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Diversity of insects in tomato (*Lycopersicon esculentum* Mill.) eco-system in mid-hills of Meghalaya

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ABSTRACT

A study on "Diversity of insects in tomato (*Lycopersicon esculentum* Mill.) eco-system in mid-hills of Meghalaya" was conducted in the experimental fields of College of Post Graduate Studies in Agricultural Sciences, Umiam, Meghalaya for two cropping seasons *viz*. winter (October, 2022- January, 2023) and Spring-summer (February, 2023 – May, 2023).A total of 29 insect species were recorded which belonged to 7 orders and 22 families, the most abundant order being Coleoptera with 9 species followed by Hemiptera (6), Diptera(5), Lepidoptera (3), Hymenoptera (3), Odonata (2) and Orthoptera (1). A total of 19615 nos. of insect pests, 411 nos. of natural enemies and 56 specimens of pollinators were recorded during October, 2022- May, 2023. During winter and spring-summer cropping seasons, Simpson's indices were 0.283 and 0.271, respectively, while Shannon indices were 1.398 and 1.447, respectively. 15 insect species were identified to be insect pests of tomato, while 10 species were natural enemies of pests of tomato and 4 species were pollinators. *Aphis gossypii* was the most abundant insect pest with a relative abundance of 42.51 %, followed by *Tuta absoluta* (25.48 %) and *Helicoverpa armigera* (20.74 %). *Nesidiocoris tenuis* (31.75 %) and *Allograpta obliqua*(42.86 %) were the dominating natural enemy and pollinator of tomato, respectively. The incidence of the major insect pests had a significant positive correlation with maximum temperature and a negative correlation with relative humidity.

1. Introduction

Tomato, *Lycopersicon esculentum* Mill. is a known source of vitamins and pro-vitamins (vitamin C, pro-vitamin A, β carotene, folate), minerals and secondary metabolites such as lycopene, flavonoids, phytosterols and polyphenols (Luthria *et al*., 2006). 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. Tomato is a crop that is relatively easy to grow and maintain. There are, however, certain factors that plague its productivity and the overall output, the most important being insect pests. The tender shoots, leaves and fruits make it extremely vulnerable to insect pest attacks at all growth stages, making it an extremely perishable commodity. The global production of tomatoes has witnessed an increase of 165 % over the last two decades and is about 180 million tons at present. (FAOSTAT, 2022). India is second only to China in the production of tomatoes worldwide. During 2021-22, the total area under tomato cultivation was 841 thousand hectares with a total production of 20.3 million metric tonnes and productivity of 25.2 tonnes/ha. (Anonymous, 2022). In Meghalaya, the area under tomato cultivation is 2.19 thousand hectares, with a total production of 35.12 thousand metric tonnes and productivity of 15.9 tonnes/ha. (Anonymous, 2021).

A total of 41 insect species, belonging to 21 families attacked on tomato crop, of these the major insect pests that played the most important role in the economic losses of tomato crop are leaf miner (*Liriomyza trifolii*),

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aphid (*Myzus persicae*), jassid (*Amrasca bigutulla bigutulla*), whitefly (*Bemisia tabaci*) and fruit borer (*Helicoverpa armigera*) (Reddy and Kumar, 2004). In NEH region, the crop is infested by fruit borer (*Helicoverpa armigera*), aphid (*Myzus persicae*), cutworm (*Agrotis ipsilon*), jassids (*Amrasca bigutulla bigutulla*) and white fly (*Bemisia tabaci*), of which fruit borer causes the most severe damage (Thakur *et al*., 2012). Seventy-seven insect species belonging to the order Hymenoptera were reported to pollinate tomato flowers, 61 % of these species belong to the family Apidae (Toni *et al.,* 2021). Natural enemies of pests of tomato are coccinellids, chrysoperla, syrphid flies, spiders, ground beetles, dragon flies, damsel flies and braconid wasps (Khan *et al.*, 2020). This experiment was conducted with the objective to study the diversity of insects and their relative abundance in tomato ecosystem, and to determine the correlation between population of major insect pests with weather parameters

2. Materials and methods

Field experiments were conducted for two seasons *viz*., winter (October, 2022 – January, 2023) and spring–summer (February, 2023 – May, 2023), in the experimental field of College of Post Graduate Studies in Agricultural Sciences, Umiam, Meghalaya. Weekly scouting of insects was done by visual observations of insects, collection was done by handpicking or by using sweep nets and aspirators. Soft bodied insects and spiders were preserved in 70 % ethanol and other arthropods were card mounted or pinned. Identification of the collected insects was done to the lowest possible taxon, by comparing with available specimen in the Entomology laboratory, CPGS-AS, and also using insect voucher specimens, CAB international manual keys and descriptions. Species dominance and species richness were determined by Simpson's Index (D) and Shannon – Wiener diversity index (H), respectively.

Simpson's index (Simpson, 1949)

Simpson's index measures the probability of two individuals picked from a population belonging to the same species.

$D_s = 1 - \Sigma(n_i (n_i - 1))/(N(N-1))$

where, D_s= Simpson's index;

N= total number of individuals of all species

N_i= total number of individuals of the species i.

Shannon-Wiener diversity index (Batten, 1976)

$H' = \sum p_i \ln p_i$

where, p_i = the proportion of individuals in the i^{th} species

Higher value of H' indicates higher diversity of species in a population.

The seasonal incidence of major insect pests was recorded throughout the growing seasons (October, 2022 – January, 2023 to February, 2023 – May, 2023) and correlation of insect population with weather parameters *viz,* maximum and minimum temperatures, morning and evening relative humidity and total rainfall was done by calculating Pearson's Correlation Coefficient (Pearson, 1973).

$$\text{Correlation coefficient (r)} = \frac{n(\Sigma xy)-(\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2-(\Sigma x)^2][n\Sigma y^2-(\Sigma y)^2]}}$$

where, x is an independent variable, y is a dependent variable and n is the sample size.

3. Results and discussion

3.1 Diversity of insects in tomato eco-system and Diversity Indices

A total of 29 species of insects were recorded, which included 15 insect pests, 10 natural enemies and 4 pollinators belonging to 7 orders and 22 families. The most abundant order was Coleoptera with 9 species followed by Hemiptera (6), Diptera(5), Lepidoptera (3), Hymenoptera (3), Odonata (2) and Orthoptera (1). The total recorded number of insects during winter and spring-summer season were 10443 and 9669, respectively. A very similar finding was reported by de Barros *et al.* (2018) who recorded a total of 10,660 insects belonging to 22 families from conventional system of farming. Hasinu *et al.* (2021) determined the diversity of insects in vegetable crops including tomato, 6 orders of insects were captured, dominated by the order Hemiptera, constituting 74.88 % of the total individuals of insects collected.

The calculated Simpson's Index (D) were 0.283 and 0.271 during winter and spring-summer, respectively. On the other hand, the calculated Shannon-Weiner Diversity index (H) values were at 1.398 and 1.447 for each respective season. de Barros *et al.* (2018) reported lower value of Simpson's index 0.19 and higher value of Shannon index 2.17 indicating greater diversity in tomato ecosystem. Hasinu *et al.* (2021) determined the diversity indices of different vegetable crops and for tomato, the obtained values of Simpson's index was 1.11 and that of Shannon index was 0.37, which indicated moderate diversity with low dominance. These findings are comparable to the findings from the present study.

3.2 Relative abundance of insect pests, natural enemies and pollinators of tomato

During both the seasons, cotton aphid, *Aphis gossypii* recorded the highest relative abundance at 42.51 %, followed by tomato pin worn*, Tuta absoluta* at 25.48 % and tomato fruit borer, *Helicoverpa armigera* at 20.74 % making them the major insect pests of tomato. The other insects recorded were white fly, *Bemisia tabaci* (2.64 %), serpentine leaf miner, *Liriomyza trifolii* (4.20 %), striped flea beetle, *Phyllotreta striolata* (1.47 %), grasshopper, *Trilophidia annulata* (0.58 %), beetles *Monolepta signata* (0.90 %), *Aulagophora foveicollis* (0.21 %) and *Dercetina flavocincta* (0.08 %), fruitfly, *Bactrocera cucurbita* (0.21 %), white backed plant hopper, *Sogatella furcifera* (0.36 %), red cotton bug, *Dysdercus cingulatus* (0.20 %), painted bug, *Bagrada hilaris* (0.29 %) and cabbage fly, *Delia radicum* (0.11 %). Similar reports were made by Chaudhuri *et al*. (2001), Rudenko *et al.* (2001) and Umeh *et al*. (2002), who stated that *Aphis gossypii, Helicoverpa armigera*, *Bamesia tabaci* and *Liriomyza trifolii* were the major pests of tomato, causing extensive damage and yield loss. The recorded low populations of whitefly and leaf miner was corroborated by a report given Kaur *et al*. (2010) who stated that *Liriomyza trifolii* recorded low incidence and *Bemisia tabaci* occurred only during the early growth period with negligible population (Table 1).

Ten natural enemies were recorded during both the seasons. Among the natural enemies, tomato mirid bug, *Nesidiocoris tenuis* had the highest relative abundance at 31.75 %, followed by ladybird beetle, *Coccinella septumpunctata* at 22.67 % and carpenter ants, *Camponicus pennsylvanicus*(13.83 %). Other natural enemies observed were ladybird beetles, *Micraspis discolor* (12.70 %) *Cheilomenes sexmaculata* (4.76 %), *Coccinella transversalis* (4.31 %) and *Oenopia sexareata* (5.21 %) and damsel flies, *Indolestes gracilis davenporti* and *Platycnemis pennipes* at 1.36 % each. An unidentified dipteran belonging to the family Micropezidae (2.04 %) was also observed at the time of ripening of fruits. Anbalagan *et al.* (2016) reported that coccinellids were the dominant group of predators with highest number of species, which is in tune with the findings of the present study. Similar to our results, Calvo *et al*. (2009) and Sanchez J. A (2009) made reports of *Nesidiocoris tenuis* effectively preying on whitefly population (Table 2).

Four species of pollinators were recorded, among which wasp moth, *Amata huebneri* and hover fly, *Allograpta obliqua* were the pre-dominant pollinators with relative abundance of 38.89 % and 36.11 %, respectively. The other two were bumble bee, *Bombus* spp. (19.44 %) and hornet, *Vespa* spp. (5.55 %). This was accorded by Bashir *et al.* (2019) who stated that hymenopterans were the major visitors of tomato flowers, along with butterflies, wasps, and moths. Kati *et al.* (2021) reported a small number of wild bees that visited tomato fields during flowering. This finding is similar to the observations made in the present study. Li *et al.* (2023) reported the dual role of hoverflies as pollinators as well as predators of aphids in tomato (Table 3).

Table 1. Relative abundance of insect pests of tomato during October,2022-January,2023 and February, 2023-May,2023.

Common name	Scientific name	Family	Order	Average relative abundance (%)
Cotton aphid	*Aphis gossypii*	Aphididae	Hemiptera	42.51
Tomato fruit borer	*Helicoverpaarmigera*	Noctuidae	Lepidoptera	20.74
Tomato pin worm	*Tutaabsoluta*	Gelechiidae	Lepidoptera	25.48
Serpentine leaf miner	*Liriomyzatrifolii*	Agromyzidae	Diptera	4.20
Grasshopper	*Trilophidiaannulata*	Acrididae	Orthoptera	0.58
Fruitfly	*Bactroceracucurbitae*	Tephritidae	Diptera	0.21
Striped flea beetle	*Phyllotretastriolata*	Chrysomelidae	Coleoptera	1.47
Painted bug	*Bagradahilaris*	Pentatomidae	Hemiptera	0.29
Red cotton bug	*Dysdercuscingulatus*	Pyrrhocoridae	Hemiptera	0.20
White backed plant hopper	*Sogatellafurcifera*	Delphacidae	Hemiptera	0.36
Red pumpkin beetle	*Aulacophorafoveicollis*	Chrysomelidae	Coleoptera	0.21
Leaf beetle	*Monoleptasignata*	Chrysomelidae	Coleoptera	0.90

Beetle	*Dercetinaflavocincta*	Chrysomelidae	Coleoptera	0.08
Cabbage fly	*Delia radicum*	Anthomyiidae	Diptera	0.11
Whitefly	*Bemisiatabaci*	Aleyrodidae	Hemiptera	2.64

Table 2. Relative abundance of natural enemies of insect pests of tomato during October, 2022 – January, 2023 and February, 2023-May, 2023.

Common name	**Scientific name**	**Family**	**Order**	**Average relative abundance (%)**
Tomato bug	*Nesidiocoris tenuis*	Miridae	Hemiptera	31.75
Ladybird beetle	*Micraspisdiscolor*	Coccinellidae	Coleoptera	22.67
Ladybird beetle	*Coccinellaseptumpunctata*	Coccinellidae	Coleoptera	12.70
Ladybird beetle	*Cheilomenessexmaculata*	Coccinellidae	Coleoptera	4.76
Ladybird beetle	*Coccinella transversalis*	Coccinellidae	Coleoptera	4.31
Ladybird beetle	*Oenopiasexareata*	Coccinellidae	Coleoptera	5.21
Ants	*Camponicuspennsylvanicus*	Formicidae	Hymenoptera	13.83
Damsel fly	*Indolestesgracilisdavenporti*	Lestidae	Odonata	1.36
Damsel fly	*Platycnemispennipes*	Platycnemididae	Odonata	1.36
Fly	Unidentified	Micropezidae	Diptera	2.04

Table 3: Relative abundance of pollinators of tomato during October, 2022 - January, 2023 and February, 2023 - May, 2023.

Common name	**Scientific name**	**Family**	**Order**	**Average relative abundance (%)**
Wasp moth	*Amata huebneri*	Eribidae	Lepidoptera	38.89
Hoverfly	*Allograptaobliqua*	Syrphidae	Diptera	36.11
Bumble bee	*Bombus*spp.	Apidae	Hymenoptera	19.44
Hornet	*Vespa* spp.	Vespidae	Hymenoptera	5.55

3.3 Seasonal incidence of major insect pests of tomato and correlation with weather parameters

During October, 2022 – January, 2023, peak populations of *Aphis gossypii, Tuta absoluta* and *Helicoverpa armigera* were recorded at 48th SWM with 38.4 nos. per three leaves, 47th SMW with 7.3 larvae/plant and 49th SMW with 7.1 larvae/plant, respectively. Whereas, during February, 2023 – May, 2023, maximum aphid population was recorded at 14th SMW (40.2 per three leaves). *Aphis gossypii, Tuta absoluta* and *Helicoverpa armigera* attained peak population at 14th SMW (40.2 adults per three leaves), 15th SMW (6.8 larvae/plant) and 16th SMW (7.3 larvae/plant) during February, 2023 – May, 2023. Similar reports were made by Umeh and Onukwu (2005), Mandal (2012), Singh (2013) and Singh *et al.* (2021).Correlation of aphid population with maximum temperature was positive and non-significant, but negative and non-significant for minimum temperature, morning and evening relative humidity and rainfall during the first season. These results conform to those of Sharma *et al.* (2013) and Rawat and Bhandari (2019), who reported the same for the same weather parameters. During the second season, however, there was a significant negative correlation between aphid population and morning relative humidity (r=-.503) while correlation with all other weather parameters remained non-significant. These results are in close relation with those of Ghosh (2017) who reported that temperature (maximum and minimum) had a non-significant positive influence on aphid population while influence of weekly rainfall was found to be non-significant and negative.

During the first season, *Tuta absoluta* had a negative correlation with all the weather parameters and the correlation was significant only for morning (r=-.600) and evening (r=-.683) relative humidity. These findings were contradicted by Chaudhary *et al*. (2022) who intimated a significant positive correlation with morning relative humidity. During the second season, there was significant positive correlation with maximum (r=.648) and minimum temperatures (r=.598). Correlation with morning relative humidity was negative and significant (r=-.520).These results were substantiated by Nayana *et al.* (2018) who reported a significant correlation with maximum temperature during both *Rabi* and *Kharif* seasons.

Table 4. Correlation of meteorological parameters with incidence of major pests of tomato during October, 2022 to January, 2023

Insects	Temperature		Relative humidity (%)		Rainfall (mm)
	Max.	Min.	Morning	Evening	
r* values					
Aphis gossypii	.138	-.201	-.440	-.463	-.203
Tutaabsoluta	-.070	-.417	-.600*	-.683*	-.473
Helicoverpaarmigera	-.122	-.448	-.475	-.610*	-.466

Table 5. Correlation of meteorological parameters with incidence of major pests of tomato during February, 2023 to May, 2023

Insects	Temperature		Relative humidity (%)		Rainfall (mm)
	Max.	Min.	Morning	Evening	
r* values					
Aphis gossypii	.467	.107	-.503*	-.383	-.331
Tutaabsoluta	.648**	.596*	-.520*	-.031	.150
Helicoverpaarmigera	.547*	.349	-.586*	-.233	-.068

*. Correlation is significant at the 0.05 level (2-tailed).

Population of larvae of *Helicoverpa armigera* during the first season was negatively correlated with evening relative humidity with a significant r value of -.610. These findings were corroborated by an account given by Kakati *et al*. (2005) that reported a non-significant negative correlation of insect population with maximum temperature. During the second season, correlation with maximum temperature (r=547) was significant and positive while it was negative for morning relative humidity (r=-.586). These results were in alignment with the findings of Vikram *et al.* (2018), who reported significant positive correlation of maximum and minimum temperatures and negative correlation of average relative humidity with population build-up of *Helicoverpa armigera*.

4. **Conclusion**

The diversity indices obtained indicated that there were very low levels of diversity and species richness in tomato eco-system. Relative abundance of insect pests of tomato showed that the borers, *Helicoverpa armigera,Tuta absoluta* and *Aphis gossypii* constituted a large proportion of the total number of insects and thus, were considered as major insect pests of tomato. Maximum temperature and relative humidity were the major factors in the population build up and abundance of major insect pests of tomato.

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