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RESEARCH PAPER

Population dynamics of major insect pests and their natural enemies in brinjal ecosystem

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Abstract: The field experiment was carried out at College of Agriculture, Vijayapura to study population dynamics of major insect pests and their natural enemies in brinjal ecosystem. The present study revealed that peak activity of sucking pest *viz*., aphid (*Aphis gossypii* Glover), leafhoppers (*Amrasca bigutulla bigutulla* Ishida) and white flies (*Bemesia tabaci* Gennadius) was during 9th, 5th and 13th standard meteorological week (SMW) respectively. Per cent shoot damage by *Leucinodes orbonalis* (Guenee) was peak during 3rd SMW (51.72% shoot damage) and minimum incidence (1.26%) was observed during 10th SMW. Per cent fruit damage was maximum during 13th SMW (58.49%) and minimum (16.8%) during 4th SMW. The coccinellid population was substantially associated with the aphid population. During 9th SMW, population was at its peak (3.62 adults/ grub/plant), whereas, least activity of coccinellid was noticed during 13th SMW (0.13 adult/ grub/plant). The correlation studies indicated that, maximum temperature had significant positive correlation with per cent fruit damage, leaf hoppers, aphids and white flies (r= 0.961**, 0.682**, 0.725** and 0.933** respectively) and non-significantly negatively correlated with per cent shoot damage (r=-0.362^{NS}). Morning relative humidity showed significant negative correlation with per cent fruit damage, leaf hoppers, aphids and white flies (r= -0.879**, -0.789**, -0.883** and -0.887**, respectively). Evening relative humidity showed significant negative correlation with per cent fruit damage, leaf hoppers, aphids and white flies (r= -0.845**, -0.940**, -0.922** and -0.921**). The correlation of aphids, leaf hoppers, white flies and per cent shoot damage with sunshine duration was positive and significant (r=0.677**,0.750**, 0.473*and 0.549* respectively). Per cent fruit damage had shown positive and non-significant correlation with sunshine duration (0.338^{NS}). Rainfall showed negative and significant correlation with aphids, leaf hoppers, white flies (r= - 0.500*, -0.565**, -0.461*) and non-significantly negatively correlated with per cent shoot damage and per cent fruit damage (-0.360^{NS} and - 0.340^{NS}).

Key words: Abiotic factors, Aphid, Brinjal, Leaf hopper, Population dynamics, Whitefly

Introduction

Brinjal or egg fruit (*Solanum melongena* L.) (Family: Solanaceae) is a predominant non-tuberous vegetable in various parts of the world. It is originated in India. The genus *Solanum* consists of diverse flowering plants including a few high-value and economically important food crops like brinjal (Anon, 2020).

Brinjal is well known for its high-water content and low calorific value. A brinjal fruit contains 91.5 per cent moisture along with 1.3 per cent protein, 6.5 per cent minerals, 6.4 per cent carbohydrates, 0.02 per cent calcium, 0.06 per cent phosphorus and 1.3 per cent iron. It is also a good source of vitamin A (5 mg/100 g), vitamin B (45 mg/ 100 g), nicotinic acid (0.08 mg/ 100 g), riboflavin (90 mg/ 100 g) and vitamin C (23 mg/ 100 g) (Wankhede, 2009).

Globally brinjal is cultivated in an area of 1.8 million ha with the production of 55.1 million tonnes and with productivity of 29.87 tonnes per ha, whereas in India brinjal is being cultivated through out the year in an area of about 749 thousand ha with the production of 12874 thousand million tonnes and productivity is about 17.44 tonnes per ha (Anon, 2019a). The major brinjal growing states in India are Maharashtra, Madhya Pradesh, Bihar, Punjab and Tamil Nadu. In Karnataka, brinjal is grown in an area of 11.29 ha with the production of 300.52 thousand million tonnes and with the productivity of 25 t/ ha. In Vijayapur, brinjal is cultivated in an area of 695 ha with production of 17,375 million tonnes with productivity of 25 t/ ha (Anon, 2019b).

The first attack of pests on the crop appeared during 1st week after transplantation and continued till crop harvested. Pests which were found attacking on the crop were jassids (*Amrasca biguttula biguttula,* Ishida), aphids (*Aphis gossypii,* Glover), white fly (*Bemisia tabaci,* Gennadius), Leaf roller (*Eublemma olivacae* Walker), Shoot and fruit borer (*Leucinodes orbonalis,* Guenee), Epilachna beetle (*Epilachna vigintioctopunctata,* Fabricius), Leaf webber (*Psara bipunctalis,* Fabricius) and Grass hopper (*Chrotogonus spp*). Among them, brinjal shoot and fruit borer (*L.* orbonalis) was recorded as major pest. Jassids (*A. biguttula biguttula*), aphid (*A. gossypii*) and epilachna beetle (*E. viginitioctopunctata*) were found to damage the crop moderately. Other insect pests recorded on the crop were of less importance and extent of damage caused by them was found without much economic loss (Soren *et al.,* 2020).

Information on seasonal incidence of the insect pests in brinjal ecosystem and their management, particularly in this agro-climatic situation is meagre. As the meteorological parameters play a vital role in the biology of any pest, the interaction study between pest activity and abiotic factors will help in developing predictive models that aids in forecast of pest incidence. Any pest management programme will require the use of monitoring practices to be effective. It is therefore, imperative to study the population fluctuation of the crop pest in relation to weather parameters that largely direct the activity of a given species of insect pest.

Material and methods

The studies on "population dynamics of major insect pests and their natural enemies in brinjal ecosystem" were carried out during 2021-22 on brinjal hybrid 'Super Mahyco - 10' at College of Agriculture, Vijaypura, Karnataka, India. The plot size was 46.08 m^2 with 120 cm x 60 cm spacing. Randomly ten selected plants forming representative samples were tagged and observation on population of following insect pests of brinjal were recorded at weekly interval right from transplanting till harvest of crop by adopting Standard operational procedures. The extent of damage caused by various insect pests was recorded to assess the economic status of the pests. Observations were also recorded on natural enemies at weekly interval from 10 randomly selected plants. Weekly data on different abiotic parameters were also recorded. Data so obtained were then subjected to statistical analysis for correlation and test of significance.

Observations recorded

1. **White fly –** Number of Adults and Nymphs per three leaves (Each from top, middle and bottom of the plant)
2. **Hoppers** - Number of Adults and Nymphs per three leaves (Each from top, middle and bottom of the plant)
3. **Aphids -** Number of Adults and Nymphs per three leaves (Each from top, middle and bottom of the plant)
4. **Fruit and shoot borer** – Percentage shoot and fruit damage
5. **Natural enemies -** Adults and grubs of predators were enumerated and expressed as a mean number per plant from ten randomly selected plants.

Results and discussion

The data regarding the population dynamics of major insect pests on brinjal and their correlation with weather parameters is presented in table 1 and 2, respectively.

Aphids (*Aphis gossypii*) Glover

Aphid activity reached its peak (26.76 aphids/3leaves/plant) during 9th SMW. During the 46th SMW, the aphid population was lowest (0.93 aphids/3leaves/plant) (Table 1).

Excess rainfall washes off the aphids but there was no rainfall recorded during 9th SMW week and at 90 per cent relative humidity aphids die but the morning relative humidity was 53 per cent and evening humidity was 17 per cent which was below lethal zone. These factors may be attributed to the multiplication of aphids on brinjal.

The present results are in line with Mari *et al*. (2013) who reported that, population of aphid started during November at 44th SMW (0.32aphids/plant) and population was maximum during 5th SMW (8.9/aphids/plant). Sharma *et al*. (2022) observed the occurrence of *Aphis gossypii* population during the 46th SMW (the second week of November) with an average of 0.92 aphids/plant during *Rabi* 2021-22.

The data presented in (Table 2) showed that there was positive and significant association with maximum temperature (r= 0.725**) and positive but non-significant association with minimum temperature (r= 0.039^{NS}). The relationship of aphid population with both morning relative humidity (r= -0.883**) and with evening relative humidity (r= -0.922**)$^{.}$ was negative and significant. The association of sunshine duration with aphid population was positive and significant (r= 0.677**) whereas, the relationship with the rainfall was negative and significant (r= -0.500*) (Table 2).

The current findings concur with Mohapatra (2008) who reported that among the weather variables, temperature had a positive relation with *A. gossypii* population, while the effects of the rainfall were negative. Borah and Saikia (2017) revealed that, the population of aphids had shown significantly positive correlation with the maximum and minimum temperature and a statistically significant negative correlation with the average relative humidity.

Leafhoppers (*Amrasca biguttula biguttula)* Ishida

The incidence of leaf hopper population was started during 46th SMW with the mean population of (0.85 leaf hoppers / 3leaves/plant) and lasted with mean population of 15.59 leaf hoppers/ 3 leaves/plant during 13th SMW. The pest population reached maximum during 5th SMW (16.76 leaf hoppers/ 3 leaves/ plant) and it was lowest during 46th SMW (0.85 leaf hoppers/3 leaves/plant) (Table 1).

Singh *et al*. (2011) opinioned that leaf hopper incidence started in the second week after transplanting and there were 1.2 leaf hoppers per plant. Sheojat *et al*. (2022) noted that, population of *Amrasca biguttula bigutulla* was initially noted in the range of 0.11/3 leaves during second week of November (46th SMW) and reached peak during 2nd SMW (4.46/plant).

The leaf hopper population and maximum temperature were found to have positive and significant (r= 0.682**) association and it was found to have negative and non-significant with minimum temperature (r= -0.098^{NS}). The association of pest population was negative and significant with morning relative humidity (r= -0.789**), evening relative humidity (r= -0.940**) and rainfall (-0.565**). The association of pest population with sunshine duration was positive and significant (r =0.750**) (Table 2).

The peak population attained during the 5th SMW at the prevailing maximum temperature of 31.33°C, minimum temperature of 12.24°C, maximum relative humidity of 70.86 per cent, minimum relative humidity of 25.71 per cent, sunshine hours of 9.93 hours and rainfall of 0.00 mm. Absence of rainfall and temperature range coinciding with the optimum temperature threshold levels for insects development which is 10-35°C might have contributed to the attainment of high population of leafhoppers during 5th SMW.

The present findings are similar with Shaikh and Patel (2013) who reported that leaf hoppers were significantly negatively correlated with mean relative humidity, rainfall and minimum temperature. Devi *et al*. (2015) reported a significant positive association between leaf hopper population and maximum and minimum temperatures.

White fly *Bemesia tabaci* (Gennadius) (Hemiptera: Aleyrodidae)

The white fly population on brinjal crop was observed from one week after transplanting (48^{th} SMW) to final harvest of the crop (13^{th} SMW), with a mean population ranging between 0.64 and 27.37 white flies/3 leaves/plant. During fruiting and maturity phase of brinjal, the maximal activity of pest was found during 13^{th} SMW (27.37 white flies/3 leaves/plant). 48^{th} SMW recorded lowest population of white flies (0.64 white flies/3leaves/plant) (Table 1).

Moderate relative humidity (57.03%) coupled with temperature or sudden raise of temperature (38.61°C) following rainfall (0.40mm), biochemical changes in the plant, presence of suitable host, absence of natural enemies in the area may be the reason for the multiplication of white fly.

Present findings are similar to Muthukumar and Kalyanasundarm (2003) who revealed that, population of *B. tabaci* was observed one week after transplanting at 47^{th} SMW and persisted throughout the season and peak incidence was observed at 15^{th} SMW. According to Chaukikar *et al*. (2020), the first incidence white fly was observed during 45^{th} SMW and continued until harvest of the crop at 15^{th} SMW.

White fly population was positive and significant relation with maximum temperature (r= 0.933**) and it was found to be positive and non-significant with minimum temperature (r= 0.336^{NS}). The relation between morning relative humidity (r= -0.887**) and evening relative humidity (r= -0.921**) was negative and significant. The association between white fly population with sunshine duration was positive and significant (r= 0.473*). The relation of pest population with rainfall was negative and significant (r= -0.461^{*}) (Table 2).

The present findings are in conformity with the results of Devi *et al.* (2015) who reported positive correlation with maximum and minimum temperatures and sunshine hours. Ajabe *et al.* (2019) reported that, population of white fly was negatively correlated with rainfall, evening relative humidity and positively correlated with maximum and minimum temperatures.

Per cent shoot damage

Data on the occurrence of *L. orbonalis* was recorded four weeks after transplanting with a mean shoot infestation of (5.36%) during 50^{th} SMW and continued up to 10^{th} SMW with a mean per cent shoot infestation of (1.26%). Maximum shoot damage was observed during 3^{rd} SMW (51.72%). Minimum incidence of shoot damage observed during 10^{th} SMW (1.26%) (Table 1).

Present findings are in line with Kumar *et al*. (2019) who observed that infestation of *L. orbonalis* started one month after transplanting (2.73% shoot damage) and continued until the fruit harvest with 25.23 per cent fruit damage. Sheojat *et al*. (2022) reported that *L. orbonalis* occurred for the first time in the December second week (49^{th} SMW) causing 2.33 per cent shoot damage and began growing rapidly in the 50^{th} SMW and it peaked 20.66 per cent in the 2^{nd} SMW.

Shoot damage had negative and non- significant correlation with maximum temperature (r= -0.362^{NS}) and with minimum temperature it was negative and significant (r= -0.759**). Per cent shoot damage with morning relative humidity was positive and non-significant (r= 0.169^{NS}), whereas, it was found to be negative and non-significant with evening relative humidity (r= -0.118^{NS}). The relationship of per cent shoot damage with sunshine duration was positive and significant (r= 0.549*) and it was negative and non-significant with rainfall (r= -0.360^{NS}) (Table 2).

Table 1. Population dynamics of major insect pests and their natural enemies on brinjal during 2021-22

Month	SMW	Stage of the crop	No. of aphids/3 leaves/plant	No. of leafhoppers/3 leaves/plant	No. of white flies/3 leaves/plant	Per cent shoot damage	Per cent fruit damage	No of coccinellids /plant
	46	Vegetative stage	0.93	0.85	0.00	0.00	0.00	0.39
	47	Vegetative stage	1.23	1.19	0.00	0.00	0.00	0.48
	48	Vegetative stage	1.73	1.86	0.64	0.00	0.00	0.51
December	49	Vegetative stage	2.56	4.00	1.04	0.00	0.00	0.59
	50	Vegetative stage	3.28	4.71	2.08	5.36	0.00	0.78
	51	Reproductive stage	4.79	6.90	3.03	13.00	0.00	0.72
	52	Reproductive stage	6.12	8.41	5.07	25.00	0.00	1.10
January	1	Reproductive stage	9.58	9.55	7.15	32.00	0.00	1.32
	2	Reproductive stage	11.42	11.35	8.22	41.00	0.00	1.56
	3	Fruiting stage	13.04	13.30	9.61	51.72	0.00	1.82
	4	Fruiting stage	15.52	15.31	11.23	40.00	16.82	1.94
	5	Fruiting stage	16.68	16.76	13.13	35.68	25.00	2.59
February	6	Fruiting stage	18.33	16.64	14.57	30.36	28.00	2.82
	7	Fruiting stage	20.64	16.52	16.62	20.00	31.04	2.91
	8	Fruiting stage	23.24	16.37	18.02	14.80	35.00	3.15
	9	Fruiting stage	26.76	16.35	20.02	5.13	39.36	3.62
March	10	Fruiting stage	24.19	16.29	22.53	1.26	42.00	3.36
	11	Fruiting stage	21.82	16.20	23.77	0.00	45.94	2.67
	12	Fruiting stage	18.63	16.16	25.16	0.00	52.64	1.83
	13	Fruiting stage	15.74	15.59	27.37	0.00	58.49	0.13

Table 2. Correlation coefficient (r) of major insect pests on brinjal with prevailing weather parameters

Weather parameters	Correlation coefficient ('r' value)				
	Aphids	Leaf hoppers	White flies	Per cent shoot damage	Per cent fruit damage
Maximum temperature (^{0}C)	0.725**	0.682**	0.933**	-0.362NS	0.961**
Minimum temperature (^{0}C)	0.039NS	-0.098NS	0.336NS	-0.759**	0.481*
Morning relative humidity (%)	-0.883**	-0.789**	-0.887**	0.169NS	-0.879**
Evening relative humidity (%)	-0.922**	-0.940**	-0.921**	-0.118NS	-0.845**
Bright sunshine (hrs)	0.677**	0.750**	0.473*	0.549*	0.338NS
Rainfall	-0.500*	-0.565**	-0.461*	-0.360NS	-0.340NS

Aphids : *Aphis gossypii* (Glover) leaf hoppers : *Amrasca biguttulla biguttulla* (Ishida) white flies *Bemesia tabaci* (Gennadius) Percent shoot and fruit damage : *Leucinodes orbonalis* (Guenee)

Table 3. Correlation between *Cheilomenes sexmaculta* (Fabricius) and *Aphis gossypii* (Glover)

Natural enemy(Y)	Correlation coefficient (r) Aphid population (X)	Coefficient of determination(R^2)	Regression Equation
Coccinellids	0.88**	77.6%	Y= 2.327+ 4.04 X_1 + 3.143

X: Aphid population Y: Coccinellid population

Present findings are in accordance with the Kumar *et al.* (2019) who determined that the correlation was negative and non-significant with maximum temperature whereas, it was found to be negative and significant with minimum temperature. Ranjith *et al.* (2020) found that, the population was active throughout the cropping period showing a significantly negative effect with evening relative humidity and minimum temperature.

Per cent fruit damage

Incidence of *Lorbonalis* on fruits was noticed from 4th SMW (tenth week after transplanting) and continued up to 13th SMW (last week of March) and mean per cent fruit damage ranged from 16.82 to 58.49 per cent. Damage was maximum during 13th SMW (58.49%) and it was minimum during 4th SMW (16.82%) (Table 1).

It was observed that, initial infestations were on shoots and later shifted to fruits when the plants started bearing fruits.

Shrivastava (2016) recorded 1st fruit damage on the crop at 100 DAT (13.95%) at 9th SMW. Jaiswal *et al.* (2018) observed shoot and fruit borer incidence at 76 DAT (at 4th SMW) with the peak population during fruiting stage (43.24% fruit damage) during 13th SMW. Similarly, Chaukikar *et al.* (2020) observed that, first incidence of shoot and fruit borer at 55DAT (52nd SMW) (2.64%) and its population reached high during (13th SMW) (50.45%).

Per cent fruit damage has positive and significant correlation with maximum temperature (r= 0.961**) and minimum temperature (0.481*). The relation between per cent fruit damage and morning relative humidity was negative and significant (r= -0.879**) and it was also found to be negative and significant with evening relative humidity (r= -0.845**) and had positive and non significant with bright sunshine (0.338NS) and negative and non significant effect with rainfall (-0.340 NS)(Table 2).

Similar findings were reported by Sharma and Tayde (2017) revealed that, *L orbonalis* incidence showed significant positive correlation with maximum and minimum temperature. According to shigwan *et al.* (2022) who reported maximum temperature, minimum temperature and evening relative humidity showed positive correlations with the percentage of fruit damage, while the morning humidity showed a negative correlation. The minimum temperature showed a substantial positive correlation with the percentage of fruits that were infested with shoot and fruit borer.

Table 4. Correlation of major insect pests of brinjal with weather parametres

(Y) pests	Correlation co-efficient (r) Meteorological parameters						Co-efficient of determination(R^2)	Regression equation
	X1 (0C)	X2 (0C)	X3 (%) (%)	X4 (%)	X5 (hrs)	X6 (mm)		
Aphids	0.725**	0.039NS	-0.883**	-0.922**	0.677**	-0.500*	89	Y=100.26-2.81X1+1.91X2-0.10X3-0.81X4+0.96X5-0.01X6
Leaf hoppers	0.682**	-0.098NS	-0.789**	-0.940**	0.750**	-0.565**	90	Y=50.94-1.11X1+0.61X2+0.07X3-0.60X4+0.22X5- 0.00X6
White fly	0.933**	0.336NS	-0.887**	-0.921**	0.473*	-0.461*	97	Y=24.10-0.04X1+0.85X2-0.00X3-0.59X4-0.39X5-0.09X6
Percent shoot damage	-0.362NS	-0.759**	0.169NS	-0.118NS	0.549*	-0.360NS	68	Y=146.07-6.04X1+1.64X2+0.86X3-1.53X4+3.04X5-0.15X6
Percent fruit damage	0.961**	0.481*	-0.879**	-0.845**	0.338NS	-0.340NS	95	Y= -13.53+1.70X1+1.67X2-0.22X3-0.75X4-0.50X5-0.04X6

Lady bird beetle, *Cheilomenes sexmaculatus* (Fabricius) (Coleoptera: Coccinellidae)

The coccinellid population was substantially associated with the aphid population, Coccinellid activity was noticed during the 46th SMW (0.39 adult /grub/plant) and persisted until the 13th SMW (0.13 adult / grub/plant). During 9th SMW, there was a peak in activity of coccinellids (3.62 adults/ grub/ plant). Least activity of the predator was noticed during 13th SMW (0.13 adult/ grub/plant) (Table 1).

Interaction between *Aphis gossypii* (Glover) and *Cheilomenes sexmaculata* (Fabricius)

The interaction between aphids and coccinellids was found to be very strong. The coefficient of correlation between the aphids and their predator coccinellid was found to be positive and significant (r=0.88**) indicating that, a rise in aphid population was the cause for the increased predator population. The regression equation $Y = 2.327 + 4.04 X_1 + 3.143$ and coefficient of determination (R^2=0.776) showed that prey population influences the predator by 77.6 per cent (Table 3).

The peak activity of lady bird beetle during 9th SMW may be attributed due to high population of aphid during the same meteriological week and coccinellids by predating on aphids increased their population.

The present findings are in accordance with the findings of Chaukikar *et al*. (2020) who observed the first occurrence of *Cheilomenes sexmaculatus* during 44th SMW and up to harvest stage of the crop at 15th SMW. Jiaswal *et al.* (2020) observed the incidence of lady bird beetle during 52nd SMW and its population reached peak during 9th SMW and continued until the 30th march 12 SMW.

Conclusion

Maximum incidence of sucking pests was recorded during 9th, 5th and 13th SMW for aphids, leafhoppers and white fly, respectively. In case of shoot and fruit borer, highest per cent shoot damage was observed during 3rd SMW and highest per cent fruit damage was observed during 13th SMW. Climatic conditions had influenced the seasonal incidence of aphids to the tune of 90.00 per cent, leaf hoppers to 90.00 per cent, white flies to the tune of 97.00 per cent, per cent shoot damage to the tune of 68.00 per cent and per cent fruit damage to the tune of 95.90 per cent. Absence of rainfall and the optimum temperature range of10-35°c might have contributed to the attainment of high population of sucking pests by rapid multiplication. It was observed that, in case of shoot and fruit damage by *L. orbonalis,* initial infestations were on shoots and later infestation shifted to fruits when the plants started bearing fruits. This will help us in scheduling pests management strategies in brinjal crop.

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