The Pharma Innovation Journal 2023; SP-12(7): 388-393

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(7): 388-393

www.thepharmajournal.com
Received: 04-05-2023
Accepted: 08-06-2023

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Seasonal incidence of major insect pests and their associated natural enemies in brinjal crop at Pantnagar, Uttarakhand

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Abstract
The present experiment entitled seasonal incidence of major insect pests and their associated natural enemies in brinjal crop at Pantnagar, Uttarakhand was conducted during the kharif season of 2019–20, at Vegetable Research Centre, GBPUA&T, Pantnagar. Population dynamics of major damaging insects, viz., leafhopper, whitefly, brinjal leaf roller, hadda beetle, BSFB, and their major associated natural enemies viz., coccinella and spider were studied in correlation to different abiotic factors. Observations were taken from crop transplanting until maturity at weekly intervals and correlated to different abiotic factors. Results revealed leafhoppers showed the lowest and highest population (0.2/3 leaves and 3.88/3 leaves) during the 48rd and 40th SMW, and a significant positive correlation with evaporation and rainfall were recorded, respectively while whitefly showed lowest and highest population (0.1/3 leaves and 5.23/3 leaves) during the 48th and 43rd SMW, and a significant negative correlation with rainfall were recorded. Leafroller and hadda beetle showed peak numbers during the 37th and 41st SMW (2.79 per plant and 3.66 per plant), a non-significant correlation to all variables was observed for leafroller, while hadda beetle showed a positive and significant correlation with sunshine hours. The most damaging pest, BSFB, showed 5.52 larvae per plant during the 46th SMW as the peak infestation level and correlation showed significant negative relations with RH eve., evaporation, rainfall, and only wind velocity showed significant positive correlation with BSBF population. Although the natural enemies coccinella and spider showed peak numbers of 2.66 per plant and 1.36 per plant, during 38th and 37th SMW respectively, and negative significant correlations were found between evaporation and coccinella, the spider population showed a negative significant correlation with rainfall and evaporation, while sunshine hours showed a positive significant correlation.

Keywords: Brinjal, RH eve., BSFB, SMW, abiotic factors

Introduction

In the subtropical and tropical regions of the world, brinjal (*Solanum melongena*) (family Solanaceae) is a common and significant vegetable crop. People refer to it as aubergine, eggplant, the poor man's vegetable, and the king of vegetables (Khan *et al*., 2018) [6].

China produces 36.6 million MT of brinjals annually, followed by India with 12.78 Million MT. In India, 700.4 thousand acres are under brinjal cultivation, with the largest proportion found in West Bengal at 23.72%, followed by Odisha at 16.66%, and Gujrat at 12.01% (FAO, 2021) [3]. The annual cultivation of 32.12 metric tonnes of brinjal in Uttarakhand accounts for 0.25 percent of the state's total proportion. In India, brinjal is the second-most popular vegetable after potatoes. India is considered the origin and diversity centre of brinjal. The leaves and seeds of the brinjal plant are also employed as stimulants and necrotics, respectively. It is important because it has a high nutritional, therapeutic, and economic value per 100 grammes 0.2 g overall fat, 25 g energy,2g sodium, 229g potassium, 6g total carbs, sugar 3.5 g, 3g dietary fibre, 3% antioxidant vitamin C, 1g protein, 6-5% vitamin B, 1% iron and3%magnesium (USDA, 2013) [17].

The brinjal crop suffers from multiple diseases, insect pests, and other environmental factors, with insect pests being one of the most significant limitations. There are approximately 140 species of insects that attack the brinjal crop (Patial and Mehta, 2008) [12]. Whitefly (*Bemisia tabaci* Gennadius) aphids (*Aphis gossypii* Glover), Jassid (*Amrasca biguttula biguttula* Ishida), Hadda beetle (*Epilachna vigintioctopunctata* Fabricius), shoot and fruit borer (*Leucinodes orbonalis* Guenee), lace wing bug, *Urentius hystricellus* (Richter), brinjal stem borer, *Euzophera perticella* Ragonot, brinjal leafhopper *Cestius phycitis*, and brinjal ash weevil *Myllocerus subfasciatus* are major insect pest that causes severe damage to the crop (Yadav *et* *al*. 2017) [18].

The infestations of leafhopper, whitefly, and shoot and fruit borer reduce brinjal production by 70–92% (Chakraborty and Sarkar, 2011) [1]. The loss of productivity due to shoot and fruit borer alone recorded as 63%, and the 6% infestation threshold for shoot and fruit borer in India means economic damage (Rahman, 2007) [15]. Due to the fact that environmental factors influence insect dispersal and abundance, climatic variables are essential to studying the biology of all pests in order to devise efficient methods of control. In order to determine the seasonal incidence of the main insect pests and their associated natural enemies in brinjal at Pantnagar, Uttarakhand, the present studies were conducted.

Methodology

The trial was conducted at the Vegetable Research Centre in Pantnagar, Uttarakhand (India), during the 2019–20 cropping seasons. In the second week of August, three replications of a Randomised Complete Block Design (RBD) with a 5×5 m^2 plot size and 60×60 cm row to row and plant to plant distances were used to plant brinjal (Pant Rituraj, Round variety) seeds. All recommended crop cultivation practises were carried out. Five plants were randomly selected from each of the three replicates to determine the number and duration of insect pests and natural enemies on the brinjal plants. Since the crop was transplanted until it was harvested, the insects population were monitored every week (Kumar and Singh, 2013) [11]. The populations of sucking insect pests, such as leafhoppers and whiteflies, were counted in the morning on tagged plants. Leaf from top, middle and bottom were used for recording individual number of insects on total three leaves without disturbing them. The number of leaf rollers and hadda beetles observed on five tagged plants per plot were selected at random, and for data on shoot and fruit borer same tagged plants were used. The infestation of shoots will be documented by calculating the total number of damaged shoots at weekly intervals, and the infestation of fruit with larvae will be recorded by calculating the number of larvae present in fruits per 5 plants per week in infested fruit. On the same randomly selected and tagged plants, the population of natural enemies (Spider and Coccinella) will be determined.

Throughout the experiment, Pantnagar's Department of Agrometeorology acquired weekly meteorological data, including temperature (maximum and minimum), relative humidity (morning and evening), evaporation, wind speed and sunlight hours (Table 2). R software and SPSS (Version 20; SPSS, Inc., Chicago, II, USA) were used for data analysis and between insect population and key weather parameter correlation studies were determined to examine the effect of weather on the population fluctuations of insect pests and their associated natural enemies.

Result

The population of insect pests and their associated natural enemies on the crop were monitored weekly, beginning with crop transplanting and continuing until crop maturity. The mean population of insects and their natural enemies, as well as the current standard meteorological week (SMW), are given in Table 2.

Leafhopper, *Amrasca biguttula biguttula* (Ishida)

The crop was transplanted during the 32nd SMW. Whereas the first appearance of insects was observed during the 33rd SMW (early vegetative stage), with the first incidence of leaf hoppers continuing up to the 48th SMW. Table 2 (fig 2) shows the highest (3.88 leaf hopper per leaf) and lowest (0.2 leaf hopper per leaf) mean populations of leaf hoppers were obtained during the 40th and 48th SMW, respectively. The correlation studies between the population of leafhoppers and weather parameters showed that only evaporation had a significant negative correlation (r = -1.30), which suggests the population of the insect pest increases with a decrease in evaporation. The regression equation revealed with reasonable accuracy (R^2 = 0.77) (Table 1, fig 1) that a variety of weather factors, including temperature (max. and min.), relative humidity (morning and evening), rainfall, wind velocity, sun shine hours, and evaporation, had an impact on the population of *Amrasca biguttula biguttula* (Ishida) on brinjal.

Whitefly, *Bemisia tabaci* (Guen.)

Table 2 (fig 2) shows that whitefly was present on the crop up to the 48th SMW, with a maximum and minimum population of 5.23/3 leaves and 0.1/3 leaves during the 43rd and 48th SMW, respectively. The correlation studies between the population of whiteflies and weather parameters showed that only rainfall had a significant negative correlation (r = -0.02) (table 1, fig 1) with the whitefly population, suggesting that an increase in rainfall would result in a lower population of whiteflies. The regression equation showed that different weather factors, such as temperature (max. and min.), relative humidity (morning and evening), rainfall, wind speed, sun shine hours, and evaporation, had an effect on the population of *B. tabaci* on brinjal with an average degree of accuracy (R^2= 0.63).

Brinjal leaf roller, *Eublemma olivacea* walker

Table 2 (fig 2) presenting the mean population of leaf roller ranged from 2.79/plant to 0.11/ plant, and the peak population of leaf roller was recorded during the 37th SMW with 2.79/plant and the least with 0.11/plant during the 40th SMW, respectively, and the pest was present on the crop until the 40th SMW. The correlation studies between the population of leaf rollers and weather parameters showed that variation in leaf rollers was explained up to R^2 = 0.53 (Table 1, fig 1)) by the influence of all the weather parameters, and the population was found to be non-significant to all the independent variables.

Hadda beetle, *Epilachna vigintioctopunctata* (Fabricius)

Table 2 (fig 2) represting the hadda beetle was present until the 46th SMW on the crop since the 35th SMW. The population of hadda beetles ranged from 0.12 to 3.66 beetles per plant. A peak population of hadda beetles (3.66 beetles per plant) was recorded during the 41st SMW and the least during the 35th SMW (0.12 beetles/plant). The correlation studies between the population of hadda beetle and weather parameters showed that sunshine hours showed a significant positive correlation (r = 0.36), whereas evaporation and rainfall showed a significant negative correlation (r = -0.01) with population growth. A study suggests that an increase in sunshine hours and a decrease in evaporation and rainfall are associated with an increase in the population of the hadda beetle, respectively. Variation in population was recorded up to 73% by the combined influence of evaporation, rainfall, and sunshine hours. (Table 1, fig 1)

Brinjal shoot and fruit borer, (*Leucinodes orbonalis* Guen.)

Table 2 (fig 2) representing the first appearance of brinjal shoot and fruit borerwas observed during the 36th SMW and continued up to the 1st SMW. The population of brinjal shoot and fruit borer (on shoot) on the crop ranged from 0.15 to 0.08 larvae per plant, with a peak during the 42nd SMW and the least during the 1st SMW. Similarly, the population of brinjal shoot and fruit borer (on fruit) ranged from 0.21 to 5.42 larvae per plant, peak 5.42 larvae per plant occurred during the 46th SMW and the lowest population of 0.21 during the 39th SMW. The correlation studies between the population of brinjal shoot and fruit borer on shoot with weather parameters showed significant negative effects of evaporation and rainfall (r = -0.83 and r = -0.01, respectively) on the population buildup of brinjal shoot and fruit borer on shoot, i.e., an increase in evaporation and rainfall will reduce the borer population on shoot. The R-squared value of 0.72 indicates that these two factors explain 72% of the total variation in brinjal shoot and fruit borer population on shoot, whereas brinjal shoot and fruit borer on fruit showed wind velocity had only a significant positive coefficient (r = 0.47) and evening relative humidity showed a significant negative coefficient (r = 0.16). An increase in wind velocity and a lowering of the evaporation rate will increase the borer incidence on fruit, respectively. Variation was recorded with an R-squared value of 0.92. (Table 1, fig 1)

Lady bird beetle, Coccinella sps.

The incidence of coccinella was observed from the 34th SMW to the 47th SMW, respectively (Table 2, fig 2) with the highest population of coccinella (2.66 per plant) during the 38th SMW and the least population (0.5 per plant) during the 47th SMW. The correlation studies between the population of coccinella and weather parameters showed that only evaporation was found to be significantly negatively.

Correlated to the population of coccinella, which indicates that an increase in evaporation will lead to a decrease in the population of coccinella. The variation explained for coccinella was 0.69, i.e., 69% (Table 1, fig 1).

Spider

Spiders were present on the crop from the 33rd to the 47th SMW, and the highest and lowest mean populations of spiders (1.36 per plant and 0.4 per plant, respectively) were recorded on the 37th and 33rd SMW, respectively, representing in table 2 and fig 2. The correlation studies between spider population and weather parameters showed that evaporation and rainfall had a significantly negative correlation, and sunshine hours had a significant positive correlation with spider population. Additionally, the study suggests a decrease in evaporation, rainfall and an increase in sunshine hours will increase the spider population. The variation explained for spiders was 0.85, i.e., 85% presented in table 1 and fig 1.

Table 1: Multiple linear regressions (MLR) for major insect pests and their associated natural enemies 2019 -2020

Variables	(Intercept)	T. max	T. min	R.H mor	R.H eve	Rainfall	Sunshine hour	Wind Velocity	Evaporation	R^2	
Coefficient	3.38	0.11	-0.20	0.11	-0.16**	0.01	-0.56	0.47*	0.02		BSFB (on fruits)
p-value	0.78	0.68	0.39	0.22	0.06	0.12	0.00	0.02	0.96	0.92	
Variables	(Intercept)	T.max	T. min	R.H mor	R.H eve	Rainfall	Sunshine hour	Wind Velocity	Evaporation		
Coefficient	17.64	-0.21	0.30	-0.11	-0.06	-0.01**	0.15	-0.02	-0.83**		BSFB (on shoots)
p-value	0.14	0.41	0.17	0.19	0.41	0.08	0.30	0.90	0.07	0.72	
Variables	(Intercept)	T. max	T min	R.H mor	R.H eve	Rainfall	Sunshine hour	Wind Velocity	Evaporation		
Coefficient	23.64	-0.32	0.53	-0.20	-0.02	-0.02**	0.46	-0.26	-1.31		Whitefly
p-value	0.38	0.58	0.29	0.31	0.92	0.07	0.19	0.50	0.20	0.63	
Variables	(Intercept)	T.max	T.min	R.H mor	R.H eve	Rainfall	Sunshine hour	Wind Velocity	Evaporation		
Coefficient	15.06	-0.27	0.39	-0.10	-0.04	-0.01**	0.36*	-0.02	-1.01*		Hadda bettle
p-value	0.25	0.35	0.12	0.27	0.62	0.06	0.04	0.90	0.05	0.73	
Variables	(Intercept)	T. max	T.min	R.H mor	R.H eve	Rainfall	Sunshine hour	Wind Velocity	Evaporation		
Coefficient	-16.44	0.36	-0.24	0.04	0.12	0.00	0.06	-0.10	-0.06		Leaf roller
p-value	0.14	0.15	0.23	0.56	0.11	0.79	0.64	0.53	0.88	0.53	
Variables	(Intercept)	T. max	T.min	R.H mor	R.H eve	Rainfall	Sunshine hour	Wind Velocity	Evaporation		
Coefficient	24.63	-0.25	0.45	-0.18	-0.07	-0.01	0.23	0.03	-1.30*		Leaf hopper
p-value	0.11	0.44	0.11	0.10	0.46	0.24	0.22	0.87	0.03	0.77	
Variables	(Intercept)	T.max	T.min	R.H mor	R.H eve	Rainfall	Sunshine hour	Wind Velocity	Evaporation		
Coefficient	11.52	0.05	0.10	-0.13	0.00	-0.01	0.05	0.12	-0.76**		Coccinella
p-value	0.32	0.83	0.64	0.13	0.95	0.15	0.75	0.45	0.09	0.69	
Variables	(Intercept)	T.max	T. min	R.H mor	R.H eve	Rainfall	Sunshine hour	Wind Velocity	Evaporation		
Coefficient	2.10	-0.02	0.12	-0.03	0.01	-0.01*	0.12*	-0.01	-0.44*		Spider
p-value	0.63	0.82	0.15	0.38	0.82	0.01	0.04	0.85	0.02	0.85	

T. min = Temperature minimum (ºC) T. max. = Temperature maximum (ºC) R.H. mor = Relative humidity morning (%) R.H. eve = Relative humidity evening (%), Rainfall (mm), Wind velocity (km-h), Evaporation (mm)

* Significant at 5% level, ** Significant at 1% level

Table 2: Seasonal incidence of major insect pests and their predators on brinjal crop during 2019-20.

Date	SMW	BSFB		HB	LR	WF	LH	Coccinella	Spider	Temp.		RH		Rainfall	Sunshine	WS	Evp.
		On shoot	On fruits							max.	min.	Mor.	Eve.				
13-19 AUG	33	0	0	0	0	0	0.15	0	0.4	32	25.4	89.3	74.1	51.2	5.2	5.8	4.8
20-26 AUG	34	0	0	0	0.35	0.21	0.53	0.31	0.29	32.3	24.7	89.9	65.6	37.8	5.3	2.4	4.1
27-02 AUG	35	0	0	0.12	0.93	0.73	1.88	0.57	0.4	33.8	25.7	85.6	66.1	174.6	6.1	1.9	4.5
03-09 SEP	36	0.15	0	0.73	1.87	1.98	1.32	1.32	0.65	33.1	25.3	90	72	112.2	5.8	3.5	4.3
10-16 SEP	37	0.65	0	1.33	2.79**	2.87	2.39	1.88	1.36**	33.1	25.7	89.4	69.9	7.8	5.5	3.5	4.3
17-23 SEP	38	1.13	0	1.67	1.03	3.97	2.88	2.66**	1.11	32.1	22.4	88.1	62.4	14.2	7	4.5	3.6
24-30 SEP	39	1.77	0.21	2.12	0.33	6.73	2.12	1.21	1.28	30.9	23	88	65.1	6.2	6.1	1.8	3.6
01-07 OCT	40	2.23	0.35	2.83	0.11	3.21	3.88**	0.91	1.4	30.9	21.3	92.3	57.3	0	7.6	1.9	2.9
08-14 OCT	41	2.81	1.45	3.66**	0	3.79	3.23	2.35	1.22	31.9	18.8	88.1	47.3	0	8.6	2.4	3.2
15-21 OCT	42	3.43**	1.98	2.46	0	4.67	3.72	2.26	1.17	31	18	85.7	49.6	0	6	1.2	2.7
22-28 OCT	43	2.26	3.02	2.33	0	5.23**	3.51	2.21	1.05	29.6	16.2	91.9	46.7	0	6.5	2.2	2.8
29-04 NOV	44	1.73	4.26	1.21	0	2.01	2.43	2	0.72	29.2	17.1	89.4	57.1	0	1.2	2.4	2
05-11 NOV	45	1.13	4.98	0.93	0	1.2	2.88	1.84	0.51	29.1	14	85.3	43.7	0	6	2.7	2.4
12-18 NOV	46	1.02	5.42**	0.32	0	0.88	1.33	0.98	0.55	29	13.3	91.4	44.3	0	6.6	3.2	2.2
19-25 NOV	47	0.65	5.16	0	0	0.32	0.18	0.5	0.12	25	11.5	94	47.3	0	4.7	1.8	2.1
26-02 DEC	48	0.67	4.86	0	0	0.1	0.2	0	0	25.6	11.5	91.6	54	29.2	6.3	3.5	2.6
03-09 DEC	49	0.39	4.57	0	0	0	0	0	0	23.8	8.3	94.6	46.9	29.2	7.2	1.4	1.9
10-16 DEC	50	0.27	3.92	0	0	0	0	0	0	20.8	9.8	94.3	62	0	5	4.6	3.2
17-23 DEC	51	0.19	3.29	0	0	0	0	0	0	15.4	9.3	94.9	78.4	79.8	2.1	5.6	1.3
24-31 DEC	52	0.11	2.67	0	0	0	0	0	0	12.5	5.9	96.4	79.3	0	1.6	3.4	1.1
01-07 JAN	1	0.08	1.61	0	0	0	0	0	0	20.1	7.5	92	60	11.4	5	2.1	2

SMW=Standard Metrological Week, BSFB=Brinjal shoot and fruit borer, HB= Hadda beetle, LR= Leafroller, Temp.. max. = maximum temperature (ºC), Temp. min. = minimum tempterature (ºC), RH mor. = Relative humidity morning (%), RH eve. = Relative humidity evening (%), WS= Wind velocity (km-h), Evap. (mm) = Evaporation

** Mean peak population

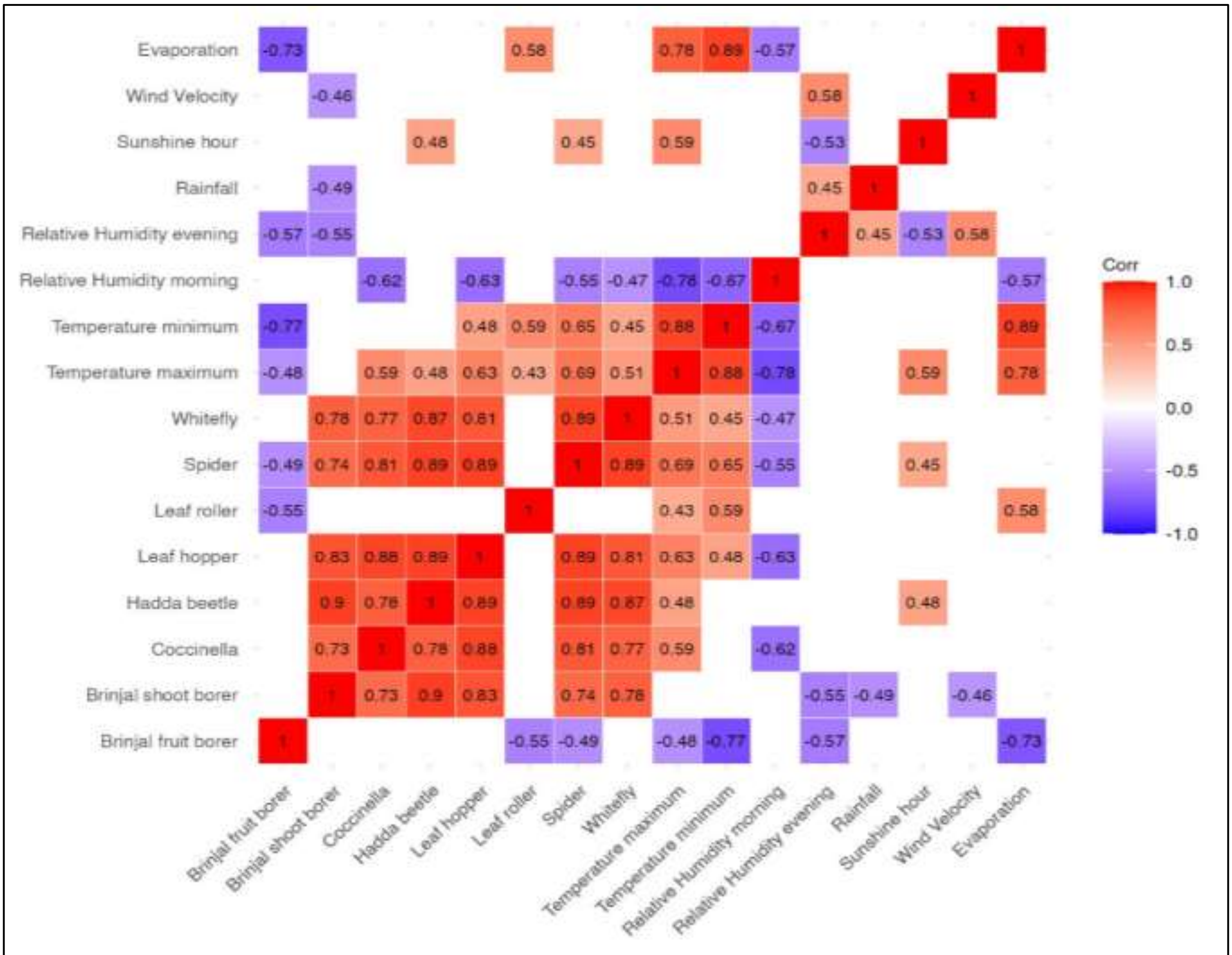

Fig 1: Correlation Matrix Plot between Insects and Different Abiotic Factors during Kharif Season 2019-2020

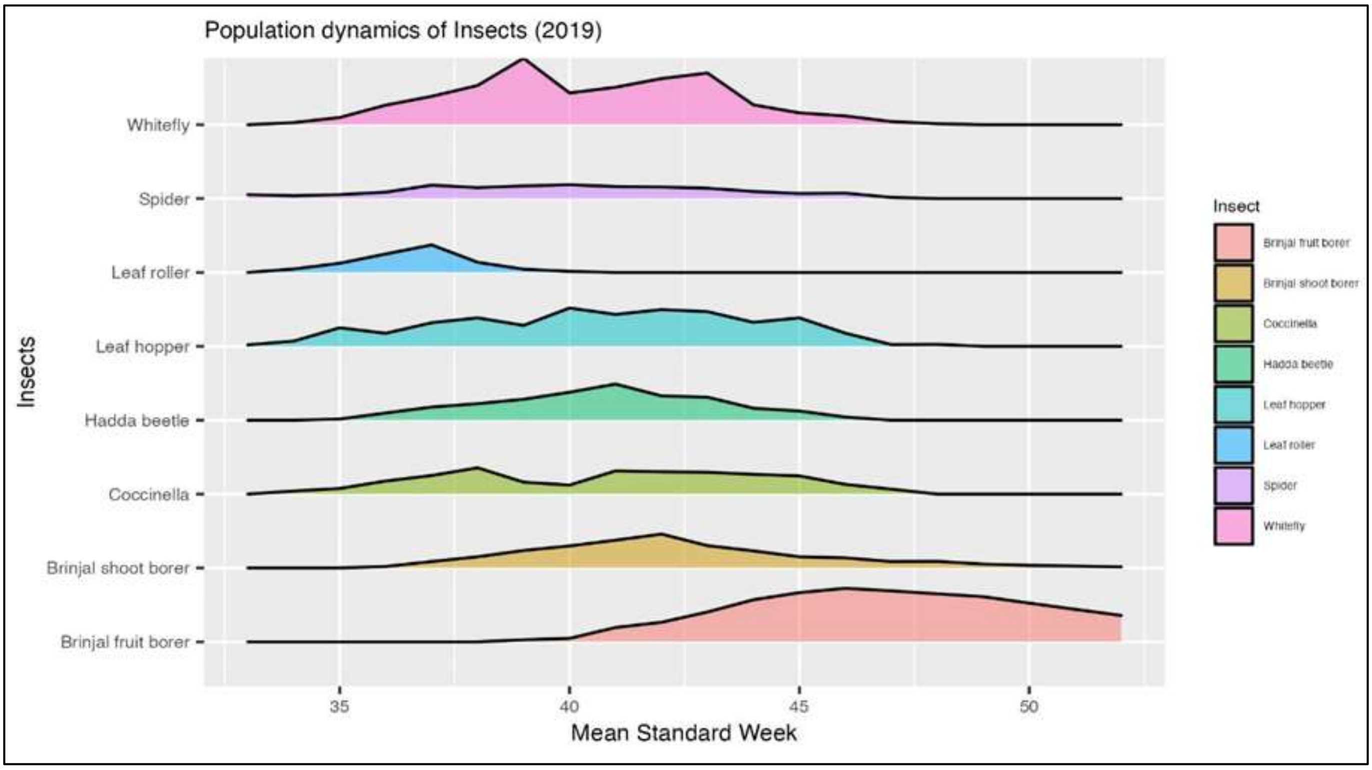

Fig 2: Population Dynamics Graph of Insects and Mean Standard Week During Kharif Season 2019-2020

Similar findings were recorded by Patel *et al*. 2021a [13] in their study of incidence *of B. tabaci* in brinjal crop, which showed that whitefly population initiated during the 38th SMW and the correlation matrix revealed that only RH morning had a positive association with population buildup, while in tomato crop, Patel *et al*. 2021b [14] explained the whitefly initiation and peak during the 38th and 48th SMW, respectively, while only evaporation and maximum humidity showed a positive association with the whitefly population with an explained variance of 78.00%.

Similarly, Kapil *et al.* (2022) [5] found that whitefly and jassid populations reached their peak during the 42nd and 44th SMW, respectively. Abiotic factors such as maximum temperature, morning and evening relative humidity, minimum temperature, sunshine hours, and rainfall had no significant negative correlation with population buildup. Similarly, Kumar and Sharma (2022) [9] noticed jassids and whiteflies as major sucking pests with peak incidence in the 41st SMW. Kumar *et al.* (2018) [10] found that the initial incidence of the BSFB noticed from August to October and continued until February, with the larval population increasing from December to January and peaking in the first week of January.

Similar findings by Kadgonkar *et al.* (2018) [4] observed *Leucinodes orbonalis* Guenee incidence during November–December and peak attained during the 4th SMW (January), with no significant positive correlation with percent shoot and fruit infestation. Kumar *et al.* (2021) [7] recorded peak shoot and fruit infestation during the 43rd and 46th SMW and hadda beetle peak population during the 43rd SMW while whitefly maximum and minimum population noticed during the 40th and 45th SMW, and jassid population attained peak during the 39th SMW.

Additionally, in the case of natural enemies, Sarta *et al.* (2022) [16] reported the maximum population of coccinellids and spiders during the 34th and 36th SMW, respectively. Weather parameters such as maximum temperature, minimum temperature, relative humidity, and rainfall were positive and significant for both species.

Conclusion

The results and discussion from the above study lead to the conclusion that leafhopper, whitefly, hadda beetle, brinjal leafroller, and brinjal shoot and fruit borer were found to be major insect pests of brinjal. Among these insect pests, brinjal shoot and fruit borer persisted throughout the crop stages as destructive pest of brinjal crop. Although different species of coccinellids and spiders are present as prominent natural enemies of insect pests. Insect pestand natural enemies showed different correlations between pest incidence and weather parameters in the brinjal crop in the Tarai region of Pantnagar, Uttarakhand

Acknowledgement

We would like to express our deepest appreciation to Govind Ballabh Pant University of Agriculture and Technology for providing the valuable resources that are required and permission to conduct the experiment.

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