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Major insect pests and natural enemies on brinjal in the *Tarai* region of Uttarakhand, India in relation to weather parameters

SONAM PANWAR[1*], N. SRIKANTH[1] and R. M. SRIVASTAVA[1]

Department of Entomology, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

***E-mail**: srikanthsrk2010@gmail.com

ABSTRACT: The present study was conducted to document major insect pests and natural enemies on brinjal grown under natural farming in the tarai region of Uttarakhand, India during *kharif* 2022-23. Major insect-pests found on the brinjal crop were brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae), leafhopper, *Amrasca biguttula biguttula* Ishida (Hemiptera: Cicadellidae), white fly *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae), hadda beetle, *Henosepilachna vigintioctopunctata* Fabricius (Coleoptera: Coccinellidae), leaf roller *Eublemma olivacea* Walker (Lepidoptera: Erebidae) and stink bug *Nezara viridula* (Hemiptera: Pentatomidae). Among natural enemies, *Coccinella* sp. (Coleoptera: Coccinellidae) and spider were recorded in present studies. Population peaks of various insect pests and natural enemies were recorded in the following pattern, whitefly was recorded in 3rd week of August (34th SMW), peak in the population of leafhopper was recorded in 4th week of August (35th SMW), leafroller in 5th week of August (35th SMW), Brinjal shoot and fruit borer in 2nd week of September (37th SMW), bugs in 2nd week of September (37th SMW), hadda beetle in 4th week of August (34th SMW), Coccinella in 1st week of October (40th SMW) and spider in 3rd week of September (38th SMW).

Keywords: Brinjal, *Leucinodes*, whitefly, hadda beetle, coccinellids, weather parameters

INTRODUCTION

Brinjal (*Solanum melongena* Linnaeus) belongs to the family Solanaceae and chromosome number (2n = 24) and is also known as eggplant. It is one of the most popular and important vegetable crops worldwide (Gleddie *et al.,* 1986) and also a popular vegetable cultivated across India. Together with the potato, it is the second most eaten vegetable in the country (Mammoun *et al.,* 2004). Brinjal occupies an area of 74.9 million ha with a production of 12874 million tonnes in India. Major brinjal growing states in India are West Bengal, Orissa, Gujarat, Bihar, Madhya Pradesh, Chattisgarh, Andhra Pradesh, Tamil Nadu, Maharashtra, Assam (https://agriexchange.apeda.gov.in**,** 2023). It is an important vegetable grown all year round, because of its short duration, high yield, nutritional richness, economic viability, and potential on-farm and off-farm jobs, vegetables are significant components of Indian agriculture and nutritional security (Samota *et al.,* 2014). The most crucial element of a balanced diet is vegetables, which also serve as a form of nutrition. Therefore, unripen fruits of brinjal are generally eaten as vegetables due to their high nutritional content, which includes minerals like iron, phosphorus, calcium, and vitamins like A, B, and C. The fruit can be added to stews or used as garnish. It can also be eaten raw or prepared as a baked, grilled, fried, or boiled vegetable. According to reports, it is used in Ayurvedic treatment for diabetes. Moreover, it functions well as an aphrodisiac, a cardiac tonic, a laxative, and an anti-inflammatory (Kalawate *et al.,* 2012). However, brinjal yield remains lower than predicted due to various restrictions, the most significant of which are insect and non-insect pests that attack the crop at various physiological growth phases from nursery to harvest causing upto 70 to 92 per cent of crop losses (Chakraborti and Sarkar, 2011).

There are 26 insect pests species and few non insect pest species infesting brinjal of which Shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae), white fly, *Bemisia tabaci Gennadius* (Hemiptera: Aleyrodidae), leafhopper, *Amrasca biguttula biguttula* Ishida (Hemiptera: Cicadellidae), hadda beetle, *Henosepilachna vigintioctopunctata* Fabricius (Coleoptera: Coccinellidae), leafroller *Eublemma olivacea Walker* (Lepidoptera: Erebidae), stink bug *Nezara viridula* (Hemiptera: Pentatomidae), and non-insect pests like red spider mite, *Tetranychus* spp are commonly known to infest brinjal crop (Vevai, 1970). *Leucinodes orbonalis* G., the brinjal shoot and fruit borer (BSFB), is often regarded as the most dangerous pest of the fruit. It has also significantly hampered output in all nations where the fruit is grown (Alam *et al.,* 2003).

Sucking pests of brinjal *viz.,* whitefly and leafhopper results in major crop losses, both directly and indirectly,

by sucking the cell sap with their piercing and sucking mouth parts and by transmitting viral diseases by forming sooty mold by whitefly and aphid and little leaf by leafhopper (Kunbhar *et al.,* 2018). Studying the population densities of insect pests that affect brinjal is crucial for efficient pest control (Sundareshwari *et al.,* 2017). Therefore, in this present study, the seasonal incidence of major insect pests and natural enemies of brinjal crop along with their relation with the various abiotic factors which is very important for formulating further management strategies.

MATERIALS AND METHODS

The field experiment was carried out at Vegetable Research Centre (VRC), G.B..U.A& T, Pantnagar, Uttarakhand during the *kharif* season of 2022. Incidence of insects was recorded per plot on randomly selected five plants. Observations were recorded once from the untreated plots in a standard week. Data was recorded 21 days after transplanting. The population estimation of brinjal shoot and fruit borer was recorded by counting the number of withered terminal shoot and infested fruits in the later stage of the crop. Sucking pests *viz.,* Leafhopper (*Amrasca biguttula biguttula, Ishida*) and whitefly (*Bemisia tabaci*) were recorded from three leaves top, middle, and bottom leaves of five randomly selected plants in the field using the method proposed by Rawat *et al.,* (1973). In case of insect pests such as *H. vigintioctopunctata* (adult and grub), pentatomid bugs, leafroller and natural enemies such as coccinellid beetles and spiders the data was recorded from entire plant in five randomly selected plants.

RESULTS AND DISCUSSION

The data collected on the insect pests infesting brinjal and associated natural enemies and their correlation with different weather factors during *kharif* crop season 2022 is presented below.

Insect- pests of brinjal

The insect pests *viz.,* brinjal shoot and fruit borer *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae), leafhopper *Amrasca biguttula biguttula* Ishida (Hemiptera: Cicadellidae), white fly *Bemisia tabaci Gennadius* (Hemiptera: Aleyrodidae), grub and adult of hadda beetle *Henosepilachna vigintioctopunctata* Fabricius (Coleoptera: Coccinellidae), leafroller *Eublemma olivacea Walker* (Lepidoptera: Erebidae), stink bug *Nezara viridula* (Hemiptera: Pentatomidae) and natural enemies such as *Coccinella sp.* (Coleoptera: Coccinellidae) and spider were recorded in present studies.

Leafhopper, *Amrasca biguttula biguttula* Ishida (Hemiptera: Cicadellidae)

The leafhopper infestation was initiated during 4th week of July as foliage started in the crop (30th Standard Meteorological Week), with 3.60 number of leafhoppers per plant (Table. 4.1). The leafhopper population started increasing gradually with maximum number (17.40 per 3 leaves) during 4th week of August (35th Standard week) as the crop was in the vegetative stage. After that, as the crop reached maturity, the leafhopper population started decreasing with a minimum number of leafhoppers (0.80/ plants) recorded in the second last week of October (43rd

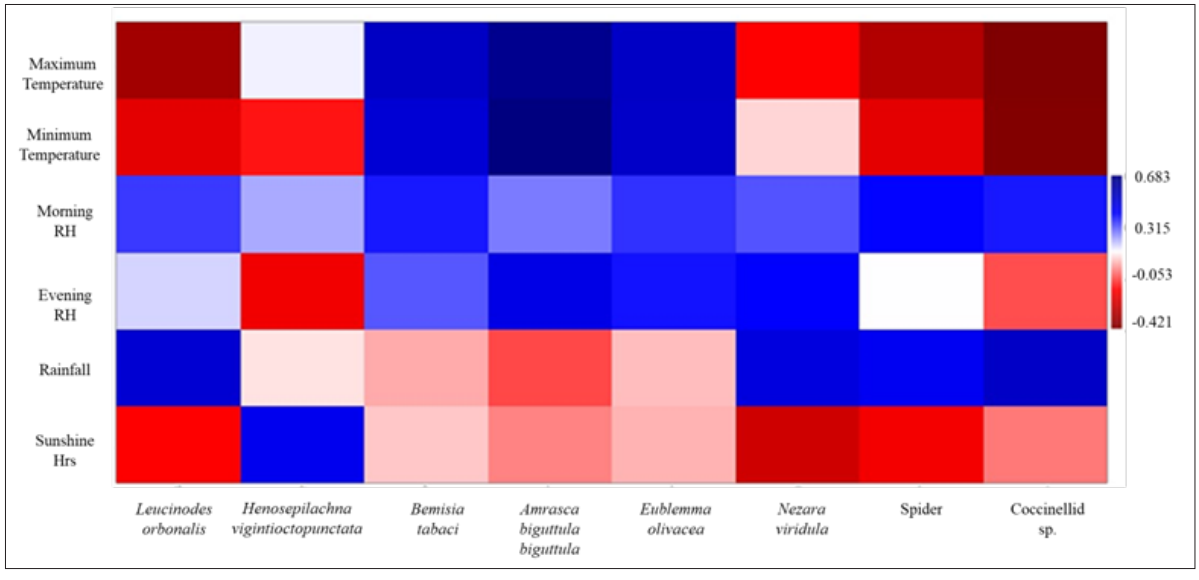

Fig. 1. Mosaic plot demonstrating the correlation between various insect pestas and natural enemies with different weather parameters

standard week). This is in keeping with Ajabe *et al.* (2019) findings who stated that the leaf hopper population grew along with the crop until it reached its highest of 11.80 leaf hoppers per 3 leaves in the second week of September (37th SMW), after which the population steadily declined.

White fly, *Bemisia tabaci Gennadius* (Hemiptera: Aleyrodidae)

The white fly infestation initiated during 4th week of July (30th standard week), with average population of 1.50 white fly per 3 leaves. The white fly population started increasing gradually with maximum number (24.70 /3 leaves) during 3rd week of August (34th standard week) due to availability of sufficient nutrition as tender foliage during vegetative stage of the crop. According to the data collected by Kumar and Sharma (2022), the presence of *B. tabaci*, was first observed in the beginning of August (33rd SMW) with initial population of 3.40 per 3 leaves. The population peaked at 60.80 whiteflies per 3 leaves in the fourth week of September (41st SMW).

Stink Bug, *Nezara viridula* Linnaeus (Hemiptera: Pentatomidae)

The stink bug (*Nezara viridula*) infestation was commenced during 1st week of August (32nd SMW) with mean population of 0.10 bugs per plant. The bug population started increasing gradually with increase in foliage as the vegetative stage proceeded with maximum number of up to 9.60 bugs per plant during 2nd week of September (37th SMW) as fruit set commenced. Later the bug population started decreasing gradually as crop reached maturity with minimum number of bugs (0.50 /plant) recorded during the 4th week of October (43rd SMW).

Brinjal shoot and fruit borer on shoot infestation

The shoot infestation of brinjal shoot and fruit borer commenced from the 1st week August with an initial population of 0.50 larvae per plant as the plant growth continued and was observed until last week of October, 2022 as crop continued to grow until maturity with a final population of 6.50 larvae per plant. The shoot infestation occurred at its peak for the first-time during 2nd week of September (37th SMW) with 22.30 larvae per plant. The shoot infestation recorded was ranging from 0.50 per cent to 22.30 per cent during the cropping period.

According to a study conducted by Sharma *et al.* (2017), the presence of brinjal shoot and fruit borer infestation was observed to begin in the 34th week, averaging at 0.64, and it reached its highest point at 5.21 during the 41st week.

Hadda beetle, *Henosepilachna vigintioctopunctata* (Coleoptera: Coccinellidae)

The hadda beetle infestation commenced during 4th week of July (30th SMW), 2022 with start of foliage with 0.15 mean of beetles per plant. The beetle population started increasing gradually as the crop growth proceeded with maximum number of 5.20 per plant recorded during 4th week of August (34th SMW). After that the beetle population started decreasing as flowering and fruiting commenced with 2.40 beetles per plant recorded in 3rd week of September (38th SMW), it again increased (4.30 beetles /plant) on 1st week of October (40th SMW) as crop attained maximum growth stage and finally decreased (2.20 beetles /plant) during 4th week of October (43rd standard week as crop reached maturity.

According to a study conducted by Sharma and Tayde (2017), the *kharif* season of 2016 began in the 30th week with an average of 1.2 hadda beetles per plant. Over time, the beetle population steadily increased and reached its highest level of 3.6 beetles per plant in the 35th week. However, by the 41st week, no hadda beetles were observed.

Leafroller, *Eublemma olivacea Walker* (Lepidoptera: Erebidae)

The leafroller infestation started 5th week of July (31st SMW) with an initial population of 1.00 larvae per plant as plant started its vegetative phase. Later, the leafroller population started increasing gradually with maximum number (7.60 larvae /plant) during 5th week of August (35th SMW) during maximum growth stage of the crop. Later, the leafroller population gradually started decreasing as crop reached maturity reaching a minimum of 0.20 larvae per plant which was recorded in the 4th week of October (43rd SMW).

NATURAL ENEMIES

Coccinellid beetle

The population of predatory coccinellids ranged between 0.60 to 4.90 beetles per plant in brinjal crop during August to October, 2022. The coccinellids were first observed in 1st week of August (32nd SMW) with appearance of sucking pests like aphids and leaf hoppers with 0.60 beetles per plant. The maximum population (4.90 /plant) of coccinellids was noticed during 1st week of October (40th SMW) after that the population was gradually decreasing as the crop reached the fruiting stage and maturity by 1st week of October (43rd SMW) with 2.70 beetles per plant.

Table 1. Temporal distribution of insect pests and natural enemies associated with brinjal crop (*kharif* 2022)

Date	SMW	*Leucinodes orbonalis*	*Henosepilachna epilachna*	*Bemisia tabaci*	*Amrasca biguttula biguttula*	*Eublemma olivacea*	*Nezara viridula*	Spider	*Coccinellid* sp.
23-07-2022	30	0.00	0.15	1.50	3.60	0.00	0.00	0.00	0.00
30-07-2022	31	0.00	0.20	4.30	6.50	1.00	0.00	0.00	0.00
06-08-2022	32	0.50	0.25	7.40	9.10	3.10	0.10	0.25	0.60
13-08-2022	33	3.10	5.20	11.30	12.40	4.50	1.30	0.43	0.88
20-08-2022	34	5.00	5.20	24.70	16.80	7.30	2.20	0.80	2.40
27-08-2022	35	9.50	3.30	22.50	17.40	7.60	3.80	2.45	2.75
03-09-2022	36	13.40	3.10	18.60	15.90	6.20	6.20	3.60	3.20
10-09-2022	37	22.30	1.60	12.25	13.50	6.10	9.60	4.20	3.90
17-09-2022	38	19.70	2.40	10.80	10.20	4.80	9.30	4.80	4.50
24-09-2022	39	20.60	2.40	10.60	8.70	3.70	8.80	2.85	4.65
01-10-2022	40	17.25	4.30	7.20	5.75	3.60	5.20	2.93	4.90
08-10-2022	41	14.50	3.70	5.40	2.60	1.50	3.70	2.60	4.40
15-10-2022	42	10.00	3.50	3.70	1.50	0.80	1.60	2.20	3.50
22-10-2022	43	6.50	2.20	0.70	0.80	0.20	0.50	1.85	2.70

Sarta *et al.* (2022) found that coccinellids up to 1.25 insects per plant were first spotted in the first week of August 2018 (32nd SMW). Coccinellids reached their peak population (2.25 /plant) in the last week of August (34th SMW).

Spider

The predatory spider count ranged between 0.25 to 4.80 spiders per plant in brinjal crop during August to October, 2022. The spiders were first observed in 1st week of August (32nd SMW) with appearance of sucking pests like aphids, thrips, and leaf hoppers with 0.25 spiders per plant with the maximum population (4.80 spiders /plant) noticed during 3rd week of September (38th SMW)

The predatory spiders were initially observed on the brinjal crop during the second week of August (32nd SMW), according to Sarta *et al.* (2022), at a rate of 2.75 per plant. Then, during the first week of September (36th SMW), the spider population increased and peaked at 3.0 per plant.

Correlation studies of weather parameters on insect pests and natural enemies in brinjal

The correlation coefficient between the mean number of insects and the climatic factors *i.e.,* maximum and minimum temperature, morning and evening relative humidity, rainfall and sunshine hours were worked out and are presented in table 1.

Leafhopper, *Amrasca biguttula biguttula* Ishida (Hemiptera: Cicadellidae)

The leafhopper population showed positive and significant correlation with maximum temperature (r = 0.649*) and minimum temperature (r = 0.683**). Whereas the correlation was positive but non-significant with morning relative humidity (r = 0.273) and evening relative humidity (r = 0.463). The correlation was found negative and non-significant with rainfall (-0.067) and sunshine hours (-0.003).

The correlation studies of Soren *et al.* (2019) indicated that there was negative and non- significant

with sunshine hours (r = -0.242) and rainfall (r = -0.159). The result showed positive and significant correlation by Tupe *et al.* (2022) minimum temperature (r = 0.68*) and maximum temperature (r = 0.71**).

White fly, *Bemisia tabaci Gennadius* (Hemiptera: Aleyrodidae)

The white fly population showed positive and significant correlation with maximum temperature (r = 0.534*). Correlation was positive but non- significant with minimum temperature (r = 0.498), morning relative humidity (r = 0.381), evening relative humidity (r = 0.312), rainfall (r = 0.041) and sunshine hours (r = 0.072).

The study by Kumar and Sharma (2022) revealed a significant and positive correlation with maximum temperature (r = 0.759**) and minimum temperature with positive and non-significant correlation (r = 0.227). Berani *et al.* (2020) reported positive and significant with maximum temperature (r = 0.533*, 0.572**) in 2018-19 and 2019-20 respectively.

Stink Bug, *Nezara viridula* Linnaeus (Hemiptera: Pentatomidae)

The bug population showed positive and significant correlation with minimum temperature (r = 0.086), morning relative humidity (r = 0.317), evening relative humidity (r = 0.407) and rainfall (r = 0.479). Whereas correlation was negative with maximum temperature (-0.31) and sunshine hours (-0.25).

Brinjal shoot and fruit borer

The correlation studies showed that the non-significant positive correlation with the morning relative humidity (r = 0.345), evening relative humidity (r = 0.177), and rainfall (r = 0.504). Whereas it showed non-significant negative correlation with maximum temperature (r = -0.346), minimum temperature (r = -0.202), and sunshine hours (r = -0.148).

Gupta *et al.* (2021) found negative and non-significant correlated with sunshine hours (r = -0.195), and positive and non- significantly correlated with rainfall (r = 0.236). Saran *et al.* (2018) reported negative and non- significant correlation with minimum temperature (r = -0.286), and positive and non-significant correlation with morning relative humidity (r = 0.126).

Hadda beetle, *Henosepilachna vigintioctopunctata* (Coleoptera: Coccinellidae)

The hadda beetle population showed positive and non- significant correlation with maximum temperature (r = 0.146), morning relative humidity (r = 0.222), rainfall (r = 0.101) and sunshine hours (r = 0.444). whereas, negative and non- significantly correlated with minimum temperature (r = -0.124) and evening relative humidity (r = -0.175).

Sharma *et al.* (2017) found that weather showed positive and non- significant correlation with rainfall (r

Table 2. Correlation between weather parameters and mean number of insect pests and natural enemies in brinjal during kharif 2022

Weather parameters	*Leucinodes orbonalis*	*Henosepilachna vigintioctopunctata*	*Bemisia tabaci*	*Amrasca biguttula biguttula*	*Eublemma olivacea*	*Nezara viridula*	Spider	*Coccinellid* sp.
Maximum temperature	-0.346	0.146	0.535*	0.649*	0.531	-0.149	-0.31	-0.421
Minimum temperature	-0.202	-0.124	0.498	0.683**	0.527	0.086	-0.205	-0.414
Morning RH	0.345	0.222	0.381	0.273	0.353	0.317	0.404	0.38
Evening RH	0.177	-0.175	0.312	0.463	0.387	0.407	0.132	-0.06
Rainfall mm	0.504	0.101	0.041	-0.067	0.06	0.479	0.434	0.528
Sunshine hrs	-0.148	0.444	0.072	-0.003	0.049	-0.25	-0.169	-0.014

= 00.781). Singh *et al.* (2023) reported positive and non-significant correlation with rainfall (r = 0.172), sunshine hour (r = 0.073).

Leafroller, *Eublemma olivacea Walker* (Lepidoptera: Erebidae)

The leafroller population showed positive and significant correlation with every weather parameter *viz.,* maximum temperature (r = 0.531), minimum temperature (r = 0.527), morning relative humidity (r = 0.353), evening relative humidity (r = 0.387), rainfall (r = 0.06) and sunshine hours (r = 0.049).

NATURAL ENEMIES

Coccinellid beetle

The population of coccinellids showed positive and non-significant correlation with morning relative humidity (r = 0.38) and rainfall (r = 0.528). The correlation with maximum temperature (r = -0.421), minimum temperature (-0.414), evening relative humidity (r = -0.06) and sunshine hours (r = -0.014) was negative and non- significant.

In their investigation, Chandrakumar *et al.* (2008) discovered that there was a strong negative association (r = -0.641) between the density of coccinellids and the highest temperature. Kumar and Sharma (2022) found negative and non- significant correlation with minimum temperature (r = -0.222), rainfall (r = -0.356).

Spider

The population of spider showed positive and non-significant correlation with morning relative humidity (r = 0.404), evening relative humidity (r =0.132) and rainfall (r = 0.434). Whereas it was negatively non-significant correlation with maximum temperature (-0.31), minimum temperature (-0.251) and sunshine hours (r = -0.169). Singh *et al.* (2023) reported negative and non- significant correlation with minimum temperature (r = -0.065).

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