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Studies on the succession and incidence of major insect pests of Brinjal, *Solanum melongena* Linnaeus in Gwalior (M.P.)

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Abstract
The present investigation was carried out at the entomological field of College of Agriculture, Gwalior, M.P. during *rabi* 2019. The results revealed that about six species of insect pests were observed at different phases of the brinjal crop starting from germination to maturity. Jassid (*Amrasca biguttula biguttula* Ishida), aphids (*Aphis gossypii* Glover), whitefly (*Bemisia tabaci* Gennadius), mealy bug (*Coccidohystrix insolita* Green), shoot and fruit borer (*Leucinodes orbonalis* Guenee), and grasshoppers, (*Melanoplus differentialis* Thomas) were observed to infest the crop. Brinjal shoot and fruit borer (*L. orbonalis*) was identified as an important pest among them. *A. biguttula biguttula* population started increasing from 47th SMW and reached its peak (4.46 jassid / 5 plant / plot) during 2nd SMW. The population then decreases after 47th SMW and stays up to the harvest of the crop. *B. tabaci* population started increasing sharply from 49th SMW and reached its peak (3.56 whitefly / 5 plant/ plot) during 1st SMW. The population then decline sharply up to 10th SMW (0.00 whitefly) and disappeared afterward. *L. orbonalis* population started out increasing sharply from 50th SMW and reached its peak (20.66%) during 2nd SMW. Population then declines during 3rd SMW and was available up to 17th SMW. Correlation studies revealed that the population of all the three insect pests *viz., A. biguttula biguttula*, *B. tabaci* and *L. orbonalis* exhibited significantly positively correlation with evening relative humidity and maximum temperature and minimum temperature showed significantly negative correlation.

Keywords: Brinjal, *Amrasca biguttula biguttula* Ishida, *Bemisia tabaci* Gennadius, *Leucinodes orbonalis* Guenee, weather parameters, correlation

Introduction
Brinjal (*Solanum melongena* Linnaeus) belongs to the family "Solanaceae" and is designated as the "King of vegetables". Brinjal occupies a distinct place in the realm of vegetable crops. It is a bushy plant that is also referred to as egg plant. In India and many other countries throughout the world, it is one of the most well-liked and significant vegetable crops. It is indigenous to the Indian subcontinent, with India likely serving as its likely origin (Gleddie *et al*., 1986) [10]. After China, India is second in terms of area (730,4000 ha), production (12800.8 metric tonnes), and productivity (17.5 metric tons/ha). Bihar, Orissa, Karnataka, Andhra Pradesh, Maharashtra, West Bengal, and Uttar Pradesh are the major states in India where brinjal is grown. It is grown on 7.1 lakh ha in India, with a yield of 19.1 MT/ha and a production of 135.58 lakh MT. Among the states that cultivate brinjal, Bihar produces the most, with a net sown area of 57,500 ha with the production of 12.40 lakh MT, and 21.6 MT/ha productivity. It is cultivated in Madhya Pradesh over an area of 51,35 thousand hectares, yielding 1073.63 metric tonnes (Anonymous 2018) [2].

Despite being extensively cultivated all year long, brinjal endures severe damage from several insect pests, which significantly reduces its production. In various parts of the world, brinjal is attacked by 142 species of insect pests, four species of mites, and three species of nematodes (Prempong and Bauhim, 1977 Sohi, 1996, Butani and Verma, 1976 Nayar *et al*., 1976) [20, 27, 5, 17]. Numerous pests are prevalent in the brinjal crop from the seedling to the harvesting stage, and the damage they do varies from season to season according on environmental circumstances (Gangwar and Sachin, 1981) [8]. The brinjal crop is infested by 26 insect pest species and a few non-insect pest species. Among all the pest species, major insect species includes, Jassid (*Amrasca biguttula biguttula* Ishida), aphids (*Aphis gossypii* Glover), whitefly (*Bemisia tabaci* Gennadius), shoot and fruit borer (*Leucinodes orbonalis* Guenee), Epilachna beetle (*Epilachna vigintioctopunctata* Fabricius), epilachna beetle, *Henosepilachna*

vigintioctopunctata (Fabricius), mealy bug, *Coccidohystrix insolita* (Green), lace wing bug, *Urentiushystricellus* (Richter) and grasshoppers and non-insect pest, red spider mite, *Tetranichus macfurlanei* (Andre) cause severe damage, necessitating initiation of control measures quite frequently (Vevai, 1970) [29].

About 70–92% less brinjal is produced when leafhopper, whitefly, and shoot and fruit borer infestations are present (Rosaiah, 2001) [23]. Shoot and fruit borer alone resulted in a production loss of 63%, according to Dhankar *et al.* (1997) [6]. The economic damage threshold in India, according to Alam *et al.* (2003) [1], corresponds to a shoot and fruit infestation of 6%. According to Regupathy *et al.* (1997) [22], the caterpillar may be a global pest that causes a yield loss of 80–90%. Because abiotic factors affect insect distribution and abundance, climatic variables are crucial to understanding the biology of all pests. The most significant abiotic factor affecting the growth and development of insect is temperature, which is particularly essential when controlling insects as pests requires precise timing. However, temperature, relative humidity, precipitation, wind speed, and wind direction are the main meteorological factors that primarily control the activity of a particular insect species. Abiotic variables and pest activity combine to provide predictive models that assist anticipate the occurrence of pests. Research on the succession and occurrence of the major insect pests of Brinjal, *Solanum melongena* Linnaeus, in Gwalior (M.P.) was undertaken keeping all of these factors in mind.

Material and Methods

A field experiment was conducted at the entomological field of the College of Agriculture, Gwalior during *rabi* 2019. Thirty days old healthy seedlings of the *Deshi* variety of brinjal were transplanted in the main field of size 9.0 m x 9.0 m with 60 cm spacing between the rows and 60 cm between plants. The standard agronomic package of practices was followed to raise and maintain a healthy crop. Observations on different insect pests were recorded from randomly selected 5 plant/plot of twice in a standard week. It was initiated after germination and continued till up to the availability of insects or maturity of the crop. For the observations of sucking pests, a total of six leaves, two leaves each from upper, middle and lower canopy of the plant were carefully examined for the presence of total nymph and adults of jassid (*Amrasca biguttula biguttula)*, aphid (*Aphis gossypii*), whitefly (*Bemesia tabaci*). For observations on per cent fruits infestation by shoot and fruit borer, the fruits were harvested at fruiting stages and weight of the total number of fruits and weight of infested fruits per plant were counted separately and per cent, of fruit infestation (by weight) was calculated by using the following formula-

$$\text{Percentage fruit infestation (by weight)} = \frac{\text{Weight of infested fruits}}{\text{Weight of the total number of fruits}} \times 100$$

The data on the jassid and whitefly population and percent shoot and fruit infestation due to *L. orbonalis* were correlated with meteorological parameters like temperature, relative humidity, rainfall during the experimental period. The meteorological data were obtained from Meteorological Observatory, Department of Agronomy, College of Agriculture, Gwalior.

Results and Discussion

1. Succession of major insect pests of brinjal during the *rabi* 2019.

The results revealed that about six species of insect pests were observed to be associated with the different phases of the brinjal crop from germination to maturity (Table 1) at Gwalior, Madhya Pradesh during the *rabi* 2019. Jassid (*Amrasca biguttula biguttula* Ishida) (Hemiptera: Cicadellidae), aphids (*Aphis gossypii* Glover) (Hemiptera: Aphididae), whitefly (*Bemisia tabaci* Gennadius) (Hemiptera: Aphididae), mealy bug (*Coccidohystrix insolita* Green) (Hemiptera: Pseudococcidae), shoot and fruit borer (*Leucinodes orbonalis* Guenee) (Hemiptera: Pyralidae), and grasshoppers, (*Melanoplus differentialis* Thomas) (Acrididae: Orthoptera) were detected attacking the crop. Brinjal shoot and fruit borer (*L. orbonalis*) was identified as an important pest among them. The present findings are in a conformation with that of Borkakati *et al*. (2019) [4] they reported total of six species in brinjal crop where brinjal shoot and fruit borer, aphid and leaf hopper as the most dominating species of the pest. Similarly, with Soren *et al.* (2020) [28], Jaiswal *et al.* (2018) [11] and Gangwar and Singh (2014) [9] they reported at various phases of the brinjal crop's lifecycle, eight bug species were identified.

In a general view, *A. biguttula biguttula* known as cotton jassid, is a polyphagous pest. Both the nymphs and adults of this pest were found to suck the sap from the undersides of the leaves and growing tips of the plant. The commonness of this pest was observed period from November to April when the crop was about 14 days old *i.e.*, begin with week after transplanting and proceeded to build up all through the crop development. The peak of the population was observed during the second week of January. In accordance with Borkakati *et al*. (2019) [4] reported jassid were dominant and considered as major insect pests of brinjal. In line with Soren *et al.* (2020) [28] and Gangwar and Singh (2014) [9] they reported population appeared in the first week after transplanting and its population continued building up throughout the crop growth.

A. gossypii is a polyphagous and one of the significant pests of the brinjal crop having a wide host range. The brinjal plant infested by *A. gossypii* became pale, weak, and stunted in growth resulting in reduced fruit size. Aphids were first observed when the crop was about 20 days old (after transplanting). The peak of the population was observed during 35 DAT. Aphid infestation was reduced from February to the last week of March and the populace was high during the first week of January. Borkakati *et al*. (2019) [4] reported aphid were dominant and considered as major insect pests of brinjal. In line with Kumar *et al.* (2019) [14], Kadam *et al.* (2006) and Elanchezhyan *et al.* (2008) [7] another major pest of brinjal was *Aphis gossypii*, according to reports.

B. tabaci nymph and small fly are mostly seen in a group on the underside of the leaves and suck the cell sap. The appearance of this pest was to begin when the crop was aged about 28 DAT. The maximum population was recorded from the first week of January. In agreement with Saha *et al.* (2020) reported peak population of white flies recorded from 10 week old crop. According to Gangwar and Singh (2014) [9], white fly as an important pest of brinjal. Patial and Mehta (2008) [19] reported white fly as a moderate pest.

C. insolita was recorded on the crop with its first appearance at 120 DAT and after that, it remained active until the week of March. According Jaiswal *et al.* (2018) [11] Mealybug was recorded on the crop with its first incidence on 125th DAT.

M. differentialis was also found as a minor pest of brinjal. This insect's nymphs and adults eat the leaves by poking holes in it. This bug was found between the months of October to April. Soren *et al*. (2020) [28] and Gangwar and Singh (2014) [9] found grasshopper as minor pest of brinjal during season.

L. orbonalis is the predominant pest inflicting intense damage to the brinjal fruits. The presence of borer was first seen on the crop when it was 35 days old after transplanting, i.e., when it was in the vegetative stage, and it remained active until the last week of April. The maximum (20.65%) fruit infestation was recorded at 70 DAT. Borkakati *et al*. (2021) [3] reported *L. orbonalis* was appeared in the brinjal field during both vegetative and reproductive stage of the crop. According to Nirmali and Saikia (2017) [18] *L. orbonalis* was major pest of brinjal. Nasif and Siddiquee (2020) [16] reported the predominant pest, the brinjal shoot and fruit borer, is responsible for a substantial drop in economic production.

Table 1: Succession of insect pests of brinjal crop during *rabi* 2019

S. No.	Common name	Scientific name	Order	Family	Crop age (DAT)	Period of activity	Crop stage
1	Jassid	*Amrasca biguttula biguttula* Ishida	Hemiptera	Cicadellidae	14	15th November to last April	VS
2	Aphid	*Aphis gossypii* Glover	Hemiptera	Aphididae	20	23rdth November to mid of March	VS
3	Whitefly	*Bemisia tabaci* Gennadius	Hemiptera	Aleyrodidae	28	30th November to first of March	VS
4	Mealybug	*Coccidohystrix insolita* Green	Hemiptera	Pseudococcidae	120	first of March to last of April	FSS
5	Shoot and fruit borer	*Leucinodes orbonalis* Guenee	Lepidoptera	Pyralidae	35	5th December to first of may	VS/ FSS
6	Grasshopper	*Melanoplus differentialis* Thomas	Orthoptera	Acrididae	10	14th November to last of April	VS

VS= Vegetative stage; FSS= Fruit Setting Stage; DAT= Day after Transplanting

2. Population dynamics of major insect pests of brinjal during the *rabi* 2019.

(A) Jassid, *Amrasca biguttula biguttula* Ishida

The first emergence of *A. biguttula biguttula* was recorded on 15th November (0.11 jassid) during the second week after transplanting in the 46th standard week (SMW) (*i.e.*, 12th to 7th November) and thereafter observations were recorded frequently twice per SMW. The number of *A. biguttula biguttula* (nymph + adult) was worked out as a weekly average of 5 plants/ plot and displayed in (Table 2, Fig. 1). *A. biguttula biguttula* population started increasing from 47th SMW (*i.e.*, 8th to 14th October) and reached its peak (4.46 jassid / 5 plant / plot) during 2nd SMW (*i.e.*, 8th to 14th January). During this, maximum and minimum temperatures have been 28.5 °C and 11.4 °C respectively, while, morning and evening relative humidity was 93.3 and 41.7 percent respectively. Further, no rainfall became recorded during this period. The population then decreases after 47th SMW and stays up to the harvest of the crop. The correlation coefficients between *A. biguttula biguttula* with evening relative humidity exhibited a significant positive correlation (r= 0.46) and maximum and minimum temperature showed significant negative correlation (r= -0.53 and -0.57, respectively) with the *A. biguttula biguttula* population (Table 3). The present findings are in line with the findings of Chakravarthy and Raju (2008) reported incidence of jassid recorded 1.0/ 3 leaves/ plant and peak was 16.20 during 49-52 SMW. Singh *et al.* (2013) [26] incidence of jassid commenced from 2nd week after sowing with an average population level of 1.2 jassid/plant where correlation with maximum, minimum temperature and maximum and minimum relative humidity showed negative correlation whereas positive correlation with rainfall.

(B) Whitefly, *Bemisia tabaci* Gennadius

The first emergence of *B. tabaci* was recorded on 30th November during the 48th standard week (SMW) (*i.e.*, 26th November to 2nd December) (0.51 whitefly, 5 plants/ plot), and thereafter observations were recorded frequently twice per SMW. The population of *B. tabaci* were worked out at weekly (SMW) intervals and data of average (5 plants/ plot) is displayed in (Table 2, Fig. 1). *B. tabaci* population started increasing sharply from 49th SMW (*i.e.*, 3rd to 9th December) and reached its peak (3.56 whitefly / 5 plant/ plot) during 1st SMW (*i.e.*, 1st to 7th January). The maximum and minimum temperatures throughout that time period were 21.7 °C and 6.6 °C, respectively, having 96.3 and 59.0 percent relative humidity in the morning and evening. However, no rainfall was recorded during this period. The population then decline sharply up to 10th SMW (5th to 11th March) (0.00 whitefly) and disappeared afterward. The correlation coefficients between *B. tabaci* with evening relative humidity showed a significant positive effect (r= 0.72) whereas, maximum and minimum temperature exhibited significant negative correlation (r= -0.78 and -0.76, respectively) (Table 3). The present studies are in confirmation with Kumar *et al*. (2016) [13] White fly (*Bemisia tabaci*) occurrence was highest in January (2nd SMW) and lowest in March, with a significant negative correlation with maximum and minimum temperatures and a positive correlation with average relative humidity and total rainfall.

(C) Brinjal Shoot and Fruit Borer, *Leucinodes orbonalis* (Guenee)

The first appearance of *L. orbonalis* was recorded on 5th December in the 49th SMW (*i.e.*, 3rd to 9th December) (2.33% damage). The fruit infestation was recorded at weekly (SMW) intervals and observations on per cent fruit damage are depicted in Table 2, Fig. 1. *L. orbonalis* population started out increasing sharply from 50th SMW (*i.e.*, 10th to 16th December) and reached its peak (20.66%) during 2nd SMW (*i.e.*, 8th to 14th January). The maximum and minimum temperatures throughout that time period were 20.4 °C and 5.60 °C, respectively; having 31.3 and 72.6 percentage relative humidity in the morning and evening. Further, 11.2 mm rainfall was recorded in the course of this period.

Population then decline during 3rd SMW (*i.e.*, 15th to 21st January) and was available up to 17th SMW (*i.e.*, 23rd to 29th April). Correlation studies revealed that, evening relative humidity exhibited significant positive correlation (r= 0.46) and maximum temperature and minimum temperature showed significant negative correlation (r= -0.45 and r= -0.54) (Table 3). The present investigations are in conformity with the findings of Kumar *et al*. (2016) [13] reported peak infestation of shoot and fruit borer was observed Feb. (6th and 7th SW) and Ranjith *et al.* (2020) [21] revealed that population was active throughout the cropping season with minimum temperature showed significant negative correlation; negative one with morning and evening relative humidity. Kumar *et al.* (2019) [14] they reported infested the crop after four weeks of transplant that is (2.73%) and reached at its peak (19.36%). Correlation with maximum temperature and morning relative humidity showed non-significant negative correlation whereas, minimum temperature showed significant negative correlation. Similarly, Kumar *et al.* (2018) [15] the number of reported shoot and fruit borers grew from December 28 to January 17, reaching a peak (5.30 larvae/plant) in the first week of January. In accordance with Sharma and Tayde (2017) reported occurrence of shoot and fruit borer with an average 0.64, BSFB infestation and reached peak level of 5.21, BSFB.

Table 2: Incidence of insect pests of brinjal crop during *rabi* 2019.

Month	SMW	Mean population (nymph + adult) per 6 leaves/plant		*L. orbonalis* (% incidence)
		A. biguttula biguttula	*B. tabaci*	
November	45	0.00	0.00	0.00
	46	0.11	0.00	0.00
	47	0.36	0.00	0.00
December	48	3.36	0.51	0.00
	49	3.66	0.13	2.33
	50	2.96	1.53	5.26
	51	1.16	2.01	7.66
	52	0.76	2.36	12.51
January	1	2.66	3.56	15.36
	2	4.46	3.26	20.66
	3	3.81	3.11	18.13
	4	3.46	2.66	16.26
February	5	2.66	2.43	15.01
	6	1.66	1.26	15.51
	7	3.33	1.06	15.16
	8	1.56	1.01	17.46
March	9	2.01	0.26	15.11
	10	1.76	0.00	12.21
	11	1.13	0.00	8.24
	12	0.66	0.00	6.56
	13	0.51	0.00	5.26
April	14	1.51	0.00	10.51
	15	1.26	0.00	7.16
	16	0.66	0.00	6.24
	17	0.26	0.00	5.56

SMW= Standard Meteorological Week.

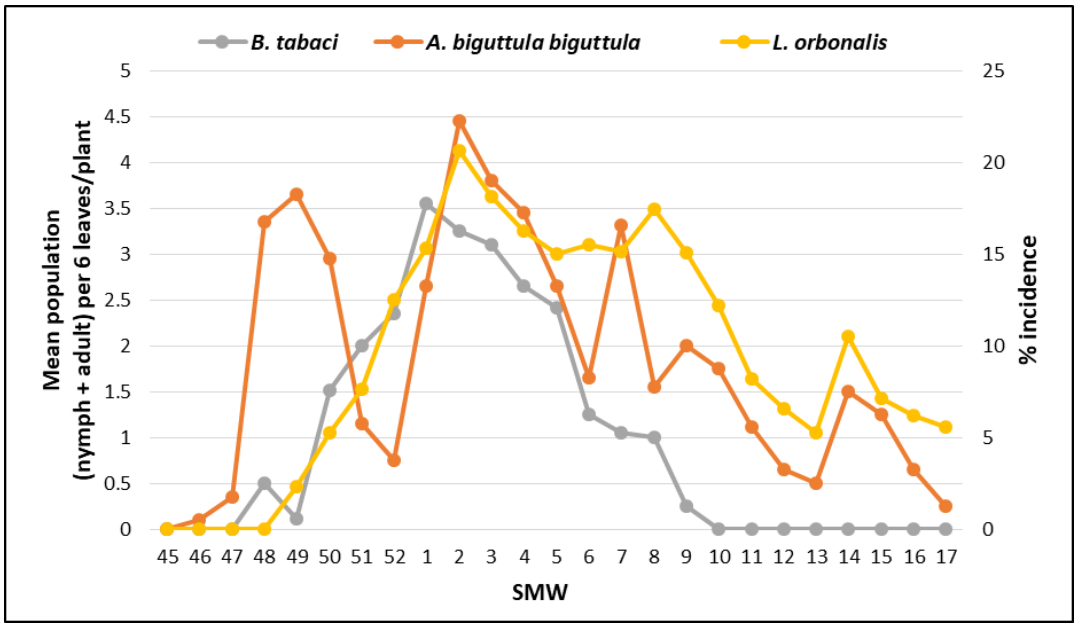

Fig 1: Graphical representation of insect pests of brinjal crop during *rabi* 2019.

Table 3: Correlation (r) and regression (b_{yx}) studies of abiotic factors on insect pest on brinjal crop during *rabi* 2019.

Weather factors	*A. biguttula biguttula*		*A. gossypii*		*L. orbonalis*	
	r	b_{yx}	r	b_{yx}	r	b_{yx}
Max. Temp. (°C)	-0.53**	-0.10	-0.78**	-0.15	-0.45*	-0.43
Min. Temp. (°C)	-0.57**	-0.15	-0.76**	-0.19	-0.54**	-0.71
Morning Relative Humidity (%)	-0.13 NS	-	-0.01 NS	-	-0.22 NS	-
Evening Relative Humidity (%)	0.46*	0.05	0.72**	0.07	0.46*	0.23
Rainfall	0.36 NS	-	0.35 NS	-	0.36 NS	-

*Significant at 5% level, **Significant at 1% level, NS= non-significant

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