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Seasonal Incidence of Major Insect Pests on Early Maturing Pigeonpea [*Cajanus cajan* (L.) Millsp.] in Relation to Abiotic Factors of Varanasi Region of Indo-Gangetic Plain

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aim: To study the seasonal incidence pattern of major insect pests on two commonly grown cultivars of pigeonpea.
Study Design: Complete Randomized Block Design.
Place and Duration of Study: Field experiments were conducted at Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *kharif* seasons of 2015 and 2016.
Methodology: The pigeonpea crops (cultivars ICPL 87 and UPAS 120) were grown in plots of 10 m X 5 m (50 m^2) replicated thrice and the crop fields were kept free from pesticide sprays. Five plants were selected randomly from each plot, and weekly observations of the respective pests were taken through Plant Inspection Method (PIM) starting from 50 per cent flowering stage till maturity of the crop and then correlated with the meteorological data.

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Results: The peak infestation by the pod pest borer complex was recorded during the second fortnight of October (44th and 45th standard week) of both the years. Correlation studies indicated that the population of these insect pests (Tur pod bug (*C. gibbosa*), Legume pod borer (*M. vitrata*), Tur pod fly (*M. obtusa*), Legume pod borer (*M. vitrata*) exhibited a significant positive correlation with maximum and minimum temperature whereas a significant negative correlation was established with relative humidity and rainfall. The multiple regression analysis revealed that variations of different weather variables caused approximately more than 80 per cent variations in the populations of these insect pests in both the cultivars during both years, respectively.

Conclusion: The information on seasonal activity and population dynamics of legume pod borer, tur pod fly and tur pod bug on pigeonpea generated to give an indication about the importance of the different weather parameters in developing weather based forecasting models for successful development and implementation of the pest management strategies against these insect pests of pigeonpea.

Keywords: Pigeonpea; population dynamics; major insect pests; abiotic factors.

1. INTRODUCTION

Pulses are an integral part of human diets across the globe and have great potential to improve health, conserve soils, protect the environment and contribute to global food security to the masses of the world [1]. Among the different pulses grown in India, pigeonpea (*Cajanus cajan* (L.) Millsp.) is the second most important crop after chickpea [2]. It is a perennial legume belonging to the family Fabaceae [3]. Even if, India contributes for nearly 90% of world's total pigeonpea production [4], the yields of this crop have remained stagnant over the past few decades largely due to its vulnerability to several biotic and abiotic stresses [5]. The average national yield (about 712 kg/ha) is disappointingly low in comparison to potential yields of 1.2-1.5 tons/ha in short duration and 2.0-3.0 tons/ha in long-duration cultivars [6]. Nearly 250 species of insect pests are known to infest pigeonpea crop at its various growth stages in India [7] but the damage caused by legume pod borer, *Maruca vitrata* (Geyer), tur pod fly [*Melanagromyza obtusa* (Malloch)] and tur pod bug [*Clavigralla gibbosa* Spinola] results in major reduction in grain yield [8]. The considerable loss in grain yield is inflicted on account of their association with fruiting bodies [9]. *M. obtusa* is a major pod infesting pest and has been found to cause 10 to 80 per cent damage [10,11,12]. Similarly, *C. gibbosa* nymphs and adults cause deformation of pods and shrivelling of grains [13] resulting in predominant grain yield loss of 50,000 tonnes annually for Uttar Pradesh alone [14]. Likewise, red gram plants infested with 8 to 16 larvae of *M. vitrata* suffers huge grain yield losses ranging between 50 to 68 per cent [15] and the losses due to spotted pod borer have been estimated at US$ 30 million annually [16]. Under these circumstances, the scientific investigations for the effective management of the above-mentioned insect pests in pigeonpea ecosystem are needed to be further strengthened. Before developing any insect pest management programme for the specific agro ecosystem, it is necessary to have basic information on abundance and distribution of pest in relation to weather parameter as it helps in determining appropriate time of action and suitable effective method of control [17]. Hence, an attempt has been made to study the incidence and a population density of *M. vitrata*, *M. obtuse* and *C. gibbosa* on two short duration pigeonpea cultivars (UPAS 120 and ICPL 87) with respect to some abiotic factors in Varanasi region of India.

2. MATERIALS AND METHODS

To study the seasonal incidence of major insect pests on early maturing pigeonpea, field experiments were conducted at Agriculture Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *kharif* 2015 and 2016. Two short duration pigeonpea cultivars were used for the study i.e., ICPL 87 (determinate) and UPAS 120 (indeterminate) and the crop fields were kept free from pesticide sprays. The populations of pod feeding insect pests *i.e*. *Maruca vitrata, Melanogromyza obtusa* and *Clavigrella gibbosa* were recorded on five randomly selected plants from three middle rows of each plot at weekly intervals starting from 50 per cent flowering stage of the crop for studying the incidence pattern of these insect pests. The number of insect count recorded from all the three replications of two cultivars were averaged separately for each cultivar on standard week basis. In case of legume pod borer (*M. vitrata*), the observations were recorded as a number of larvae per plant. In the case of *M. obtusa,* the number of maggots per 10 pods per plant was recorded and for *C. gibbosa*, the observations were recorded as a number of bugs per plant. The influence of weather parameters on their population was also worked out. For this, the data were subjected to correlation and regression analysis with weather parameters *viz*., maximum and minimum temperatures, morning and evening relative humidity and rainfall, in respect of the corresponding standard week. The meteorological data for the above analysis were obtained from the meteorological observatory of the university. The significance of simple correlation was estimated by using *t*-test [18] and the regression equations were derived by using the formula as suggested by Panse and Sukhatme [19].

3. RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarised under the following heads:

3.1 Incidence Pattern of Pod Borer Pest Complex on Short duration Pigeonpea

3.1.1 Legume pod borer (*M. vitrata*)

The first incidence of *M. vitrata* larvae was observed at the flowering stage during the 39th standard week in both the years (*Kharif* of 2015 and 2016), in both the varieties and the pest population persisted up to 49th standard week. During *Kharif* 2015 and 2016, in case of ICPL 87, maximum mean larval population was recorded in a 44th standard week *i.e.* 13.20 larvae/plant and 13.26 larvae/plant respectively when the crop was at pod formation stage. While the minimum population was recorded in a 49th standard week *i.e.* 0.60 larvae/plant and 0.66 larvae/plant respectively the pod maturity stage (Fig. 1 and Fig. 2). Similarly in UPAS 120 during both the years *i.e.* 2015 and 2016, the maximum mean larval population recorded in a 44th standard week (12.93 larvae/plant) and 43rd standard week (13.00 larvae/plant) respectively, when the crop was at pod formation stage. While the minimum population was recorded during the 49th standard week with 0.53 larva/plant and 0.60 larvae/plant pod maturity stage during both the years of study (Fig. 3 and Fig. 4).

The present findings were in accordance with those of Akhauri and Yadav [20] who reported that the larval population of *M. vitrata* started infesting cowpea from the second week of October until the end of December. The period of maximum activity was between the second and last week of November when the mean population fluctuated around 12.67 to 15.17 larvae per plant. Chetan *et al.* [21] also reported that larval incidence of *M. vitrata* commenced after the 3rd week of September with 0.11 larvae per plant and gradually increased and attained a peak of 3.56 larvae per plant during the last week of October. The findings of Sujithra and Chander [22] further support the present findings.

3.1.2 Tur pod fly (*M. obtusa*)

The first incidence of *M. obtusa* was observed in 42nd standard week in both the years, in both the varieties and persisted up to 51st standard week at pod maturity stage of the crop, with peak population in the 45th standard week during 2015 (2.93 maggots/10 pods / plant) and 44th standard week during 2016 (2.60 maggots/10 pods / plant) on ICPL 87. Whereas in case of UPAS 120, highest peak population was observed in the 45th standard week with 2.80 maggots/10 pods /plant and 2.73 maggots/10 pods /plant during both the years respectively, which was mainly when the crop was at pod filling stage. During 2015 and 2016 the mean minimum population of pod fly maggot in case of ICPL 87 was recorded during 51st standard week *i.e.* 0.13 maggot/10 pods /plant and 0.20 maggot /10 pods /plant, respectively at pod maturity stage (Fig. 1 and Fig. 2). Similarly, in UPAS 120, the minimum pod fly maggot population was recorded at the 51st standard week in both the years of experimentation *i.e.* 0.13 maggot/10 pods /plant and 0.16 maggot /10 pods /plant respectively, at pod maturity stage (Fig. 3 and Fig. 4).

The present findings were in accordance with those of Pandey et al. [23] who reported that the maggot population of *M. obtusa* started infesting from the 42nd standard week with a mean population of 0.10 maggot/plant and existed till the end of December in pigeonpea cv. UPAS 120, where the maggot population peaked during the 45thstandard week with a mean population of 0.30 maggot/plant. Similarly, Pillai and Agnihotri [24] reported that the maggot population of *M. obtusa* attends its maximum peak level during the 46th standard week while the population was minimum (31/100 pods) during the 49th standard week. Meena et al. [25] also examined the seasonal incidence of *M. obtusa* on long-duration pigeonpea in Varanasi region and revealed that maximum incidence of *M. obtusa* in terms of maggot population was recorded in a 9th standard week. In another study, Kumar and Nath [26] deciphered that pod fly infestation

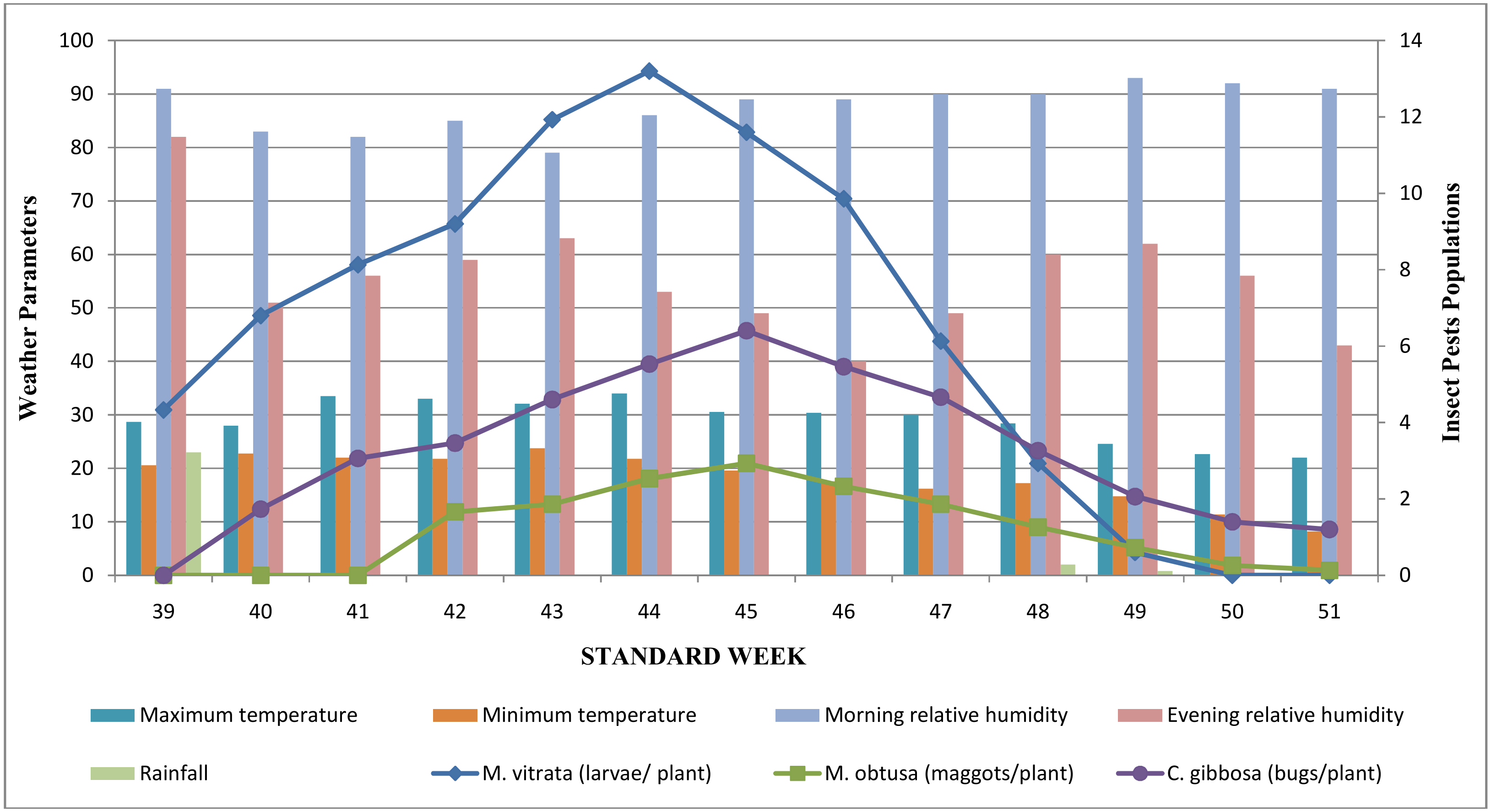

Fig. 1. Population fluctuation of major insect pests on pigeonpea (cv. ICPL 87) in relation to meteorological observations during *Kharif* 2015

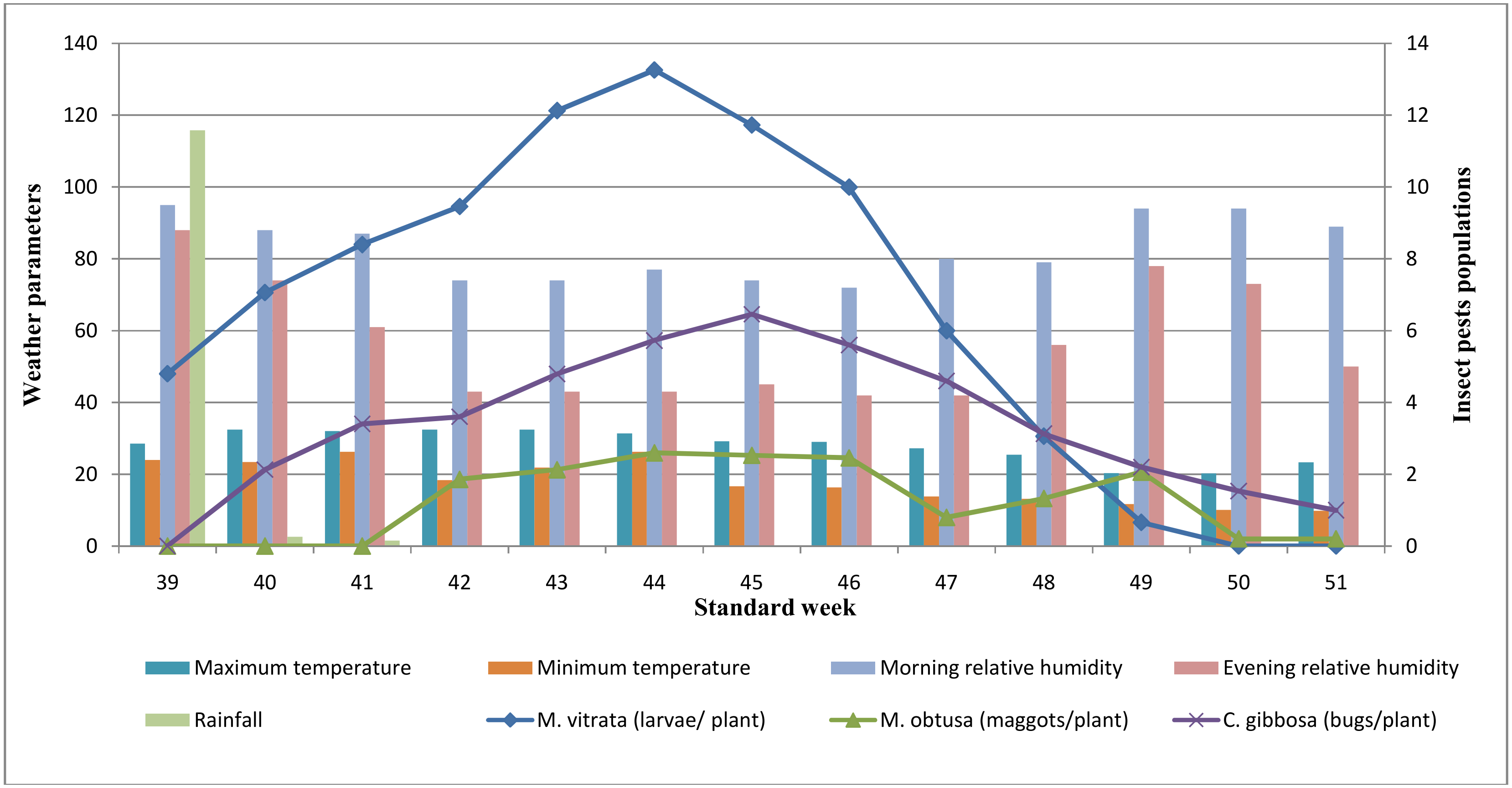

Fig. 2. Population fluctuation of major insect pests on pigeonpea (cv. ICPL 87) in relation to meteorological observations during *Kharif* 2016

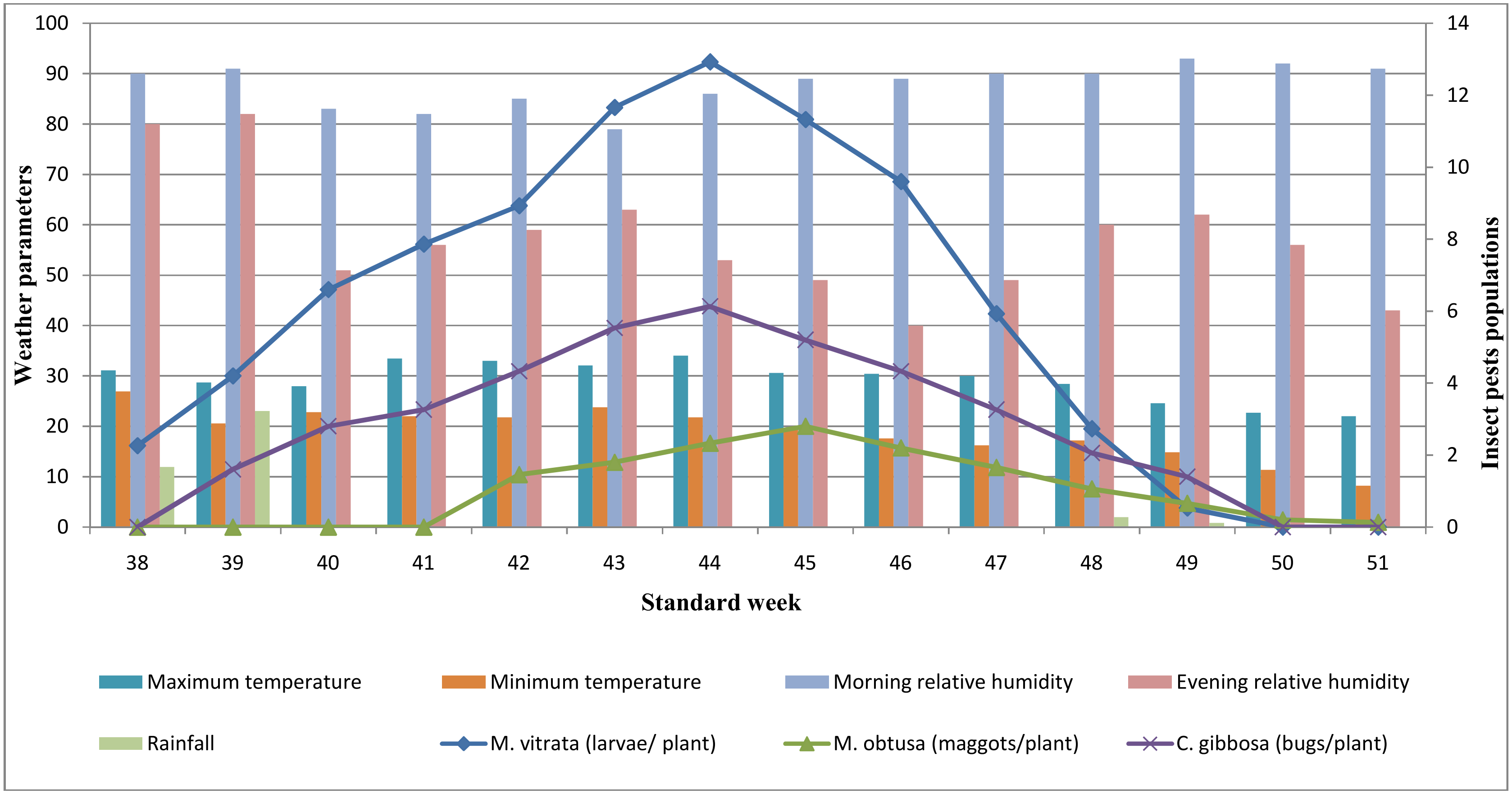

Fig. 3. Population fluctuation of major insect pests on pigeonpea (cv. UPAS 120) in relation to meteorological observations during *Kharif* 2015

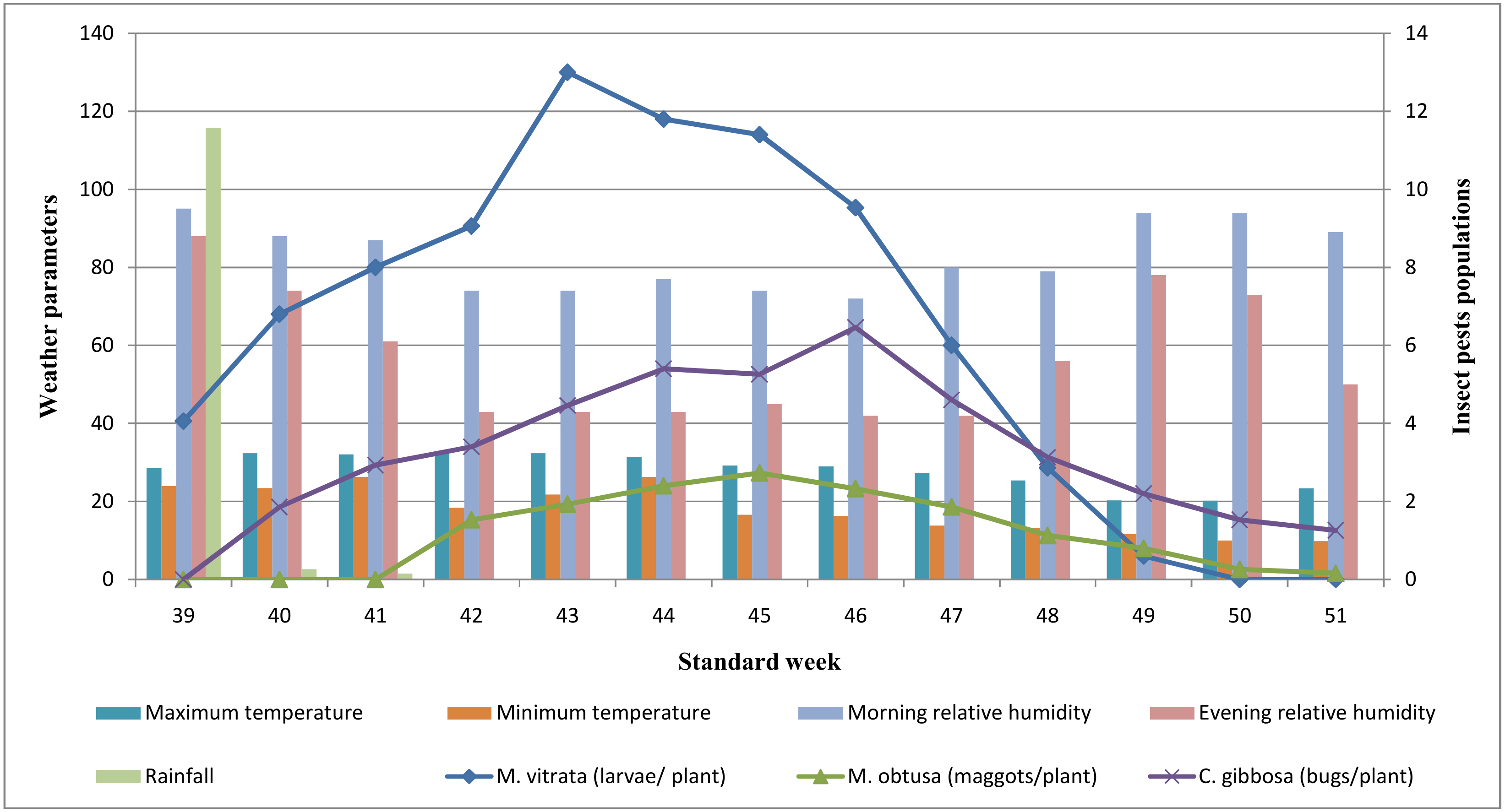

Fig. 4. Population fluctuation of major insect pests on pigeonpea (cv. UPAS 120) in relation to meteorological observations during *Kharif* 2016

remained from 23 January to 8 April and its peak population was observed on 22 February and the activity of *M. obtuse* started with pod formation and grain filling stage i.e., the 4th standard week [27]. Similar findings were also observed by Keval and Srivastava [28] and Vikram et al. [29] which further supports the result of the present investigation.

3.1.3 Tur pod bug (*C. gibbosa*)

The first incidence of *C. gibbosa* was observed at 40thstandard week in both the years of experimentation in ICPL 87, and persisted till pod maturity stage of the crop (51ststandard week), with peak population in the 45th standard week (6.40 bugs / plant and 6.46 bugs / plant, respectively) *i.e*. during the pod formation stage. While the minimum population was recorded during the 51st standard week with 1.20 bugs/plant and 1.00 bug /plant pod maturity stage in both the seasons of study (Fig. 1 and Fig. 2). However, in UPAS 120 the first infestation of pod bug was recorded at 39th standard week during *Kharif* 2015 (1.6 bugs/plant) and during the 40th standard week during *Kharif* 2016 (1.86 bugs/plant). The maximum mean population of bugs were recorded in the 44th standard week *i.e.*6.13 bugs/ plant during the first year of study and 6.46 bugs/ plant at 46th standard week during the successive year of study when the crop was at pod formation stage. On the other hand, the minimum population during 2015 was recorded at 49thstandard week (1.40 bugs/plant) and at 51st standard week (1.00 bug /plant) during 2016, mainly pod maturity stage (Fig. 3 and Fig. 4).

The present findings are in partial accordance with the findings of Srujana and Keval [13] who recorded that the adult peak population of *C. gibbosa* was during 9th standard week (6.4 bugs/plant), followed by 8th standard week (5.8 bugs/plant) and the lowest population of 0.2 bugs /plant was in the 1st standard week when they studied pod bug incidence in long-duration pigeon pea. Kumar and Keval [30] also reported that the incidence of pod bug on long-duration pigeonpea genotypes was initially observed on 4th standard week in all genotypes except BAHAR. The findings Pandey et al. [23] are in conformity with the present findings where they recorded that the first occurrence of *C. gibbosa* was during 40thstandard week with a mean population of 0.03 bugs/plant, which attained the peak during 44th and 45thstandard weeks with 0.40 bugs/plant and the population existed until the end of December in pigeonpea cv. UPAS 120 similar to that of the present study where the pod bug population was available till the 51st standard week.

3.2 Influence of Weather Parameters on the Incidence of Pod Pest Complex of Pigeonpea

The prevailing temperature, relative humidity (RH) and rainfall of locality are known to have a profound influence on the growth, development and population build-up of insect pests. The activity of these insect pests appears to be influenced by these abiotic factors. The variation in the population of different insect species appeared to be because of fluctuation in the temperature, relative humidity, and rainfall. This is a common phenomenon since the optimum weather condition required for different insect species for their growth and development are different.

3.2.1 Legume Pod Borer (*M. vitrata*)

In two years of experimentation (Table 1), it was observed that *M. vitrata* had a highly significant positive correlation (r = 0.827** in 2015 and r = 0.783** in 2016) with maximum temperature and significantly positive association (r = 0.631*) with minimum temperature in the first year, but non-significant correlation (r = 0.520 ns) with minimum temperature in the next year of study *i.e.* 2016 in cultivar ICPL 87. While in the other cultivar *i.e*. UPAS 120 the population growth of legume pod borer showed highly significant correlation with maximum temperature (r = 0.729** in 2015 and r = 0.778** in 2016) and non- significant (r = 0.256 and r = 0.473 in 2015 and 2016 respectively) effect of the minimum temperature in both the years of study. However, other weather parameters *viz.* morning relative humidity, evening relative humidity and rainfall showed a negative correlation in both the cultivars (ICPL 87 and UPAS 120), with rainfall being non- significantly correlated [(r = -0.339 in 2015 and r = -0.258 in 2016) and (r = -0.432 in 2015 and r = -0.297 in 2016) in ICPL 87 and UPAS 120, respectively] in both the years of study. From the present study, it can be concluded that the larval activity of *M. vitrata* in an early maturing variety of pigeonpea crop was increased with increasing maximum temperature, minimum temperature, and decreased with increasing morning and evening relative humidity and rainfall. The results are in accordance with Saxena and Ujagir [18] who claimed that the larval populations of *M. vitrata* were significantly associated with temperature and relative humidity in 2003-04. Similarly, Sahoo and Behera [31] also revealed that *M. vitrata* had a positive correlation with minimum, maximum and average temperatures that further supported the present findings.

The regression coefficient revealed that the abiotic factors were highly influencing as parameters that governed the population fluctuation and contributed (R^2 = 0.839 and 0.902) 83.9 and 90.2 per cent variation in *M. vitrata* population during both the years, respectively in ICPL 87, and it was also found that one unit increase in maximum and minimum temperature would cause 0.732 and 1.020 unit increase in 2015, and 0.114 and 0.536 unit increase in the second year of study in the *M. vitrata* population. However, one unit increase in the other weather parameters like morning relative humidity, evening relative humidity and rainfall would cause 0.406 and 0.341, 0.160 and 0.036, and 0.032 and 0.002 unit decrease in the pest population during both the years of study respectively. Similarly, in UPAS 120, 78.2 per cent and 88.0 per cent variations in the *M. vitrata* populations were brought about by the weather parameters. The findings of the present study are to a certain extent in accordance with the claims of Lakshmi [32] and Sivaramakrishna et al. [33]. However, positive correlation (r=0.86) between rainfall and incidence of *M. vitrata* has been reported by Sharma et al. [34]. Moreover, Sreekanth et al. [35] reported that there existed a highly significant correlation between *M. vitrata* and minimum temperature and mean temperature and the moderately significant correlation was present between *M. vitrata* and evening relative humidity with a correlation coefficient (r) -0.609.

3.2.2 Tur Pod Fly (*M. obtusa*)

The *M. obtusa* population showed a highly significant positive association with the maximum temperature (r = 0.871** and r = 0.853**) during *kharif* 2015 in both the cultivars under study *i.e.* ICPL 87 and UPAS 120, whereas, during 2016 there existed non- significant interaction (r = 0.623 ns) in ICPL 87 and highly significant positive (r = 0.787**) interaction in UPAS 120 between the pest population and the maximum temperature. However, the population of *M. obtuse* showed highly positive significant interaction with minimum temperature during 2015 in both ICPL 87 (r = 0.784**) and UPAS 120(r = 0.774**) while, the significant positive interaction was present during the next year in both the cultivars. On the other hand, weather parameters like the morning and evening relative humidities, and the rainfall showed non-significant negative association with the pest population during both the years, in both the cultivars except for morning relative humidity during 2016, which showed significant negative correlation with *M. obtusa* population in both the cultivars (r = -0.644* in ICPL 87 and r = 0.849**) (Table 1). The results of the present study were found to be in accordance with that of Kumar and Nath [36] where they revealed that. *obtusa* exhibited a positive correlation with maximum temperature and relative humidity, and a negative correlation was established with rainfall, minimum temperature and mean temperature. More recently, Chakravarty et al. [37] also reported that *M. obtusa* exhibited as a positive correlation with maximum temperature, whereas a negative correlation was established with evening relative humidity.

The regression coefficient exhibited the fact that the abiotic factors were highly influential while governing the population fluctuation and contributed (R^2 = 0.952 and 0.785) 95.2 and 78.5 per cent variation in *M. obtuse* population during both the years respectively, in ICPL 87. It was also found that an increase of one unit in maximum and minimum temperature would cause 0.067 and 0.326 unit increase in 2015 and 0.129 and 0.144 unit increase in the second year of study in the *M. obtusa* population. However, when the other weather parameters like morning relative humidity, evening relative humidity and rainfall increases by an unit it caused 0.105, 0.075 and 0.018 unit decrease in the pest population during 2015 but 0.142 unit decrease and 0.050 unit increase in *M. obtusa* populations due to one unit increase in morning relative humidity and evening relative humidity respectively during 2016. Likewise, in UPAS 120, 94.7 per cent and 82.8 per cent variations in the *M. obtusa* populations were brought about by the weather parameters. The findings are in accordance with the results of Keval and Srivastava [28], who studied the seasonal incidence of tur pod fly on pigeonpea and found that the maggot population had a significant and positive correlation with temperature and significant negative correlation with relative humidity and sunshine hours. Lall and Kumar [38] also reported that a positive significant correlation of pod fly population was observed with maximum temperature, minimum temperature and sunshine during 2009-10 and 2010-11 at Allahabad.

Table 1. Correlation matrix of incidence of different insect species with weather parameters in short duration pigeonpea (cv. ICPL 87 and cv. UPAS 120) during *Kharif* 2015 and 2016

Weather parameters	Legume pod borer (*M. vitrata*)		Tur pod fly (*M. obtusa*)		Tur pod bug (*C. gibbosa*)		Legume pod borer (*M. vitrata*)		Tur pod fly (*M. obtusa*)		Tur pod bug (*C. gibbosa*)	
	cv. ICPL						cv. UPAS 120					
	2015	**2016**	**2015**	**2015**	**2016**	**2015**	**2015**	**2016**	**2015**	**2015**	**2016**	**2015**
Maximum temperature (ºC)	0.827**	0.783**	0.871**	0.623 ns	0.723**	0.557 ns	0.729**	0.778**	0.853**	0.787**	0.774**	0.486 ns
Minimum temperature (ºC)	0.631*	0.520 ns	0.784**	0.734*	0.497 ns	0.436 ns	0.256 ns	0.473 ns	0.774**	0.745*	0.499 ns	0.344 ns
Morning relative humidity (%)	- 0.602*	- 0.711*	- 0.467 ns	- 0.644*	- 0.209 ns	- 0.841**	- 0.621*	- 0.735**	- 0.477 ns	- 0.849**	- 0.527 ns	- 0.852**
Evening relative humidity (%)	- 0.414 ns	- 0.683*	- 0.179 ns	- 0.345 ns	- 0.191 ns	- 0.710**	- 0.524 ns	- 0.705*	- 0.195 ns	- 0.696*	- 0.460 ns	- 0.743**
Rainfall (mm)	- 0.339 ns	- 0.258 ns	- 0.223 ns	0.000 ns	- 0.157 ns	- 0.275 ns	- 0.432 ns	- 0.297 ns	- 0.254 ns	0.000 ns	- 0.466 ns	- 0.342 ns

**Correlation issignificant at the 0.05 level (Two-tailed), **Correlation is significant at 0.01 level (Two-tailed), ns = non significant*

Table 2. Regression equations showing impact of weather parameters on populations of major insect pests on pigeonpea (cv. ICPL 87) during *Kharif* 2015and 2016

Insect pest	Regression equation	R^2 value
M. vitrata	$Y_{(2015\text{-}16)} = -60.882 + 0.732\,(X_1) + 1.020\,(X_2) - 0.406\,(X_3) - 0.160\,(X_4) - 0.032\,(X_5)$	0.839
	$Y_{(2016\text{-}17)} = 30.637 + 0.114\,(X_{1a}) + 0.536\,(X_{2a}) - 0.341\,(X_{3a}) - 0.036\,(X_{4a}) + 0.002\,(X_{5a})$	0.902
M. obtusa	$Y_{(2015\text{-}16)} = -7.360 + 0.067\,(X_1) + 0.326\,(X_2) - 0.105\,(X_3) - 0.075\,(X_4) - 0.018\,(X_5)$	0.952
	$Y_{(2016\text{-}17)} = 11.753 + 0.129\,(X_{1a}) + 0.144\,(X_{2a}) - 0.142\,(X_{3a}) + 0.050\,(X_{4a}) + 0.000\,(X_{5a})$	0.785
C. gibbosa	$Y_{(2015\text{-}16)} = -27.668 + 0.403\,(X_1) + 0.088\,(X_2) - 0.239\,(X_3) - 0.055\,(X_4) - 0.152\,(X_5)$	0.730
	$Y_{(2016\text{-}17)} = 38.608 + 0.544\,(X_{1a}) + 0.304\,(X_{2a}) - 0.290\,(X_{3a}) - 0.028\,(X_{4a}) - 0.636\,(X_{5a})$	0.841

Where, X_1 and X_{1a} = Maximum temperature (ºC), X_2 and X_{2a} = Minimum temperature (ºC), X_3 and X_{3a} = Morning relative humidity (%), X_4 and X_{4a} = Evening relative humidity (%), X_5 and X_{5a} = Rainfall (mm) during 2015 and 2016 respectively.

Table 3. Regression equations showing impact of weather parameters on populations of major insect pests on pigeonpea (cv. UPAS 120) during *Kharif* 2015 and 2016

Insect pest	Regression equation	R^2 value
M. vitrata	$Y_{(2015\text{-}16)} = 24.146 + 0.784\,(X_1) + 0.030\,(X_2) - 0.319\,(X_3) - 0.223\,(X_4) - 0.206\,(X_5)$	0.782
	$Y_{(2016\text{-}17)} = 25.721 + 0.032\,(X_{1a}) + 0.416\,(X_{2a}) - 0.311\,(X_{3a}) - 0.033\,(X_{4a}) + 0.001\,(X_{5a})$	0.880
M. obtusa	$Y_{(2015\text{-}16)} = -5.496 + 0.114\,(X_1) + 0.352\,(X_2) - 0.095\,(X_3) - 0.080\,(X_4) - 0.038\,(X_5)$	0.947
	$Y_{(2016\text{-}17)} = 16.662 + 0.220\,(X_{1a}) + 0.129\,(X_{2a}) - 0.133\,(X_{3a}) - 0.009\,(X_{4a}) + 0.000\,(X_{5a})$	0.828
C. gibbosa	$Y_{(2015\text{-}16)} = -32.546 + 0.324\,(X_1) + 0.396\,(X_2) - 0.233\,(X_3) - 0.027\,(X_4) - 0.102\,(X_5)$	0.757
	$Y_{(2016\text{-}17)} = 44.503 + 0.665\,(X_{1a}) + 0.306\,(X_{2a}) - 0.311\,(X_{3a}) - 0.048\,(X_{4a}) + 1.032\,(X_{5a})$	0.876

Where, X_1 and X_{1a} = Maximum temperature (ºC), X_2 and X_{2a} = Minimum temperature (ºC), X_3 and X_{3a} = Morning relative humidity (%), X_4 and X_{4a} = Evening relative humidity (%), X_5 and X_{5a} = Rainfall (mm) during 2015 and 2016 respectively.

3.2.3 Tur Pod Bug (*C. gibbosa*)

During *Kharif* 2015, it was observed that the *C.gibbosa* population had a highly significant positive correlation with maximum temperature in both the cultivars *i.e*. r = 0.723** in ICPL 87 and r = 774** in UPAS 120 under study. While, the other weather parameters had a non- significant effect on the pest populations during the first year of experimentation in both the genotypes.in case of morning relative humidity observed positive correlation and negative correlation with evening relative humidity, then while with rainfall observed positively correlated during 2015 in both the varieties. However during 2016, there existed non-significant relationship of maximum and minimum temperature, and rainfall with pod bug population in both the cultivars. While during the same year, the relative humidity was strongly and positively correlated with the tur pod bug population in both the genotypes *i.e*. ICPL 87 and UPAS 120 (Table 1). The results are in conformity with Kaushik et al. [39], where they reported that both maximum and minimum temperature exhibited a positive impact on the pest population. In our findings also the maximum and minimum temperatures showed a positive correlation with the pest population during the first year. The finding of Khamoriya et al. [40] further supports the present findings.

The regression coefficient revealed that the various abiotic factors contributed (R^2= 0.730 and 0.841) 73.0 and 84.1 per cent variation in *C. gibbosa* population during both the years, respectively. The regression equation was fitted to study the effectiveness of weather parameters for both the years, and it indicated that for an increase in every unit of maximum and minimum temperature, there was an increase of 0.403 and 0.088 unit during 2015, and 0.544 and 0.304unit during 2016 of *C. gibbosa* population respectively, in ICPL 87. While for every unit increase of morning and evening relative humidity and rainfall there was a decrease of *C. gibbosa* population (Table 1). Similarly, in UPAS 120, the weather factors were found to responsible for bringing (R^2 = 0.757 and 0.876) 75.7 and 87.6 per cent variation in the pod bug population in both the years of study respectively (Tables 2 and 3). The present results confirm the findings of Mishra and Das [41] and Kaushik et al. [39] which further supports the obtained results. Moreover, Chakravarty et al. [17] also found that the variations of different weather variables like temperature, relative humidity, sunshine hours and wind velocity caused approximately 91.1 per cent variation in *C. gibbosa* population in pigeonpea ecosystem which was approximately near to the result of the present experiment.

4. CONCLUSION

From the present study, it can be concluded that *M. vitrata*, *M. obtusa* and *C. gibbosa* are among the major insect pests infesting both the determinate (ICPL 87) and indeterminate (UPAS 120) cultivars of short duration pigeonpea in Varanasi region of Uttar Pradesh. Different weather parameters determine the seasonal activity and population dynamics of these insect pests on pigeonpea. The information generated in present study gives an indication about the importance of the different weather parameters in developing weather based forecasting models for successful development and implementation of the pest management strategies against insect pests of pigeonpea for increasing production efficiency, profit, besides safety to the environment.

ETHICAL APPROVAL

As per international standard or university standard written ethical permission has been collected and preserved by the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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