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Population Dynamics of Major Pod Borers of Field Bean (*Lablab purpureus* L.) and Influence of Meteorological Variables

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Abstract

The studies on population dynamics of major pod borer of filed bean was undertaken at College of Agriculture, V. C. Farm, Mandya, Karnataka during 2017-18. The pod borer complex on field bean consisted of mainly *Helicoverpa armigera, Adisura atkinsoni, Maruca vitrata* and *Exelastis atomosa*. The observations recorded during *kharif* revealed the infestation pattern gradually increased from October second fortnight to November first fortnight. While, in *rabi* the infestation increased from December second fortnight to January first fortnight. During *kharif* and *rabi* the pod borer population showed a significant negative association with maximum temperature.

Keywords: Pod borer, Field bean, *Helicoverpa armigera, Adisura atkinsoni, Maruca vitrata, Exelastis atomosa*

Lablab purpureus (L.), commonly called as field bean is one of the ancient leguminous crops cultivated mainly in southern parts of India. The immature green pods are used as vegetables, rich in proteins (22.4 - 31.3%) and carbohydrates (55%) and can be a perfect substitute of expensive animal proteins besides being the rich source of potassium, magnesium, calcium, phosphorous and vitamins like B1, B2, B3, folate and vitamin C. The pods also possess anti-diabetic, anti-inflammatory, analgesic, antioxidant, cytotoxic, hypolipidemic, antimicrobial, insecticidal, hepatoprotective, antilithiatic, antispasmodic properties and also used in treating anaemia (Snafi, 2015).

Field bean has been cultivated in dry tropical parts of Asia, Africa, East and West Indies, South Central America and China. In India, it is being cultivated in all southern states and Assam. In Karnataka, field bean is cultivated in 0.6 lakh hectares with an annual production and productivity of 0.5 lakh tonnes and 892 kg ha-1, respectively (Anon., 2015). Though the crop is cultivated in almost all regions of Karnataka, it is highly grown as a mixed crop with finger millet and sorghum and to a smaller extent as a pure crop under rainfed as well as irrigated conditions.

The insect pests damage is considered as one of the major drawbacks in achieving the potential yield in field bean. Many insect pests severely ravage the buds, flowers and developing seeds of bean crop resulting in crop loss. Earlier studies reported that around 55 species of insects and one species of mite feeding on the crop from seedling stage till the harvest in Karnataka. Among sucking pests lablab bug, Coptosoma cribraria (Fabricius), Riptortus pedestris (Fabricius) and Nezara viridula (Linnaeus) occurred commonly in large numbers throughout the cropping period. The significant crop damage was attributed to the pod borer complex including *Helicoverpa armigera* (Hubner), *Adisura atkinsoni* (Moore), *Maruca testulalis* (Geyer), *Etiella zinckenella* (Treitschke), *Cydia ptychora* (Meyrick), *Exelastis atomosa* (Walshinghan), *Sphenarches caffer* (Zeller) and *Lampides boeticus* (Linnaeus) and *Callosobruchus theobromae* (L.) which are of considerable importance causing 80 per cent pod damage Mahalakshmi, *et al.,* 2016). The inflorescence is attacked by several species of borers, of which *E. atomosa*, *A. atkinsoni* and *H. armigera* have been considered as major pests (Mallikarjuna, *et al.,* 2012). Currently, spotted borer, *M. vitrata* is attaining a major pest status on Lablab varieties, blooming throughout the year. The seed yield loss caused by *A. atkinsoni* has reported to be more than 95 per cent and pod damage, more than 49.43 per cent.

The pod borer, *A. atkinsoni* is a dominant and specific insect pest of field bean occurring from August to March under field conditions which coincided with flowering and pod formation stage of the crop. It was found specific only feeding on the flowers and pods of field bean. The damage inflicted by *H. armigera* is generally limited to flower buds, seeds and pods. The plume moth attacks the crop during the stage of flowering and continues up to pod maturity and affected pods exhibit small and round holes.

The spotted pod borer, *M. vitrata* is an important insect pest of grain legumes appear on the crop from vegetative to reproductive stage and cause substantial damage to flowers, by webbing and also boring into the pods. The young larvae of *L. boeticus* damage flowers and pods. The young caterpillar of *C. ptychora* remains inside the pods, while the grown-up larvae cut an exit hole on the pod. The larvae of *E. zinckenella* bore the pods to feed on the seeds. The damage done by these pod borers drastically reduce the marketable yield of pods (Mallikarjuna, 2009). By considering the seriousness of damage caused by the pod borers it is felt necessary to understand the population dynamics of major pod borers of field bean in relation to meteorological variables.

MATERIAL AND METHODS

The present investigation was carried out at College of Agriculture, V. C. Farm, Mandya, during 2017-18. Mandya is situated in Southern dry region (Zone-6) of Karnataka between 12° 32' N latitude, 76° 53' E longitude and 690m above mean sea level. The average rainfall is 751mm confined to monsoon from June to November with occasional showers in pre-monsoon period (March-May). The maximum rainfall was received in September and October. The average maximum temperature and minimum temperature varies between 28-35^{O} C and 24-26^{0} C, respectively.

In order to study the population dynamics of major pod borers of field bean in relation to meteorological variables, a popular variety, HA-4 was sown in third week of August and fourth week of October during *Kharif* and *Rabi*, respectively during 2017-18. The crop was raised in 3 plots of size 4.5 m X 6 m (27 m^2) with a spacing of 45 cm X 15 cm, between rows and plants, respectively. The crop was maintained devoid of plant protection measures but cultural operations and irrigation were made as per the requirements.

The observations on the seasonal incidence and abundance of the major pod borers *viz.,* plume moth, *Exelastis atomosa* (Walshinghan), *Helicoverpa armigera* (Hubner), *Adisura atkinsoni* (Moore) and *Maruca vitrata* (Geyer) as well as natural enemies were recorded in each plot at weekly intervals on 20 randomly selected and tagged plants both in *Kharif* and *Rabi* during 2017-18. The larval count on flowers and pods in each selected plant was recorded from flowering till the harvest. The data obtained on the incidence of insect pests was assessed and average population per plant were worked out for analysis. The immature stages of different pod borers which occurred on the crop were collected and reared till adults emergence and they were identified by comparing with the literature and laboratory specimen, Department of Agricultural Entomology, College of Agriculture, Hassan. To know the relationship between pod borer incidence and meteorological variables, the data on meteorological variable prevailed during the study period *viz.,* maximum and minimum temperature, morning and afternoon relative humidity, sunshine hours, rainfall and number of rainy days were collected from agro-meteorological observatory unit, College of Agriculture, V. C. Farm, Mandya and weekly means were worked out.

The relationship between meteorological variables *viz.,* maximum and minimum temperature, morning and afternoon relative humidity, sunshine hours, rainfall and number of rainy days and pest population was studied by subjecting the weekly mean observation made on insect pests to Pearson's correlation co-efficient analysis. Further, to know the influence of meteorological variables on growth and abundance of pod borer population, the data was subjected to "Multiple Linear Regression Analysis Techniques (Pans and Sukhatme, 1967) by fitting different functions using software "SAS Syntax Reference

Guide 2016, version 16.0 (SPSS 16), South Wacker Drive, Chicago, IL (SPSS, 2009).

Results and Discussion

The results of investigations on the population dynamics of major pod borers of field bean as influenced by meteorological variables on their population are presented and discussed. In the present investigation four species *viz., Exelastis atomosa*, *Helicoverpa armigera, Adisura atkinsoni, Maruca vitrata* belonged to different families of order Lepidoptera constituted the pod borer complex. Among them, E. *atomosa* was found dominant and three natural enemies *viz.,* coccinellids (*Menochilus sexmaculata*), green lace wings (*Chrysoperla* sp.) and reduviid bugs were observed and recorded from flowering till harvest.

Plume moth, *E. atomosa* (*Pterophoridae: Lepidoptera*):

In *Kharif*, 2017 the larval population of plume moth was observed right from the flowering stage and continued till harvest. The population ranged from 0.40-5.57 larvae / plant with the mean population of 2.91 larvae / plant. The incidence started from last week of September and reached peak during second week of November with 5.57 larvae/ plant. However population dwindled gradually from third week of November onwards (Table 1).

These observations are in conformity with Mallikarjuna *et al.* (2012) who found peak incidence of plume moth during second week of November. Reddy *et al.* (2017a) reported that plume moth incidence started from first week of October and was highest during third week of November and first week of December. The slight change in the results may be due to change in the location, weather parameters existing in that particular location and population density of the pest. During *Rabi*, 2017-18 the larval population ranged from 0.00-1.77 larvae / plant with mean population of 0.84 larvae / plant. The maximum larval incidence was observed during first week of January with mean population of 1.77 larvae / plant. However, peak activity was seen throughout January month, later the larval population gradually decreased. Overall the highest larval population in both the seasons was observed on 70-80 days old crop (Table 2).

Table 1

Population dynamics of major pod borers and natural enemies of field bean during *kharif*, 2017

Month	MSW	Average population per plant			
		E. atomosa	*H. armigera*	*A atkinsoni*	*M. vitrata*
Sep-Oct	39	0.40	0.73	0.00	0.00
	40	2.07	1.47	0.53	0.67
	41	2.93	1.27	1.17	0.90
	42	1.67	2.10	0.83	1.40
Nov	43	5.20	3.23	2.07	3.13
	44	5.53	4.60	3.30	1.17
	45	5.57	4.57	3.87	1.93
	46	3.33	2.43	2.23	0.20
Dec	47	1.73	1.90	1.20	0.27
	48	0.67	0.50	0.39	0.00
Mean		2.91	2.28	1.56	0.97
Max		5.57	4.60	3.87	3.13
Min		0.40	0.50	0.00	0.00
SD ±		1.85	1.38	1.21	0.94

However, Rekha and Mallapur (2007) recorded the highest incidence of plume moth in second week of November. The variation in results may be due to change in location, cropping pattern or availability of host crops, natural enemies and abiotic factors.

Influence of meteorological variables on the larval incidence of plume moth, *E. atomosa*

The data pertaining to the relationship between the incidence of plume moth, *E. atomosa* with meteorological variables during *Kharif*, 2017 revealed that, maximum temperature (r = -0.69) had shown significant negative correlation with plume moth population, while, minimum temperature (r = -0.20), morning (r = -0.40) and afternoon relative humidity (r = -0.31), rainfall (r = -0.42), rainy days (r = -0.48) had non-significant negative correlation with larval population, whereas, sunshine hours (r = 0.41) showed

TABLE 2

Population dynamics of major pod borers and natural enemies of field bean during *rabi*, 2017-18

Month	MSW	Average population per plant			
		E. atomosa	*H. armigera*	*A atkinsoni*	*M. vitrata*
Dec	49	0.20	0.00	0.00	0.00
	50	0.87	0.27	0.53	0.32
	51	1.20	0.90	1.07	0.23
	52	0.83	1.10	1.00	0.40
Jan	1	1.77	0.20	0.12	1.03
	2	1.10	0.70	0.13	0.25
	3	1.03	0.12	0.03	0.07
	4	1.00	0.20	0.00	0.00
Feb	5	0.40	0.05	0.00	0.00
	6	0.00	0.00	0.00	0.00
Mean		0.84	0.35	0.32	0.23
Max		1.77	1.10	1.07	1.03
Min		0.00	0.00	0.00	0.00
SD ±		0.49	0.38	0.47	0.30

non-significant positive correlation with larval population (Table 3).

When the data was subjected to linear regression analysis to know the effect of significant variable on larval population, the results indicated that the maximum temperature influenced the pest population to the extent of 47.5 per cent (R^2 = 0.475) on field bean (Table 4).

During 2017 *Rabi*, correlation between weather data and plume moth population indicated that the larval population showed negative correlation with maximum temperature (r = -0.47), minimum temperature (r = -0.30) and afternoon relative humidity (r = -0.47). However, positive correlation with morning relative humidity (r = 0.29) and sunshine hours (r = 0.07) but they were non-significant (Table 5).

The multiple linear regression analysis revealed that, all the meteorological variables studied collectively influenced the plume moth population to the extent of 86 and 72 per cent during *Kharif* and *Rabi* respectively (Table 16 and 17).

The results on influence of meteorological variables on plume moth population are in close agreement with

TABLE 3

Correlation between larval incidence of plume moth, *E. atomosa* and meteorological variables, *Kharif* 2017

Parameters	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Y- larval population	-0.69 *	-0.20	-0.40	-0.31	-0.42	-0.48	0.41
X_1-Maximum temperature	1.00	0.46	0.63	0.11	0.25	0.46	-0.10
X_2-Minimum temperature		1.00	0.54	-0.17	0.29	0.54	0.43
X_3-Morning relative humidity			1.00	-0.41	0.60	0.66	-0.08
X_4-Afternoon relative humidity				1.00	-0.59	-0.37	-0.19
X_5-Rainfall					1.00	0.87	-0.07
X_6-Rainy days						1.00	0.23
X_7-Sunshine hours							1.00

N= 10; * Significant at p d" 0.05

TABLE 4

Stepwise regression analysis showing significant variables against *E. atomosa*, *Kharif* 2017

Parameters	Regression coefficient	Standard error	't'value	'F' value	R^2value
Maximum temperature	-3.72	1.38	2.69	7.25	0.475

TABLE 5

Correlation between larval incidence of plume moth, *E. atomosa* and meteorological variables, *Rabi* 2017-18

Parameters	X_1	X_2	X_3	X_4	X_5
Y-Plume moth larval population	-0.47	-0.30	0.29	-0.47	0.07
X_1-Maximum temperature	1.00	-0.15	-0.11	0.78	0.72
X_2-Minimum temperature		1.00	0.44	-0.41	-0.69
X_3-Morning relative humidity			1.00	-0.22	-0.04
X_4- Afternoon relative humidity				1.00	0.66
X_5-Sunshine hours					1.00

the findings of Reddy *et al.* (2017a) who reported the significant negative correlation with maximum temperature and minimum temperature. Whereas, significant positive correlation with afternoon relative humidity. In contrary Shinde *et al.* (2017) showed the correlations of E. *atomosa* population with maximum temperature, minimum temperature, relative humidity were negatively non-significant.

Gram pod borer, *H. armigera* (Noctuidae: Lepidoptera):

In *kharif*, 2017 the population of *H. armigera* started from last week of September with mean population of 2.28 larvae / plant. The maximum population (4.60 larvae / plant) was observed in the first week of November followed by 4.57 larvae / plant in second week coinciding with pod maturity stage of the crop. The minimum population (0.50 larvae / plant) was observed in first week of December (Table 1).

Mallikarjuna *et al.* (2012) reported that the gram pod borer on field bean reached peak during second week of November (Pod maturing stage). Rekha and Mallapur (2007) noticed the peak activity of the pest during November month on field bean. Shinde *et al.* (2017) also observed peak incidence of *H. armigera* during second week of November (45th SW) on pigeon pea. Thus the observations on incidence of *H. armigera* during the study are in accordance with the above reports.

In *Rabi*, 2017-18 the larval population started from Second week of December (0.27 larvae / plant). The population varied from 0.00 to 1.10 larvae / plant with mean population of 0.35 larvae / plant. The peak population (1.10 larvae / plant) was observed at last week of December later the pest population gradually decreased (Table 2).

Influence of meteorological variables on the incidence of *H. armigera*

The analytical data on correlation coefficient between population of gram pod borer and weather parameters during *Kharif* 2017, indicated that among all the weather parameters, Maximum temperature (r = -0.84) showed significant negative association with pod borer population. Other parameters *viz.,* minimum temperature (r = -0.24), morning (r = -0.52) and afternoon relative humidity (r = -0.25), rainfall (r = -0.37), rainy days (r = -0.48) showed non-significant negative association. Whereas sunshine hours (r = 0.25) exerted positive and non-significant association with pod borer population (Table 6).

The linear regression analysis revealed that maximum temperature which showed significant correlation with larva population had an influence of 70 per cent (R^2 = 0.70) over the incidence of *H. armigera* population in *Kharif* (Table 7). However, Multiple linear regression analysis revealed that all the weather parameters had combined effect of 91 per cent (R^2 = 0.91) and 57 per cent (R^2 = 0.57) on pest population during *Kharif* and *Rabi*, respectively (Table 16 and 17).

The data pertaining to the correlation between the incidence of *H. armigera* with meteorological variables during Rabi revealed that, maximum temperature (r = -0.65) showed significant negative correlation with larval population, while, minimum temperature (r = -0.01), Morning (r = -0.28) and afternoon relative humidity (r = -0.44) and sunshine hours (r = -0.52) had non-significant negative

TABLE 6

Correlation between larval incidence of *H. armigera* and meteorological variables, *kharif* 2017

Parameters	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Y- *H. armigera* larval population	-0.84 **	-0.24	-0.52	-0.25	-0.37	-0.48	0.25
X_1-Maximum temperature	1.00	0.46	0.63	0.11	0.25	0.46	-0.10
X_2-Minimum temperature		1.00	0.54	-0.17	0.29	0.54	0.43
X_3-Morning relative humidity			1.00	-0.41	0.60	0.66	-0.08
X_4- Afternoon relative humidity				1.00	-0.59	-0.37	-0.19
X_5-Rainfall					1.00	0.87	-0.07
X_6-Rainy days						1.00	0.23
X_7-Sunshine hours							1.00

N= 10; ** Significant at p d" 0.01

TABLE 7

Stepwise regression analysis showing significant variables against *H. armigera*, *Kharif* 2017

Parameters	Regression coefficient	Standard error	't'value	'F' value	R^2value
Maximum temperature	-3.37	0.77	4.35	18.91	0.70

TABLE 8

Correlation between larval incidence of *H. armigera* and meteorological variables, *rabi* 2017-18

Parameters	X_1	X_2	X_3	X_4	X_5
Y- *H. armigera* larval population	-0.65 *	-0.01	-0.28	-0.44	-0.52
X_1-Maximum temperature	1.00	-0.15	-0.11	0.78	0.72
X_2-Minimum temperature		1.00	0.44	-0.41	-0.69
X_3-Morning relative humidity			1.00	-0.22	-0.04
X_4- Afternoon relative humidity				1.00	0.66
X_5-Sunshine hours					1.00

N= 10; * Significant at P d" 0.05

correlation with larval population, (Table 8). Also, when the data was subjected to regression analysis the results showed that maximum temperature influenced the pest population to the extent of 43 per cent (R^2 = 0.43) (Table 9).

Umbarkar *et al.* (2010) reported that among all the weather parameters, only minimum temperature (r = -0.557) and afternoon relative humidity (r = -0.583) showed significant negative correlation with pod borer population. The correlation between the pest population and morning relative humidity, wind speed, rainfall and rainy days were non-significant and negative. Shinde *et al.* (2017) and Keval *et al.* (2017) also registered negative correlation of pest population with relative humidity. Hence, the present findings are more or less in close agreement with the above mentioned reports.

TABLE 9

Stepwise regression analysis showing significant variables against *H. armigera*, *Rabi* 2017-18

Parameters	Regression coefficient	Standard error	't'value	'F' value	R^2value
Maximum temperature	-0.28	0.12	2.43	5.92	0.43

Avare pod borer, *A. atkinsoni* (Noctuidae: Lepidoptera):

During *Kharif*, 2017 *A. atkinsoni* population appeared in first week of October (0.53 larvae / plant) to December (0.39 larvae / plant). The population varied from 0-3.87 Larvae / plant with mean population of 1.56 larvae / plant and the maximum population was observed in second week of November (3.87 larvae / plant) later the population decreased gradually (Table 1).

However, Mallikarjuna *et al.* (2012) reported that the incidence of Adisura atkinsoni started in the late pod maturity stage *i.e.* first week of November and reached peak during last week of December.

The population of *A. atkinsoni* during *rabi*, was noticed during second week of December (0.53 / plant) and maximum population was observed during third week of December (1.07 / plant). The population ranged from 0-1.07 larvae / plant with mean incidence of 0.32 larvae / plant (Table 2). However, there were no exact reports on population of *A. atkinsoni* during Rabi to corroborate and contradict the present findings.

Influence of meteorological variables on the larval incidence of *A. atkinsoni*

During *Kharif*, the correlation matrix indicating relationship between the avare pod borer, *A. atkinsoni* incidence and meteorological variables revealed that, the population of *A. atkinsoni* had shown a significant negative association with maximum temperature (r = -0.76). However, minimum temperature (r = -0.38), morning relative humidity (r = -0.49) and rainfall (r = -0.41) exerted non-significant negative association on *A. atkinsoni* population. Likewise, the population exerted positive association with afternoon relative humidity (r = 0.32), rainy days (r = 0.6) and sunshine hours (r = 0.11). However, their influence was found to be non-significant (Table 10).

The linear regression analysis between maximum temperature and *A. atkinsoni* population revealed that 58 per cent (R^2 = 0.58) of avare pod borer population was influenced by maximum temperatute negatively (Table 11).

During Rabi, the correlation matrix indicating relationship between the avare pod borer, *A. atkinsoni* incidence and meteorological variables revealed that,

TABLE 10

Correlation between larval incidence of *A. atkinsoni* and meteorological variables, *Kharif* 2017

Parameters	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Y- *A. atkinsoni* larval population	-0.76 **	-0.38	-0.49	0.32	-0.41	0.6	0.11
X_1-Maximum temperature	1.00	0.46	0.63	0.11	0.25	0.46	-0.10
X_2-Minimum temperature		1.00	0.54	-0.17	0.29	0.54	0.43
X_3-Morning relative humidity			1.00	-0.41	0.60	0.66	-0.08
X_4- Afternoon relative humidity				1.00	-0.59	-0.37	-0.19
X_5-Rainfall					1.00	0.87	-0.07
X_6-Rainy days						1.00	0.23
X_7-Sunshine hours							1.00

N= 10; ** Significant at p d" 0.01

TABLE 11

Stepwise regression analysis showing significant variables against *A. atkinsoni*, *kharif* 2017

Parameters	Regression coefficient	Standard error	't'value	'F' value	R^2value
Maximum temperature	-2.70	0.81	3.35	11.21	0.58

the population of *A. atkinsoni* had shown a significant negative association with maximum temperature

(r = -0.69) and sunshine hours (r = -0.72). However, morning relative humidity (r = -0.39), exerted non-significant negative association on *A. atkinsoni* population. Likewise, the population showed positive association with minimum temperature (r = 0.16) and afternoon relative humidity (r = 0.50). However, their influence was found to be non-significant (Table 12).

TABLE 12

Correlation between larval incidence of *A. atkinsoni* and meteorological variables, *rabi* 2017-18

Parameters	X_1	X_2	X_3	X_4	X_5
Y- *A. atkinsoni* larval population	-0.69 *	0.16	-0.39	0.50	-0.72 *
X_1-Maximum temperature	1.00	-0.15	-0.11	0.78	0.72
X_2-Minimum temperature		1.00	0.44	-0.41	-0.69
X_3-Morning relative humidity			1.00	-0.22	-0.04
X_4- Afternoon relative humidity				1.00	0.66
X_5-Sunshine hours					1.00

N= 10; * Significant at P d” 0.05

The linear regression analysis between maximum temperature and sunshine hours and *A. atkinsoni* population revealed that maximum temperature and sunshine hours influenced avare pod borer population negatively to the extent of 47 per cent (R^2 = 0.47) and 52 per cent (R^2 = 0.52), respectively (Table 13).

Multiple linear regression analysis on extent of relationship between meteorological variables and *A. atkinsoni* population revealed that all the weather parameters had combined influence to the extent of 91 per cent (R^2 = 0.91) and 79 per cent (R^2 = 0.79) on A. *atkinsoni* population during *Kharif* and *Rabi*, respectively (Table 16 and 17).

Earlier studies reported that the weather parameters such as mean minimum and maximum temperature, mean relative humidity, total rainfall and sunshine hours had shown non-significant relationship on the occurrence of the borer infestation. Some variation in the earlier reports and the present results may be due to change in the locality, weather parameters and time of the present study period.

Spotted pod borer, *M. vitrata* (Pyralidae: Lepidoptera)

During *Kharif* 2017, the population of *M. vitrata* varied from 0.00 to 3.13 larvae / plant, with mean population of 0.97 larvae / plant. The incidence started from first week of October (0.67 larvae / plant) and there was a gradual increase with a maximum population of 3.13 larvae / plant during fourth week of October. However, population started gradually decreasing from third week of November and there was no incidence in first week of December (Table 1).

Similarly Mahipal *et al.* (2017) reported that spotted pod borer infestation was first appeared during fifth week of September, increased gradually and peak infestation was recorded during third week of October. However, Rekha and Mallapur (2007) observed the peak infestation of spotted pod borer during the last week of November to December. This may be due to different agro climatic conditions.

During *Rabi* 2017, the population of *M. vitrata* varied from 0.00 to 1.03 larvae / plant, with mean population of 0.23 / plant. The incidence started from second

TABLE 13

Stepwise regression analysis showing significant variables against *A. atkinsoni*, *Rabi* 2017-18

Parameters	Regression coefficient	Standard error	't'value	'F' value	R^2value
Maximum temperature	-0.37	0.14	2.67	7.12	0.47
Sunshine hours	-0.08	0.03	2.94	8.63	0.52

week of December (0.32 larvae / plant). The maximum larval population of 1.03 larvae / plant was observed in first week of January. Later population started gradually decreasing and there was no incidence from third week of January onwards (Table 2).

However, Reddy *et al.* (2017b) reported that the incidence of *M. vitrata* on field bean was commenced from second week of November and continued up to January. The peak incidence of *M. vitrata* population was recorded at second week of December. This may be due to change in the location, cropping period and respective weather parameters.

Influence of meteorological variables on the larval incidence of *M. vitrata*

The data pertaining to the relationship between the incidence of spotted pod borer, *M. vitrata* and meteorological variables during *kharif* 2017 revealed that, maximum temperature (r = -0.58), morning relative humidity (r = -0.06) and, rainfall (r = -0.29), rainy days (r = -0.21) had non-significant negative correlation with larval population, whereas, minimum temperature (r = 0.05), afternoon relative humidity (r = 0.09) and sunshine hours (r = 0.48) were positively non-significant with larval population (Table 14). During *rabi*, correlation between weather data and *M. vitrata* population indicated that the larval population showed negative correlation with maximum temperature (r = -0.40), minimum temperature (r = -0.05), afternoon relative humidity (r = -0.28) and Sunshine hours (r = -0.08). However, positive correlation with morning relative humidity (r = 0.19) but they were non-significant (Table 15).

Whereas, Multiple linear regression analysis on extent of relationship between meteorological variables and *M. vitrata* population revealed that all the weather parameters had combined influence to the extent of 92 per cent (R^2 = 0.92) and 74 per cent

(R^2 = 0.74) on *M. vitrata* population during *kharif* and *rabi* seasons, respectively (Table 16 and 17).

The results of the present findings are in close agreement with Sravani *et al.* (2015 and Mahalakshmi, *et al.,* 2016, who reported that afternoon relative humidity showed negative influence on *M. vitrata.* Sonune *et al.* (2010) also recorded the negative association with minimum temperature.

The population dynamics of major pod borer of field bean was assessed during *Karif* and *Rabi* season of the year 2017-18. The pod borer complex on field bean

TABLE 14

Correlation between larval incidence of *M. vitrata* and meteorological variables, *Kharif* 2017

Parameters	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Y- *M. vitrata* larval population	-0.58	0.05	-0.06	0.09	-0.29	-0.21	0.48
X_1-Maximum temperature	1.00	0.46	0.63	0.11	0.25	0.46	-0.10
X_2-Minimum temperature		1.00	0.54	-0.17	0.29	0.54	0.43
X_3-Morning relative humidity			1.00	-0.41	0.60	0.66	-0.08
X_4- Afternoon relative humidity				1.00	-0.59	-0.37	-0.19
X_5-Rainfall					1.00	0.87	-0.07
X_6-Rainy days						1.00	0.23
X_7-Sunshine hours							1.00

N= 10.

TABLE 15

Correlation between larval incidence of *M. vitrata* and meteorological variables, *Rabi* 2017-18

Parameters	X_1	X_2	X_3	X_4	X_5
Y- *M. vitrata* larval population	-0.40	-0.05	0.19	-0.28	-0.08
X_1-Maximum temperature	1.00	-0.15	-0.11	0.78	0.72
X_2-Minimum temperature		1.00	0.44	-0.41	-0.69
X_3-Morning relative humidity			1.00	-0.22	-0.04
X_4- Afternoon relative humidity				1.00	0.66
X_5-Sunshine hours					1.00

N= 10.

consisted of mainly *Helicoverpa armigera*, *Adisura atkinsoni*, *Maruca vitrata* and *Exelastis atomosa* species. The population of *H. armigera* was observed from Sept to November and peak incidence was observed during 2nd week of November in *Karif* whereas the peak was observed during 1st week of January in *Rabi* season. For, *A. atkinsoni* peak incidence was observed during 1st week of November in *Karif* season and in *Rabi* season it was observed during 1st week of December. In *Karif* season *M. vitrata* peak incidence was observed during 2nd week of November whereas in *Rabi* season the peak was during 4th week of December. The *E. atomosa,* peak incidence was observed during 4th week of October in *Karif* season and in *Rabi* season the peak was observed during 1st week of January. Except *M. vitrata* all other species incidences showed significant negative correlated with maximum temperature.

TABLE 16

Multiple regression model for pod borer population and meteorological variables, *Kharif* 2017

Pod borers	R^2 value	Regression equation
E. atomosa	0.86	$106.73-2.90X_1-0.16X_2+0.1X_3-0.28X_4+0.06X_5+0.36X_6+0.11X_7$
H. armigera	0.91	$129.48-3.30X_1+0.30X_2-0.15X_3-0.23X_4-0.06X_5+0.8X_6-0.20X_7$
A. atkinsoni	0.91	$86.99-1.85X_1+0.01X_2-0.11X_3-0.24X_4-0.05X_5+0.35X_6-0.15X_7$
M. vitrata	0.92	$35.78-2.97X_1-0.08X_2+0.54X_3+0.08X_4-0.01X_5-0.16X_6+0.25X_7$

TABLE 17

Multiple regression model for pod borer population and meteorological variables, *Rabi* 2017-18

Pod borers	R^2 value	Regression equation
E. atomosa	0.72	$-2.29+0.36X_1-0.38X_2+0.11X_3-0.15X_4-0.09X_5$
H. armigera	0.57	$22.65-0.73X_1+0.21X_2-0.09X_3+0.05X_4+0.10X_5$
A. atkinsoni	0.79	$18.52-0.47X_1+0.11X_2-0.09X_3+0.03X_4+0.01X_5$
M. vitrata	0.74	$52.11-2.12X_1+0.89X_2-0.20X_3+0.17X_4+0.52X_5$

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