.082), minimum temperature (r = 0.196), and total rainfall (r = 0.306) (Harshita *et al.*, 2018). Nonetheless, the pest's incidence showed a non-significant negative correlation with bright daylight hours (r = -0.329), whereas a substantial negative impact on the pest's population growth was recorded with average relative humidity (r = -0.557). Her experiment's results were somewhat consistent with the current investigation. Rishikesh *et al.* (2015) also noted this kind of relationship. He found that during both cropping seasons, the number of bright sunshine hours had a non-significantly negative effect on the *H. armigera* larval population (r = -0.347, r = -0.329). According to research by Kakati *et al.* (2005), there was a non-significant association between the tomato fruit borer pest's population growth and max. temp. and a substantial negative correlation with the former. The reason behind the variations might be due to different weather conditions in which the experiments were conducted.

L. trifolii showed important negative correlation with max temp. (r = -0.060), min temp. (r = -0.073) and evening relative humidity (r = -0.177); whereas morning relative humidity recorded a significant positive correlation (r = 0.298). From the multiple regression equation *i.e.*,

Y_1 = - 86.890 - 7.763X_1 + 9.135X_2 + 3.432X_3 - 2.367X_4 - 0.292X_5 + 7.024X_6 + 0.734X_7 (100R^2 = 83.10)

It was observed that R^2 = 83.10; which indicated that weather parameters together were responsible for 83.10% fluctuation in the *L. trifolii* population. Our findings were partially supported by Ravipati *et al.* (2020), who found a negative correlation between the no. of mines, leaf infestation, and larvae and the minimum temperature (-0.61**), evening relative humidity (-0.34*), maximum temperature (-0.57*), sunshine hours (-0.52*), and evening relative humidity. The present work's findings are consistent with those of Chakraborty (2011), who found that temperature, maximum relative humidity, and minimum relative humidity had a significant negative impact on the population of *L. trifolii*. According to Choudary and Rosaiah (2000), the population of *L. trifolii* in tomatoes was inversely connected with both the lowest temperature and the relative humidity in the evening. Similar results were obtained by Variya and Patel (2010), who discovered that sunshine and the highest temperature had a detrimental effect on the number of leaf miner larvae. Additionally, the occurrence of *L. trifolii* was found to have a negative connection with morning RH by Galande and Ghorpade (2010).

Aphid population was found to record a significant negative correlation with maximum temperature (r = -0.276), evening relative humidity (r = -0.223) and significant positive correlation with minimum temperature (r = 0.369). However, rainfall, rainy days and bright sunshine hours were found to be non-significant. From the multiple regression equation *i.e.*,

Y_1 = 321.824 - 8.991X_1 + 5.317X_2 - 0.507X_3 - 2.911X_4 - 0.130X_5 + 5.033X_6 - 2.961X_7 (100R^2 = 76.6)

It was observed that R^2 = 76.60; which indicated that weather parameters together were responsible for 76.60% and 72.70% fluctuation in the *A. gossypii* population. The current study's results were found to be comparable to those of Salam *et al.* (2023), who recorded a substantial negative maximum and minimum relative humidity with the population of aphids. Findings from Kachave *et al.* (2020) and Muhammad *et al.* (2014) corroborated the current findings, which indicate a negative association between aphid population and lowest maximum evening relative humidity. Aphid population and evening relative humidity had a non-significantly negative correlation (r = -0.308), according to Wade *et al.* (2020).

Table 3: Incidence of major insect pests of tomato during 2020-2021

Days after germination	Standard meteorological week	Max T (°C)	Min T (°C)	RH (%)		RF (mm)	Rainy days	BSSH (hr)	*H. armigera* (larvae plant^{-1})	*L. trifolii* (Mined leaves plant^{-1})	*Aphis gossypii* (Nymph and adult plant^{-1})
				I	II						
15 DAG	51	23.9	9.4	99	61	0	0	5.4	0	0	0
22 DAG	52	24.3	8.2	99	58	0	0	7	0	14.69	8.67
29 DAG	1	25	8.1	100	50	0	0	7.1	0	19.57	25
36 DAG	2	23.2	12.7	99	72	0	0	1.7	0.67	23.35	24.33
43 DAG	3	21	11.5	100	77	11.9	2	0.9	1.33	27.39	24
50 DAG	4	23.6	9.4	100	58	0	0	6.4	1	29.46	23.67
57 DAG	5	25.3	9.6	99	50	2.4	0	7.8	2	33.26	32.33
64 DAG	6	27	9.6	99	42	0.8	0	8.8	2.33	37.44	35.53
71 DAG	7	27.5	11.7	96	44	0	0	6.2	2	33.97	39.87
78 DAG	8	29.3	12.4	97	43	0	0	5.5	3.98	33.47	35.54
85 DAG	9	26.5	15.6	95	61	2.5	0	3	4.67	35	29.87
92 DAG	10	26	14.8	97	67	43.6	4	2.9	5.33	40.17	24.43
99 DAG	11	29.9	17	95	52	3.6	0	6.1	4.65	37.92	17.67
106 DAG	12	32.1	17.4	91	47	0	0	5	4	34.35	16
113 DAG	13	30.1	16.6	95	58	20.6	2	3.8	3.36	30.13	14
120 DAG	14	31.4	17	89	47	0.8	0	6.5	3	27.69	14
127 DAG	15	31.1	18.5	88	52	0	0	4.3	1.33	20.19	14.67
134 DAG	16	29.6	19.3	88	62	26	1	5.1	2.67	16.1	13
141 DAG	17	35.2	19.6	82	40	0	0	9.1	1.37	12.18	10.22
148 DAG	18	32.5	20.7	87	63	7.4	2	1.5	0.87	10.07	11.34

Table 4: Multiple regression of different meteorological parameters on major insect pests of tomato during 2020-21

Dependent variable	Temperature		RH		RF (X_5)	Rainy days (X_6)	BSSH (X_7)
	Max. (X_1)	Min. (X_2)	Morning (X_3)	Evening (X_4)			
H. armigera	0.327	0.408*	-0.138*	-0.130	0.451	0.304	-0.129
Regression Equation (Y_1)	Y_1 = - 27.789 - 0.533X_1 + 1.009X_2 + 0.459X_3 - 0.233X_4 + 0.068X_5 - 0.080X_6 - 0.056X_7 (100R^2 = 82.50)						
L. trifolii	-0.060*	-0.073*	0.298*	-0.177*	0.193	0.123	0.009
Regression Equation (Y_1)	Y_1 = - 86.890 - 7.763X_1 + 9.135X_2 + 3.432X_3 - 2.367X_4 - 0.292X_5 + 7.024X_6 + 0.734X_7 (100R^2 = 83.10)						
A. gossypii	-0.276*	0.369*	0.436	-0.223*	-0.70	-0.84	0.078
Regression Equation (Y_1)	Y_1 = 321.824 - 8.991X_1 + 5.317X_2 - 0.507X_3 - 2.911X_4 - 0.130X_5 + 5.033X_6 - 2.961X7 (100R^2 = 76.6)						

Conclusion

From the study, 10 numbers of insect pests from eight families and five orders and 11 natural enemies belonging to five families and five orders were recorded. *Helicoverpa armigera* and leaf miner, *L. trifolii* recorded the maximum population in the 10th SMW and *A. gossypii* recorded the peak population in the 7th SMW. During the study period, the min temp. revealed major positive correlation with *H. armigera* and *Aphis gossypii* population and significant negative correlation with *L. trifolii*. The max temp. showed major negative correlation with *L. trifolii* and *Aphis gossypii*. The morning relative humidity was found to possess significant positive correlation with *L. trifolii* and negative correlation with *H. armigera*. The evening relative humidity revealed negative correlation with *L. trifolii* and *Aphis gossypii*. Rainfall, rainy days and bright sunshine hours had no significant role in the occurence of *H. armigera*, *L. trifolii* and *Aphis gossypii*. This study will provide us with the present scenario of insect pest in the tomato ecosystem as well as their interaction with the different environmental conditions which will further help in making effective pest management approach to manage the various insect pests.

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