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Population dynamics of major insects of pigeonpea (*Cajanus Cajan* (L) Millsp.)

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Abstract
An experiment was conducted during *kharif* season 2015-2016 at experimental field of Department of Entomology, Live Stock Farm, Adhartal, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). To observe the "Population Dynamics of Major Insects of Pigeonpea (*Cajanus Cajan* **(**L**)** Millsp.)". Result revealed that thirteen insects were observed in pigeonpea i.e. Jassids *Empoasca fabae* Harris, Cow bug *Otinotus oneratus* W., Pod bug *Clavigralla gibbosa* Spinola, *Riptortus* sp., Red cotton bug *Dysdercus koenigii* Fabricius, Green stink bug *Nezara viridula* Linn, Grasshopper *Cyrtacanthacris* sp. (L.), Red pumpkin beetle *Aulacophora foveicollis* (Lucas), Thrips *Megalurothrips usitatus* Baganll, Pod fly *Melanagromyza obtusa* (Malloch), Leaf webber *Grapholita critica* (Meyr), Gram pod borer *Helicoverpa armigera* (Hub.) and Tur plume moth *Exelastis atomosa* (W.).

Keywords: Population dynamics, major insects, pigeonpea

1. Introduction
Pigeonpea (*Cajanus cajan* (L) Millsp.) is an important multi-use shrub legume of the tropics and subtropics. The crop originated from India and moved to Africa about 4,000 years ago. Unlike other grain legumes, pigeonpea production is concentrated in developing countries, particularly in a few South and Southeast Asia and Eastern and Southern African countries. It is the preferred pulse crop in dryland areas where it is intercropped or grown in mixed cropping systems with cereals or other short duration annuals without significantly reducing the yield (Joshi *et al*., 2001) [13]. Its grain is of high nutritional value with high protein content that ranges from 21% to over 25% making it very valuable for improving food security and nutrition for many poor families who cannot afford dairy and meat-based diet (Kimani, 2001) [15].

Pigeonpea has a wide range of products, including the dried seed, pods and immature seeds used as green vegetables, leaves and stems used for fodder and the dry stems as fuel. It also improves soil fertility through nitrogen fixation as well as from the leaf fall and recycling of the nutrients (Snapp *et al*., 2002) [29]. It is an important pulse crop that performs well in poor soils and regions where moisture availability is unreliable or inadequate.

Pigeonpea a tropical grain legume, mainly grown in India and ranks second in area and production and contributes about 90% of the world's pulse production. In India during 2014 pigeonpea was cultivated in an area of 3.88 million ha and production of about 3.29 million tonnes, with a productivity of 849 kg /ha (DES, 2014) [9].

In the country, the crop is extensively grown in Uttar Pradesh, Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh and Gujarat. Uttar Pradesh has a unique distinction of contributing about 20% production in the country followed by Madhya Pradesh (Sahoo and Senapati, 2000) [26].

In Madhya Pradesh, during 2014 pigeonpea was cultivated in an area of about 0.49 million hectare with production of 0.46 million tonnes and 955 kg/ha productivity (DES, 2014) [9]. In Jabalpur, during 2013-14 it was cultivated in an area of 10,930 hectare with a total production of 9,700 tonnes and 886 kg/ha productivity (www.mpkrishi.org 2013-14) [32].

Though India is the largest producer of pigeonpea, the productivity has always been a great concern, and the productivity of pigeonpea has not increased considerably during last decade. The damage caused by insect pests is one of the major reasons of low productivity. They key pests include pod borer complex *viz.* gram pod borer (*Helicoverpa armigera* Hubner), plume moth (*Exelastis atomosa* Walsingham), pod fly (*Melanagromyza obtusa* Malloch) and pod bug

(*Clavigralla gibbosa* Spinola) which cause considerable losses in grain yield ranging from 30 to 100% (Satpute and Barkhade, 2012) [27].

Pod infesting insect pests recorded at Jabalpur are gram pod borer (*H. armigera* Hubner), pod bug (*C. gibbosa* Spinola), pod fly (*M. obtusa* Malloch) and plume moth (*E. atomosa* Walsingham). Out of the four pests, *M. obtusa* has established as the most important pest on the basis of pod and grain damage which range from about 55 to 85 and 29 to 63 per cent, respectively (Landge, 2009) [2]. Pod fly now has become an important biotic constraint in increasing the production and productivity under subsistence farming conditions, irrespective of agro ecological zones. The survey of Marathwada region of Maharashtra during 2007–08 revealed that the damage by pod fly ranged from 25.5 to 36% (Anonymous 2008) [6]. The estimates of avoidable losses due to pod borer complex, mainly pod fly and *H. armigera* were 43.5 and 30.2%, respectively (Anonymous 2012) [7]. The present study was done to observe the "Population Dynamics of Major Insects of Pigeonpea (*Cajanus Cajan* (L) Millsp.)"

2. Methods and Materials

The present investigation entitled, "Population Dynamics of Major Insects of Pigeonpea (*Cajanus Cajan* (L) Millsp.)" was carried out in the experimental field of Department of Entomology, Live Stock Farm, Adhartal, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during *kharif* season 2015-2016.

2.1 Mathodology of observations

Observations on different insects was recorded on 25 randomly selected plants twice in a standard week. It was initiated after germination and was taken upto the maturity of the crop. Observations of jassids (nymph + adult) were recorded on six leaves per plant viz., each from 2 upper, middle and lower leaves per plant. Observations on leaf webber, spider, green stink bug (nymph + adult), pod bug (nymph + adult), pod borer larvae and plume moth(larvae + pupae) were recorded on per plant basis, while pod fly maggot were recorded on randomly selected 25 pods per 5 plants. Sweep nets were used for population monitoring of weak and active insect fliers and the methodology was adopted as proposed by Abd-Elsamed *et al* (2011) [4]. Meteorological data were collected and correlation studies were carried out with the various insect population.

2.2 Statistical Methods

Correlation and regression of the abiotic factors on major insect pests were worked out by using the formula as suggested by Snedecor and Cochran (1967) [30].

$$\text{Correlation } 'r' = \frac{\sum XY - \frac{\sum X \sum Y}{n}}{\sqrt{\frac{\{\sum X^2 - (\sum X)^2\}}{n} \frac{\{\sum Y^2 - (\sum Y)^2\}}{n}}}$$

Where,
r = Correlation coefficient
$\sum xy$ = Sum of product of both variables x and y
$\sum x$ = Sum of variable x
$\sum y$ = Sum of variable y
$\sum x^2$ = Sum of square of variable x
$\sum y^2$ = Sum of square of variable y
n = Number of observations

$$\text{Regression } Y = a + b\,x\,(R^2)$$

Where,
a = Intercept
b = Régression coefficient
R^2 = Coefficient of multiple détermination

3. Results and Discussion

Result revealed that thirteen insects were observed in pigeonpea i.e. Jassids *Empoasca fabae* Harris, Cow bug *Otinotus oneratus* W., Pod bug *Clavigralla gibbosa* Spinola, *Riptortus* sp., Red cotton bug *Dysdercus koenigii* Fabricius, Green stink bug *Nezara viridula* Linn, Grasshopper *Cyrtacanthacris* sp. (L.), Red pumpkin beetle *Aulacophora foveicollis* (Lucas), Thrips *Megalurothrips usitatus* Baganll, Pod fly *Melanagromyza obtusa* (Malloch), Leaf webber *Grapholita critica* (Meyr), Gram pod borer *Helicoverpa armigera* (Hub.) and Tur plume moth *Exelastis atomosa* (W.).

3.1 Jassids, *Empoasca fabae* Harris (Hemiptera: Cicadellidae): (Table 1 & 2)

The jassids, *E. fabae* was first recorded during the third week of August *i.e.,* on 21st August (34thSW). The activity of the pest continued from 22ndAugust to second week of December. In the present study, the peak population of the pest were observed during 37th SW (*i.e.,* second week of September), 43rd SW (*i.e*., third week of October) and 47th SW (*i.e.,* third week of November).

On the contrary, Pandey and Das (2014) [21] reported that incidence of jassids started from second week of September and was available upto first week of February.

Correlations between various abiotic factors and jassid population exhibited significant positive impact of maximum temperature and minimum temperature on pest population.

The present findings are in accordance with the findings of Reddy *et al*., (2001) [25], Kaushik *et al*., (2008) [14] and Pandey and Das (2014) [21]. They also reported significant positive influence of minimum temperature on jassid population. The present findings contradicts the findings of Reddy *et al*., (2001) [25], Kumar and Nath (2003) [16], Kaushik *et al*., (2008) [14] and Kumar *et al*., (2010) [17]. They reported that maximum temperature showed negative influence on jassid population. The present findings are in conformity with the findings of Pandey and Das (2014) [21]. they also reported significant positive influence of minimum temperature on jassid population.

In the present findings evening relative humidity showed positive impact on jassid population. The present findings are in accordance with the findings of Kaushik *et al*., (2008) [14]. They also reported positive impact of evening relative humidity on the pest population.

Present findings indicate that morning relative humidity exhibited positive influence on jassid population but was non-significant. Similar findings have been reported by Reddy *et al*., (2001) [25] and Kaushik *et al*., (2008) [14]. They also reported positive influence of morning relative humidity on jassid population.

In the present findings evaporation showed positive impact on the jassid population. It contradicts the findings of Kumar and Nath (2003) [16] and Kumar *et al*., (2010) [17]. They also reported negative influence of evaporation on jassid population. (Similar findings have been reported by Pandey and Das (2014) [21]. They also reported that evaporation showed positive influence on jassid population).

Present findings indicate that wind speed exhibited positive influence on jassid population. The present findings contradicts the findings of Kaushik *et al*., (2008) [14], as they have reported negative impact of wind speed on jassid population.

In the present findings sunshine showed negative impact on jassid population. The present findings confirms the findings of Kumar and Nath (2003) [16] and Kumar *et al*., (2010) [17]. They have also reported negative impact of sunshine on jassid population.

3.2 Cow bug, *Otinotus oneratus* W. (Hemiptera: Membracidae): (Table 2 & 3)

The cow bug was first recorded during the third week of August *i.e.*, on 21st August (34th SW). The activity of the pest continued from 22nd August to first week of November. The peak population of the pest were observed during 38th SW (*i.e.*, third week of September), 42nd SW (*i.e*., third week of October) and 44th SW (*i.e.*, last week of October).

Correlation between various abiotic factors (*viz.* maximum temperature, minimum temperature, morning relative humidity and evening relative humidity, wind speed, sunshine, rainfall, rainy days, morning and evening vapour pressure and evaporation) exhibited positive influence on cow bug population, but statistically found to be non significant.

3.3 Pod bug, *Clavigralla gibbosa* Spinola (Hemiptera: Coreidae): (Table 2 & 3)

The pod bug, *C. gibbosa* was first recorded during the second week of September *i.e.*, on 11st September (37th SW). The activity of the pest continued from 12th September to second week of January.

The present findings corroborates the findings of Pandey and Das (2014) [21]. They have also reported that the incidence of pod bug was observed from first week of September (36thWS). On the contrary, Mishra and Dash (2001), Kumar and Nath (2004) [19] and Rathore (2011) reported the incidence from 2nd week of November (46thWS), 4th week of January (4thWS) and 3rd week of November (47thWS), respectively.

The peak population of the pest was observed during 49th SW *(i.e.* first week of December) and 52nd SW (i.e. fourth week of December).

In the present study two peaks were recorded, during 49th and 52nd SW, whereas Mishra and Dash (2001) reported two peaks but during 50th and 4th SW, respectively. However, Kumar and Nath (2004) [19] and Pandey and Das (2014) [21]. reported that the pest attained only one peak (12th WS and 5th WS, respectively).

Correlations between various abiotic factors and pod bug population exhibited that evaporation had significant negative impact on the pest population. The present findings confirms the findings of Pandey and Das (2014) [21]. they also reported negative impact of evaporation on the pest population.

In the present findings maximum and minimum temperature showed negative effect on pest population. On the contrary Kaushik *et al*., (2008) [14] reported positive impact of minimum temperature on the pest population. However, Mishra and Dash (2001) reported that there was no relationship of both the temperature on pod bug population.

In the present findings evening relative humidity showed negative effect on the pest population, but statistically found to be non significant. The present findings confirms the findings of Mishra and Dash (2001) and Kaushik *et al*., (2008) [14]. They also reported negative influence of evening relative humidity on the pest population. On the contrary Kumar and Nath (2004) [19] reported positive effect on pest population.

In the present findings morning vapour pressure showed significant negative correlation with pod bug population

In the present findings wind speed, sunshine, rainfall and rainy days, showed negative correlation with pod bug population, but statistically found to be non significant. Similar findings have been reported by Kaushik *et al*., (2008) [14]. They also reported negative impact of wind speed on pod bug population. However, Mishra and Dash (2001) reported that rainfall had no influence on pod bug population.

In the present findings morning relative humidity showed positive correlation with pod bug population, but statistically found to be non significant. Similar findings have been reported by Kumar and Nath (2004) [19] and Kaushik *et al*., (2008) [14]. On the contrary Mishra and Dash (2001) reported negative influence of morning relative humidity on pod bug population.

3.4 Riptortus, *Riptortus* sp. (Hemiptera: Coreidae): (Table 2 & 3)

The riptortus bug *Riptortus* sp. was first recorded during the second week of September *i.e.*, on 11th September (37th SW). The activity of the pest continued from 12th September to first week of January. The peak population of the pest was observed during 40th SW (*i.e.* first week of October) and 49thSW (*i.e.* first week of December).

Correlation between various abiotic factors *viz.* maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind speed, sunshine, rainfall, rainy days, morning an d evening vapour pressure and evaporation exhibited negative influence on riptortus bug population, but statistically found to be non significant

3.5 Red cotton bug, *Dysdercus koenigii* Fabricius (Hemiptera: Pyrrhocoridae): (Table 2 & 3)

The red cotton bug, *D. Koengi* was first recorded during the second week of September *i.e.*, on 11th September (37th SW). The activity of the pest continued from 12th September to second week of November. The peak population of the pest was observed during 40th– 41stSW (*i.e.* first week of October to second week of October).

Correlation between various abiotic factors *viz.* maximum temperature, wind speed, sunshine and morning vapour pressure showed significant positive effect on bug population. Whereas, morning relative humidity and evening vapour pressure exhibited significant negative impact on the bug population.

While minimum temperature and rainfall showed negative influence on bug population, but statistically found to be non significant. Similarly, evening relative humidity, rainy days and evaporation exhibited positive impact on bug population, but statistically found to be non significant.

3.6 Green stink bug, *Nezara viridula* Linn (Hemiptera: Pentatomidae): (Table 2 & 3)

The green stink bug, *N. viridula* was first recorded during the fourth week of September *i.e.*, on 25thSeptember (39th SW). The activity of the pest continued from 26th September to first week of January.

The present findings contradicts the findings of Pandey and Das (2014) [21]. They have reported that the incidence of green stink bug was observed from 36th SW (1st week of September) and was available upto 5th WS (1st week of February).

The peak population of the pest were observed during 41st SW (*i.e.* second week of October), 47th SW (*i.e.,* third week of November) and 49th SW (*i.e.,* first week of December).
Sunshine showed significant negative impact on green stink bug population.
Whereas, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall, rainy days, morning and evening vapour pressure showed positive influence on green stink bug population, but statistically found to be non significant. Similarly, wind speed and evaporation showed negative effect on green stink bug population, but statistically found to be non significant.
The present findings confirms the findings of Pandey and Das (2014) [21]. They also reported negative influence of wind speed on green stink bug population.

3.7 Grasshopper, *Cyrtacanthacris* sp. (Orthoptera: Acrididae): (Table 4 & 5)
The grasshopper, *Cyrtacanthacris* sp**.** was first recorded during the first week of September *i.e.,* on 5th September (36th SW). The activity of the pest continued from 6th September to third week of November. The peak population of the pest was observed during 40th SW (*i.e.* first week of October) and 42nd SW (*i.e.* third week of October).
Morning relative humidity, evening relative humidity, wind speed, rainfall, rainy days, morning and evening vapour pressure and evaporation showed negative effect on pest population, but statistically found to be non significant.
Whereas, maximum temperature, minimum temperature and sunshine exhibited positive impact on the pest population, but statistically found to be non significant.

3.8 Red pumpkin beetle, *Aulacophora foveicollis* (Lucas) (Coleoptera: Chrysomelidae): (Table 4 & 5)
The red pumpkin beetle, *A. Foveicollis* was first recorded during the second week of September *i.e.,* on 11th September (36th SW). The activity of the pest continued from 12th September to second week of October. The peak population of the pest was observed during 39th SW (*i.e.* fourth week of September).
Maximum temperature showed significant negative effect on the beetle population.
Whereas, minimum temperature, evening relative humidity, wind speed, rainfall, rainy days, morning and evening vapour pressure and evaporation exhibited positive impact on the beetle population, but statistically found to be non significant.

3.9 Thrips, *Megalurothrips usitatus* Bagnall (Thysanoptera: Thripidae): (Table 4 & 5)
The thrips, *M. usitatus* was first recorded during the first week of October *i.e.,* on 2nd October (40th SW). The activity of the pest continued from 3rd October to first week of January. The peak population of the pest was observed during 48th SW (*i.e.* fourth week of November), 50th SW (*i.e.* second week of December) and 52nd SW (*i.e.* fourth week of December).
In the present findings all the abiotic factors *viz.* maximum and minimum temperature, morning and evening relative humidity, wind speed, sunshine, rainfall, rainy days, morning and evening vapour pressure and evaporation exhibited negative impact on thrips population, but statistically found to be non significant.
The present findings are in conformity with the findings Reddy *et al*., (2001) [25], Kumar and Nath (2003) [16] Kaushik *et al*., (2008) [14], Mahalle (2008), Kumar *et al*., (2010) [17] and Landge (2009) [2]. They also reported negative impact of maximum temperature, minimum temperature, evening relative humidity, wind speed, sunshine, evening vapour pressure and evaporation on thrips population.
However, the present findings contradicts the findings of Reddy *et al*., (2001) [25], Kaushik *et al*., (2008) [14] and Landge (2009) [2] as they reported positive impact of maximum temperature and morning relative humidity, on thrips population.

3.10 Pod fly, *Melanagromyza obtusa* Malloch (Diptera: Agromyzidae): (Table 4 & 5)
The maggot of pod fly, *M. obtusa* was first recorded during the third week October *i.e.,* on 16th October (42nd SW). The activity of the pest continued from 17th October to first week of January. The peak population of the pest were observed during 45th SW (*i.e.,* first week of November) and 51st SW (*i.e.,* third week of December).
The present findings are in conformity with the findings of Dwivedi *et al*., (2013). They also reported that the insect attained peak when the maximum and minimum temperatures were 31.7 ºC and 15.2ºC, respectively coupled with relative humidity of 87.30%.
Das and Katiyar (1998), Kumar *et al* (2003), Kumar and Nath (2004) [19], Subharani and Singh (2007) and Rathore (2011) reported that the first appearance of the pest was recorded during the last week of October, first week of February, fourth week of January, third week of January and last week of December (i.e., pod filling stage), respectively. The activity of the pest continued from 16th October to first week of January i.e., podding stage.
The present findings contradicts the findings of Kumar *et al*., (2003) and Kumar and Nath (2004) [19]. They reported that the pest was available upto first and second week of April, respectively. The peak population of the pest was observed during 45th SW (i.e., second week of November) and 51st SW (third week December).
Akhauri *et al*., (1994), Das and Katiyar (1998) reported that the pest attained two peaks i.e., 2nd week of February first week of March and first week of February third week of December, respectively. However, Subharani and Singh (2007) recorded one peak *viz*. 2nd- 3rd week of February.
In the present findings maximum temperature exhibited negative impacton the pest population, but statistically found to be non significant and it confirms the findings of Landge (2009) [2]. However, it contradicts with Subharani and Singh (2007) and Kaushik *et al*., (2008) [14], as they reported no relationship and positive impact on the pest population, respectively.
Minimum temperature showed positive effect on the pest population, but statistically found to be non significant. The present findings corroborates the findings of Subharani and Singh (2007), Kaushik *et al*., (2008) [14] and Landge (2009) [2]. They also reported positive influence of minimum temperature on pest population.
Morning relative humidity exhibited positive impact on the pest population, but statistically found to be non significant. The present findings confirms the findings of Kumar and Nath (2004) [19], Kaushik *et al*., (2008) [14] and Landge (2009) [2]. On the contrary Subharani and Singh (2007) and Mahalle (2008), reported negative influence of morning relative humidity on the pest population.
Evening relative humidity exhibited positive impact on the pest population, but statistically found to be non significant. The present findings confirms the findings of Subharani and Singh (2007) and Kaushik *et al*., (2008) [14], as they reported

negative influence of evening relative humidity on pest population.

Sunshine had negative effect on the pest population and it corroborates the findings of Subharani and Singh (2007) and Landge (2009) [2].

Evaporation showed negative impact on the pest population, but statistically found to be non significant and are in conformity with the findings of Landge (2009) [2], but are not in accordance with that of Mahalle (2008) as he reported positive effect of evaporation on the pest population.

Wind speed had positive effect on the pest population, but statistically found to be non significant and it is in conformity with the findings of Subharani and Singh (2007), but contradicts with Kaushik *et al*., (2008) [14].

Evening vapour pressure had positive influence on the pest population and it confirms the findings of Landge (2009) [2].

Rainfall had positive impact on pest population, but statistically found to be non significant. The present findings are in conformity with the findings of Subharani and Singh (2007).

3.11 Leaf webber, *Grapholita critica* Meyr (Lepidoptera: Tortricidae): (Table 6 & 7)

The leaf webber, *G. critica* was first recorded during the first week of August *i.e.*, on 7th August (32nd SW). The activity of the pest continued from 8th September to first week November. The peak population of the pest were observed during 33rd SW (*i.e.* third week of August), 37th SW (*i.e.* second week of September) and 40th SW (*i.e.* first week of October).

The present findings are in conformity with the findings of Dwivedi *et al*., (2013). They also reported that the pest attained peak when the maximum and minimum temperature were 34.3 ºC and 21.20 ºC, respectively, coupled with relative humidity of 65%.

In the present findings, wind speed had negative effect on the pest population, but statistically found to be non significant. It contradicts the findings of Kumar *et al*., (2010) [17] and Dwivedi *et al*., (2013) they also reported positive impact on the pest population but of the preceding week.

In the present findings maximum and minimum temperature had positive effect on the pest population, but statistically found to be non significant. The present findings confirms the findings of Kumar *et al*.,(2010) [17].

Evaporation exhibited positive influence on the pest population. The present findings are in conformity with the findings of Kumar *et al*., (2010) [17]. They also reported positive effect on pest population, but of the preceding week.

3.12 Gram pod borer, *Helicoverpa armigera* Hub. (Lepidoptera: Noctuidae): (Table 6 & 7)

The pod borer, *H. armigera* larva was first recorded during the third week of October i.e., on 16th October (42nd SW). The activity of the pest continued from 17th October to first week of January.

However, Akhauri *et al*., (1994), Patel and Koshiya (1999), Kumar *et al*., (2003), Kumar and Nath (2004) [19], Ambulkar (2008) and Rathore (2011) reported that the pest activity were observed from January to March, first week of October to last week of November, first week of February to last week of March, last week of January to first week of April third week of October and third week of November, respectively.

The peak population of the pest was observed during 48th SW (i.e., fourth week of November). During this period maximum and minimum temperature were 30.8ºC and 14.5ºC, respectively, whereas morning and evening relative humidity were 88 and 34%, respectively. However, Dwivedi *et al*., (2013) reported that the pest attained its peak when the maximum and minimum temperature was 26.1ºC and 8.5ºC, respectively and relative humidity was 51.4%.

However, Akhauri *et al*., (1994), Patel and Koshiya (1999) and Dhar *et al*., (2003) reported that the peak activity of the pest was recorded from February end to third week of March, last week of October and first week of March to first week of April, respectively.

In the present findings maximum temperature showed positive influence on pest population and it confirms the findings of Reddy *et al*., (2001) [25], Ram *et al*., (2003), Saxena and Ram (2007) and Kaushik *et al*., (2008) [14]. However, it contradicts with those of Deshmukh *et al*., (2005), as they reported negative impact on the pest population.

Minimum temperature showed negative impact on pest population it confirms the findings of Ram *et al*., (2003), Deshmukh *et al*., (2005) and Saxena and Ram (2007). However, it contradicts the findings of Reddy *et al*., (2001) [25], Dhar *et al*., (2003) and Kaushik *et al*., (2008) [14] as they reported positive correlation with pest population.

Morning relative humidity had positive influence on insect population and it is in agreement with those of Reddy *et al*., (2001) [25], Ram *et al*., (2003), Kumar and Nath (2004) [19], Saxena and Ram (2007) and Kaushik *et al*., (2008) [14] as they also reported positive impact of morning relative humidity on the pest population.

Evening relative humidity showed negative impact on the pest population and it is in accordance with those of Reddy *et al*., (2001) [25] and Kaushik *et al*., (2008) [14]. However, it contradicts with the findings of Ram *et al*., (2003), Kumar and Nath (2004) [19] and Saxena and Ram (2007) as they reported positive correlation with pest population.

Wind speed had negative impact on the pest population; however it confirm the findings of Reddy *et al*., (2001) [25] and Kaushik *et al*., (2008) [14].

Sunshine had negative effect on the pest population and is in conformity with those of Reddy *et al*., (2001) [25] but contradicts with Ram *et al*., (2003)

Rainfall had negative non significant effect on the pest population and it contradicts the findings of Dhar *et al*., (2003) and Ram *et al*., (2003). They reported rainfall to have positive but non significant effect on the pest population.

3.12 Tur plume moth, *Exelastis atomosa* Walsingham (Lepidoptera: Pterophoridae) (Table 6 & 7)

The larva of plume moth, *E. atomosa* was first recorded during the last week of the October *i.e.*, on 30th October (44th SW). The activity of the pest continued from 31stOctober to second week of January. The peak population of the pest were observed during 49th SW (*i.e.,* first week of December) and 51st SW (*i.e.*, third week of December).

However, Dwivedi *et al*., (2013) reported that the pest attained its peak during 44th SW (last week of October to first week of November).

Correlations between various abiotic factors and tur plume moth larval population exhibited non significant impact on the pest population

In the present findings, maximum temperature exhibited positive impact on pest population, which are in conformity with the findings of Reddy *et al*., (2001) [25] and Kaushik *et al*., (2008) [14]. They also reported positive impact of maximum temperature on the pest population. Further, minimum temperature showed negative impact on the pest population, which confirms the findings of Reddy *et al*., (2001) [25], Deshmukh *et al*., (2005), and Kaushik *et al*., (2008) [14].

Morning relative humidity exhibited negative impact on the pest population and are in accordance with those of Deshmukh *et al*., (2005), but contradicts the findings of Reddy *et al*., (2001) [25] and Kaushik *et al*., (2008) [14]. They reported positive correlation between morning relative humidity and pest population.

Evening relative humidity and sunshine had negative effect on pest population, which is in conformity with the findings of Reddy *et al*., (2001) [25] and Kaushik *et al*., (2008) [14].

Wind speed had positive influence on pest population. The present findings are not in agreement with the findings of Reddy *et al*., (2001) [25] and Kaushik *et al*., (2008) [14], as they also reported negative impact of wind speed on pest population.

Evening vapour pressure exhibited negative impact on pest population, which confirms the findings of Landge (2009) [2].

Table 1: Incidence of Jassids, *Empoasca fabae* Harris on different plant canopy of pigeonpea (cv. TJT-501) at Jabalpur during 2015-16

SW	Mean jassid (nymph and adult) population per leaf on different plant canopy			
	Upper leaf	**Middle leaf**	**Lower leaf**	**Mean**
34	7.40 (2.81)	2.80 (1.81)	0.80 (1.14)	3.67
35	10.10(3.25)	3.25 (1.93)	0.20 (0.80)	4.52
36	9.20 (3.11)	3.50(2.00)	0.30 (0.08)	4.33
37	10.20(3.27)	7.85(2.88)	2.00 (1.58)	6.68
38	9.20 (3.25)	6.00 (2.54)	0.90 (1.18)	5.37
39	7.20 (2.77)	5.10 (2.36)	0.20 (0.83)	4.17
40	5.40 (2.42)	5.70 (2.48)	0.00 (0.70)	3.70
41	3.90 (2.09)	3.60 (2.02)	0.00 (0.70)	2.50
42	4.40 (2.21)	5.60 (2.46)	0.00 (0.70)	3.33
43	5.60 (2.46)	5.00 (2.34)	0.00 (0.70)	3.53
44	3.25 (1.93)	3.20 (1.92)	0.00 (0.70)	2.15
45	3.00 (1.87)	3.60 (2.02)	0.00 (0.70)	2.20
46	4.08 (2.14)	4.20 (2.16)	0.00 (0.70)	2.76
47	4.30 (2.19)	4.30 (2.19)	0.00 (0.70)	2.87
48	3.53(2.00)	2.50 (1.73)	0.00 (0.70)	2.01
49	1.00 (1.22)	0.98 (1.21)	0.00 (0.70)	0.66
50	0.20 (0.83)	0.30 (0.89)	0.00 (0.70)	0.17
Mean	5.40(2.34)	3.96(2.11)	0.25(0.78)	3.21
SD.	0.55	1.65	0.56	
SE±	0.16	0.23	0.21	
Variance	0.74	0.81	0.75	
Tcal	Upper vs middle	Upper vs lower	Middle vs lower	
Tcal	1.71 NS	9.75*	9.74*	

NS = Non Significant SE = Standard error
* = Significant at 5% SW = Standard weeks
Tcal = T calculated vs = versus
SD = Standard Deviation

Table 2: Correlation (r) and regression coefficient (byx) of abiotic factors on Hemipteran insect pests (nymph+adult) infesting pigeonpea

Weather factors	Jassids		Cow bug		Pod bug		Riptortus sp.		Red cotton bug		Green stink bug	
	R	**Byx**	**R**	**byx**	**r**	**byx**	**r**	**byx**	**R**	**Byx**	**r**	**byx**
Max. temperature ˚C	0.61*	0.42	0.06 NS	-	-0.38 NS	-	-0.31 NS	-	0.76*	0.11	0.18 NS	-
Min. temperature ˚C	0.86*	0.28	0.31 NS	-	-0.52*	-0.34	-0.33 NS	-	-0.05 NS	-	0.11 NS	-
Morning RH (%)	0.30NS	-	0.26 NS		0.16 NS	-	-0.108 NS	-	-0.88*	-0.04	0.41 NS	-
Evening RH (%)	0.64*	0.07	0.21 NS	-	-0.46 NS	-	-0.18 NS	-	0.47 NS	-	0.15 NS	-
Wind speed (km/ hr)	0.43NS	-	0.14 NS	-	-0.35 NS	-	-0.15 NS	-	0.87*	0.09	-0.35 NS	-
Sunshine (hrs)	-0.08NS	-	0.01 NS	-	-0.16 NS	-	-0.09 NS	-	0.79*	0.16	-0.54*	-1.77
Rainfall (mm)	0.35NS	-	0.19 NS	--	-0.27 NS	-	-0.31 NS	-	-0.28 NS	-	0.09 NS	-
Rainy days (nos.)	0.48*	0.57	0.2 NS	-	-0.32 NS	-	-0.25 NS	-	0.62 NS	-	0.09 NS	-
Morn. Vapour pressure (mm)	0.88*	0.31	0.38 NS	-	-0.54*	-0.40	-0.34 NS	-	0.80*	0.02	0.05 NS	-
Even. Vapour pressure (mm)	0.84*	0.28	0.35 NS	-	-0.54*	-0.45	-0.28 NS	-	-0.90*	-0.01	0.11 NS	-
Evaporation (mm)	0.77*	1.53	0.27 NS	-	-0.56*	-2.47	- 0.28 NS	-	0.40 NS	-	-0.22 NS	-

NS =Non significant * Significant at 5%

Table 3: Incidence of Hemipteran insect pests infesting pigeonpea at Jabalpur during 2015-16

SW	Mean population of Hemipterans (nymph+adult)/plant				
	Cow bug	**Pod bug**	**Riptortus bug**	**Red cotton bug/sweep**	**Green stink bug**
34	0.44	-	-	-	-
35	0.88	-	-	-	-
36	1.50	-	-	-	-
37	2.78	0.14	8.80	0.50	-
38	3.08	0.10	1.60	0.80	-
39	1.32	0.10	4.00	1.00	0.96

40	0.66	0.24	4.10	1.60	3.60
41	0.44	1.68	4.00	1.60	5.20
42	2.53	1.68	4.80	0.90	4.04
43	1.10	2.04	3.20	0.80	6.42
44	1.65	1.80	4.80	0.80	7.24
45	0.44	3.48	5.80	0.40	8.88
46	-	3.76	6.00	0.20	12.72
47	-	7.44	7.00	-	14.16
48	-	10.32	7.20	-	7.56
49	-	13.56	13.68	-	8.40
50	-	7.56	11.20	-	3.60
51	-	3.80	10.40	-	2.40
52	-	4.60	3.20		2.16
1	-	3.36	0.50	-	1.20
2	-	0.20	-	-	-

SW = Standard weeks

Table 4: Incidence of insect pests infesting pigeonpea at Jabalpur during 2015-16

SW	Mean population of insect pests/plant			
	Grasshopper (nymph+adult)/ sweep	**Red pumpkin beetle/ sweep**	**Thrips/flower**	**Pod fly (maggot +pupa)/25 pods**
36	0.90	-		-
37	1.80	16.0	-	-
38	3.00	32.0	-	-
39	3.00	36.0	-	-
40	7.50	24.0	2.0	-
41	3.0	8.0	0.3	-
42	16.50	-	0.32	0.10
43	6.00	-	0.47	2.70
44	4.50	-	0.73	4.80
45	4.50	-	0.80	6.00
46	1.00		2.56	6.00
47	1.00	--	3.67	6.00
48	-	-	5.20	5.00
49	-		4.47	4.80
50	-	-	4.97	4.00
51	-	-	3.87	4.00
52	-	-	4.57	2.10
1		-	3.30	0.50

SW= Standard weeks

Table 5: Correlation (r) and regression coefficient (byx) of abiotic factors on insect pests infesting pigeonpea

Weather factors	**Grasshopper**		**Red pumpkin beetle**		**Thrips**		**Pod fly**	
	R	**byx**	**r**	**Byx**	**r**	**byx**	**r**	**byx**
Max. temperature ˚C	0.34NS	-	-0.91*	-8.98	-0.32 NS	-	-0.02 NS	-
Min. temperature ˚C	0.009 NS	-	0.50 NS	-	-0.38 NS	-	0.13 NS	-
Morning RH (%)	-0.32 NS	-	-0.26 NS	-	-0.04 NS	-	0.22 NS	-
Evening RH (%)	-0.27 NS	-	0.47 NS	-	-0.51 NS	-	0.27 NS	-
Wind speed (km/ hr)	-0.13 NS	-	0.73 NS	-	-0.19 NS	-	0.005 NS	-
Sunshine (hrs)	0.35 NS	-	-0.41 NS	-	-0.11 NS	-	-0.74*	-1.46
Rainfall (mm)	-0.12 NS	-	0.41 NS	-	-0.26 NS	-	0.14 NS	-
Rainy days (nos.)	-0.23 NS	-	0.32 NS	-	-0.26 NS	-	0.14 NS	-
Morn. Vapour pressure (mm)	-0.002 NS	-	0.32 NS	-	-0.48 NS		0.05 NS	-
Even. Vapour pressure (mm)	-0.16 NS	-	0.40 NS	-	-0.28 NS	-	0.15 NS	-
Evaporation (mm)	-0.18 NS	-	0.26 NS	-	-0.39 NS	-	-0.29 NS	-

NS =Non significant * Significant at 5%

Table 6: Incidence of Lepidopteran insect pests infesting pigeonpea Jabalpur during 2015-16

SW	**Mean population of Lepidopterans (larvae/plant**		
	Leaf webber	**Pod borer**	**Plume moth**
32	3.00	-	-
33	9.00	-	-
34	2.40	--	-
35	6.60	-	
36	9.00	-	-
37	23.85	-	-
38	9.30	-	-

39	8.40	-	--
40	9.60	-	-
41	1.20	-	-
42	3.00	0.50	-
43	2.40	0.80	-
44	2.25	0.60	0.50
45	-	1.20	0.80
46	-	2.80	0.98
47	-	3.40	2.03
48	-	5.00	2.66
49	-	4.40	3.50
50	-	2.50	1.00
51	-	1.10	1.33
52	-	0.50	1.16
1	-	0.40	1.12
2	-	-	0.60

SW = Standard weeks

Table 7: Correlation (r) and regression coefficient (byx) of abiotic factors on Lepidopteran insect pests infesting pigeonpea

Weather factors	Leaf webber		Pod borer		Tur plume moth	
	R	**byx**	**r**	**byx**	**r**	**byx**
Max. temperature ˚C	0.16 NS	-	0.08 NS	-	0.18 NS	-
Min. temperature ˚C	0.41 NS	-	-0.07 NS	-	-0.08 NS	-
Morning RH (%)	0.19 NS	-	0.09 NS	-	0.37 NS	-
Evening RH (%)	0.11 NS	-	-0.24 NS		-0.33 NS	-
Wind speed (km/ hr)	-0.01 NS	-	-0.21 NS	-	-0.20 NS	-
Sunshine (hrs)	0.07 NS	-	-0.11 NS	-	0.19 NS	-
Rainfall (mm)	0.05 NS		-0.25 NS	-	-0.32 NS	-
Rainy days (nos.)	0.13 NS	-	-0.25 NS		0.32 NS	-
Morn. Vapour pressure (mm)	0.46 NS	-	-0.14 NS	-	-0.07 NS	-
Even. Vapour pressure (mm)	0.34 NS	-	-0.16 NS	-	-0.19 NS	-
Evaporation (mm)	0.35 NS	-	-0.16 NS	-	-0.19 NS	-

NS =Non significant

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