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# Relative incidence of insect pests in transgenic and non transgenic cotton

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**ABSTRACT:** A two year field investigation was carried out during *kharif* 2015 and 2016 to know the incidence of insect pests in *Bt* and non *Bt* cotton. Seven sucking insect pests *viz.*, aphid, leafhopper, thrips, whitefly, mealybug, red cotton bug and dusky cotton bug were recorded in *Bt* and non *Bt* cotton. Infestation by leafhopper, thrips, whitefly and aphid initiated from second fortnight of June to first fortnight of July. The aphid population reached a peak in the second fortnight of September during *kharif* 2015 and 2016; whereas, leafhopper, thrips and whitefly attained the peak population in the second fortnight of August. The mealy bug, red and dusky cotton bugs appeared in the later part of the crop growth period in both years. The leafhopper population evinced a significant positive correlation with relative humidity in *Bt* and non *Bt* cotton; likewise, the population of thrips (in *Bt* and non *Bt* cotton) and whitefly (*Bt* and non *Bt* cotton) showed a significant positive correlation with relative humidity. The populations of leafhopper (*Bt* and non *Bt* cotton) and thrips (*Bt* cotton) had a significant positive correlation with the mean atmospheric temperature and leafhopper population had a significant negative correlation with the hours of sunshine in both *Bt* and non *Bt* cotton during *kharif* 2016.

**Key words:** *Bt*, correlation, non *Bt* cotton, sucking insect pests

Cotton (*Gossypium* spp) is the world's leading natural textile fibre crop and a significant contributor of oilseed. The highest cotton acreage in the world is in India cultivating in 12 to 13 million ha which is 37.5 per cent of the global cotton area in 2014. About 1326 pests have been reported to damage the cotton crop. Cotton is prone to pest attacks at all the stages of crop growth. Among 162 insect pests attack cotton in India, only a dozen are major and half of them are key production constraints which cause losses to the extent of 30-80 per cent. Simulation studies on cotton under projected climate change scenarios indicate a reduction in cotton yields in Haryana, Gujarat, Punjab and Rajasthan (Vision 2050 by CICR). At this point, studies are needed on regular basis to know the dynamics of pests under different abiotic factors.

## MATERIALS AND METHODS

The experiment was carried out at the Instructional farm, Rajasthan College of Agriculture, MPUAT, Udaipur during *kharif* 2015 and 2016. The incidence of insect pests in *Bt* and non *Bt* cotton were studied in uniformly laid 5 plots. Each plot measured 20.5 $m^2$ (4.5 m x 4.5 m). Varieties Ankur 3028 (*Bt* cotton) and H 8 (non

*Bt* cotton) were grown under unprotected conditions maintaining a row to row and plant to plant spacing of (90 x 90 cm), respectively. Five plants/plot were selected randomly and tagged for recording the observations for insect pests. The number of sucking insect pests *viz.,* aphid, leafhopper, thrips and whitefly was recorded on five randomly selected plants in each plot at fortnight interval starting from three weeks after sowing in all the treatments. The sample population of both nymphs and adults of leafhopper, aphid, thrips and whitefly was recorded from three leaves *viz.*, one each from top, middle and bottom canopies of the plant. The correlation and Multiple Linear Regression analysis (MLR) was done using MS excel.

## RESULTS AND DISCUSSION

**Aphid :** Aphid incidence started in the first fortnight of July (*kharif* 2015) and second fortnight of June (*kharif* 2016) and; thereafter, reached its peak in the second fortnight of September in *Bt* (112, 45 aphids/ 3 leaves) and non *Bt* cotton (64, 34 aphids / 3 leaves) during both the seasons. The population remained throughout the crop growth period. The seasonal incidence was slightly higher in *Bt* cotton than in non *Bt* cotton (Table :1(a) and 4 (a)). There was 41 ($R^2$= 0.41) and 61 ($R^2$= 0.61) (*Bt* cotton) and 27 ($R^2$= 0.27) and 60 ($R^2$= 0.60) (non *Bt* cotton) per cent variation in aphid population due to the influence of all the abiotic factors during the two consequent seasons *i.e.*, *kharif* 2015 and 2016 (Table 2,3 and 5,6)

Sitaramaraju *et al.,* (2010) noticed peak population during August and September months. Soujanya *et al.,* (2010) reported a 32.7 per cent variation in aphid population due to the influence of all abiotic factors.

**Leafhopper :** Leafhopper incidence started in the second fortnight of June, thereafter, reached its peak in the second fortnight of August during *kharif* 2015 and 2016 in *Bt* (9.60 and 8 leafhoppers / 3 leaves)and non *Bt* cotton (8.30 and 6.20 leafhoppers / 3 leaves). The population remained till October (*kharif,* 2015) and November (*kharif*, 2016). The seasonal mean incidence was slightly higher in *Bt* cotton than in non *Bt* cotton. Leafhopper population exhibited a significant positive correlation with relative humidity only in non *Bt* cotton during *kharif* 2015, while in *Bt* and non *Bt* cotton during *kharif* 2016. The mean atmospheric temperature also exhibited a significant positive correlation with leafhopper population. Sunshine hours showed a significant negative correlation with the population of leafhoppers in both *Bt* cotton and non *Bt* cotton during *kharif* 2016 (Table :1(a) and 4 (a)). The MLR analysis during *kharif* 2015 indicated that the total influence of all the weather parameters were 74 ($R^2$= 0.74) and 83 ($R^2$= 0.83) per cent on the population of leafhoppers in *Bt* and non *Bt* cotton, respectively. The regression equation further indicated that total rainfall had significant negative impact on the leafhopper population in *Bt* cotton, whereas in non *Bt* cotton, relative humidity had significant positive impact and rainfall had significant negative impact on leafhopper population. The MLR analysis of *kharif* 2016 indicated that the total influence of all the weather parameters was 71 ($R^2$= 0.71) and 75 ($R^2$= 0.75) per cent on the population of leafhoppers in *Bt* and non *Bt* cotton, respectively

**Table 1(a).** Comparative seasonal incidence of sucking insect pests in transgenic and non transgenic cotton during *kharif* 2015

| Dates of Observation | Mean Atm. Temp. (°C) | Mean R.H. (%) | Mean Sunshine (Hrs) | Total Rainfall (mm) | Aphids / 3 leaves/plant | | Leaf hopper/ 3 leaves / plant | | Thrips / 3 leaves / plant | | Whiteflies/ 3 leaves / plant | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Bt* | Non *Bt* | *Bt* | Non *Bt* | *Bt* | Non *Bt* | *Bt* | Non *Bt* |
| 20th June | 30.99 | 58.63 | 6.66 | 34.60 | - | - | 3.60 | 3.70 | 7.30 | 2.50 | 0.70 | 0.50 |
| 4th July | 29.23 | 65.25 | 6.81 | 24.20 | 0.50 | 0.50 | 5.40 | 6.30 | 13.00 | 8.70 | 0.70 | 1.20 |
| 18th July | 29.79 | 59.14 | 4.99 | 0.00 | 5.70 | 4.50 | 7.87 | 7.00 | 7.90 | 5.40 | 1.10 | 0.90 |
| 1st August | 36.34 | 83.54 | 0.78 | 290.60 | 2.90 | 3.20 | 3.00 | 4.10 | 1.30 | 1.40 | 2.10 | 2.90 |
| 15th August | 27.13 | 76.75 | 3.30 | 76.20 | 6.80 | 9.10 | 9.60 | 8.30 | 25.00 | 22.00 | 9.50 | 8.00 |
| 29th August | 26.96 | 73.32 | 5.24 | 29.20 | 18.00 | 12.00 | 6.30 | 6.00 | 18.00 | 15.00 | 7.00 | 6.00 |
| 13th September | 26.89 | 64.77 | 7.79 | 0.00 | 95.00 | 35.00 | 8.50 | 7.90 | 8.30 | 10.50 | 5.90 | 5.00 |
| 28th September | 27.17 | 68.53 | 6.07 | 41.60 | 112.00 | 64.00 | 4.20 | 5.60 | 0.50 | 0.60 | 3.60 | 2.90 |
| 13th October | 26.37 | 45.53 | 8.63 | 0.00 | 26.00 | 20.00 | 4.00 | 3.50 | 0.60 | 0.40 | 1.40 | 1.70 |
| 28th October | 26.61 | 44.36 | 8.11 | 0.00 | 13.00 | 12.00 | 1.50 | 1.30 | - | - | 0.60 | 0.50 |
| 12th November | 23.20 | 49.60 | 8.09 | 0.00 | 5.00 | 2.80 | - | - | - | - | 0.50 | 0.50 |
| 27th November | 22.03 | 48.30 | 8.14 | 0.00 | 3.50 | 2.00 | - | - | - | - | - | - |
| Coefficient of correlation (r) with mean atm. temp. (°C) | | | | | -0.09 | -0.08 | 0.27 | 0.39 | 0.10 | 0.03 | 0.01 | 0.10 |
| Coefficient of correlation (r) with R.H. (%) | | | | | 0.12 | 0.11 | 0.55 | 0.67* | 0.56* | 0.58* | 0.64* | 0.70* |
| Coefficient of correlation (r) with sunshine (Hrs)0.19 | | | | | 0.15 | -0.37 | -0.45 | -0.39 | -0.38 | -0.41 | -0.48 | |
| Coefficient of correlation (r) with total rainfall (mm) | | | | | -0.16 | -0.14 | -0.00 | 0.11 | 0.00 | 0.01 | 0.13 | 0.24 |

* Significant at 5%

**Table 1(b).** Comparative seasonal incidence of sucking insect pests in transgenic and non transgenic cotton during *kharif* 2015

| Dates of Observation | Mean Atm. Temp. (°C) | Mean R.H. (%) | Mean Sunshine (Hrs) | Total Rainfall (mm) | Mealybug/ plant | | Red cotton bug/ plant | | Dusky cotton bug/plant | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Bt* | Non *Bt* | *Bt* | Non *Bt* | *Bt* | Non *Bt* |
| 20th June | 30.99 | 58.63 | 6.66 | 34.60 | - | - | - | - | - | - |
| 4th July | 29.23 | 65.25 | 6.81 | 24.20 | - | - | - | - | - | - |
| 18th July | 29.79 | 59.14 | 4.99 | 0.00 | - | - | - | - | - | - |
| 1st August | 36.34 | 83.54 | 0.78 | 290.60 | - | - | - | - | - | - |
| 15th August | 27.13 | 76.75 | 3.30 | 76.20 | - | - | - | - | - | - |
| 29th August | 26.96 | 73.32 | 5.24 | 29.20 | - | - | - | - | - | - |
| 13th September | 26.89 | 64.77 | 7.79 | 0.00 | 0.70 | 1.30 | 3.50 | 4.50 | - | - |
| 28th September | 27.17 | 68.53 | 6.07 | 41.60 | 0.80 | 0.90 | 10.00 | 12.00 | - | - |
| 13th October | 26.37 | 45.53 | 8.63 | 0.00 | 0.60 | 0.70 | 13.00 | 11.00 | 6.00 | 5.00 |
| 28th October | 26.61 | 44.36 | 8.11 | 0.00 | 0.80 | 0.80 | 28.00 | 9.70 | 7.90 | 8.60 |
| 12th November | 23.20 | 49.60 | 8.09 | 0.00 | 1.00 | 1.00 | 25.00 | 15.00 | 13.00 | 7.90 |
| 27th November | 22.03 | 48.30 | 8.14 | 0.00 | 0.70 | 0.90 | 18.00 | 16.00 | 14.00 | 13.00 |
| Coefficient of correlation (r) with mean atm. temp. (°C) | | | | | -0.30 | -0.06 | -0.43 | -0.78 | -0.97* | -0.80 |
| Coefficient of correlation (r) with R.H. (%) | | | | | 0.03 | 0.55 | -0.75 | -0.41 | -0.41 | -0.52 |
| Coefficient of correlation (r) with sunshine (Hrs) | | | | | -0.23 | -0.15 | 0.36 | 0.04 | 0.42 | 0.48 |
| Coefficient of correlation (r) with total rainfall (mm) | | | | | 0.12 | -0.11 | -0.33 | 0.07 | -0.57 | -0.59 |

* Significant at 5%

(Table 2,3 and 5,6).

Positive correlation with relative humidity was reported by Rameshbabu and Meghwal (2014) in *Bt* cotton and Laxman *et al.,* (2014) in *Bt* and non *Bt* cotton. All the weather factors together influenced the leafhopper incidence to an extent of 48 per cent in *Bt* MRC 7351; 57 per cent in non *Bt* MRC-7351(Halappa *et al.,* 2016).

**Thrips :** Incidence of thrips started in the second fortnight of June, thereafter, reached its peak in the second fortnight of August during *kharif* 2015 and 2016 in *Bt* (25 and 15 thrips / 3 leaves) and non *Bt* cotton (22 and 15 thrips / 3 leaves) and the population remained till October. The seasonal mean incidence was slightly higher in *Bt* cotton than in non *Bt* cotton. The population of thrips exhibited a significant positive correlation with relative humidity in both *Bt* cotton and non *Bt* cotton during *kharif* 2015. The population of thrips exhibited a significant positive correlation with mean atmospheric temperature in *Bt* cotton during *kharif* 2016 (Table :1(a) and 4 (a)).

The MLR analysis for *kharif* 2015, indicated that the total influence of all the weather parameters was 69 ($R^2$= 0.69) and 71 ($R^2$= 0.71) per cent on the population of thrips in *Bt* and non *Bt* cotton, respectively. The regression equation further indicated that the rainfall had a significant negative impact on the

**Table 2.** Multiple linear regression analysis between weather parameters and pests of *Bt* cotton during *kharif* 2015

| Pests | Equation | $R^2$ |
|---|---|---|
| Aphids | Y = - 395.783 + (2.13) $X_1$ + (3.53) $X_2$ + (23.39) $X_3$ + (0.03) $X_4$ | 0.41 |
| Leafhoppers | Y = - 11.18 + (0.36) $X_1$ + (0.19) $X_2$ + (-0.67) $X_3$ + (-0.05*) $X_4$ | 0.74 |
| Thrips | Y = - 0.09 + (-0.120) $X_1$ + (0.49) $X_2$ + (-2.50) $X_3$ + (-0.11*) $X_4$ | 0.69 |
| Whiteflies | Y = 1.08 + (-0.41) $X_1$ + (0.25*) $X_2$ + (-0.31) $X_3$ + (-0.02) $X_4$ | 0.71 |
| Mealybugs | Y = 5.16 + (-0.01) $X_1$ + (-0.01) $X_2$ + (-0.42) $X_3$ + (-0.01) $X_4$ | 0.46 |
| Red cotton bug | Y = 316.14 + (0.02) $X_1$ + (-1.63) $X_2$ + (-26.62) $X_3$ + (-0.80) $X_4$ | 0.93 |
| Dusky cotton bug | Y = 97.11 + (-1.79) $X_1$ + (-0.34) $X_2$ + (-3.23) $X_3$ | 0.98 |

Note: Y – Dependent variable $X_1$ – Temperature °C (Mean) $X_2$ – Relative Humidity % (Mean)
$X_3$ – Sunshine hours $X_4$ – Total Rainfall (mm) *Significant at 5 %

**Table 3.** Multiple linear regression analysis between weather parameters and pests of non *Bt* cotton during *kharif* 2015

| Pests | Equation | $R^2$ |
|---|---|---|
| Aphids | Y = - 146.55 + (0.69) $X_1$ + (1.41) $X_2$ + (8.94) $X_3$ + (0.01) $X_4$ | 0.27 |
| Leafhoppers | Y = - 18.20 + (0.40) $X_1$ + (0.23*) $X_2$ + (-0.17) $X_3$ + (-0.04*) $X_4$ | 0.83 |
| Thrips | Y = 1.82 + (-0.47) $X_1$ + (0.49) $X_2$ + (-1.73) $X_3$ + (-0.08) $X_4$ | 0.71 |
| Whiteflies | Y = -0.54 + (-0.32) $X_1$ + (0.21*) $X_2$ + (-0.15) $X_3$ + (-0.01) $X_4$ | 0.71 |
| Mealybugs | Y = 2.74 + (-0.02) $X_1$ + (0.02) $X_2$ + (-0.28) $X_3$ + (-0.02) $X_4$ | 0.93 |
| Red cotton bug | Y = 46.35 + (-1.63) $X_1$ + (-0.20) $X_2$ + (1.96) $X_3$ + (0.29) $X_4$ | 0.98 |
| Dusky cotton bug | Y = 97.71 + (-1.09) $X_1$ + (-0.52) $X_2$ + (-4.54) $X_3$ | 0.83 |

Note: Y – Dependent variable $X_1$ – Temperature °C (Mean) $X_2$ – Relative humidity % (Mean)
$X_3$ – Sunshine hours $X_4$ – Total rainfall (mm) *Significant at 5 %

population of thrips in *Bt* cotton. The MLR analysis for *kharif* 2016 indicated that the total influence of all the weather parameters was 94 ($R^2$= 0.94) and 88 ($R^2$= 0.88) per cent on the population of thrips in *Bt* and non *Bt* cotton, respectively. The regression equation further indicated that total rainfall had a significant negative impact on the population of thrips in *Bt* cotton and non *Bt* cotton; whereas, the relative humidity had significant positive impact on the population of thrips in *Bt* cotton and non *Bt* cotton (Table 2,3 and 5,6).

Soni and Dhakad (2016) too reported that the first incidence of thrips was noted in third week of July (1.97 thrips/ 3 leaves) during 2011 and 1.10 thrips/ 3 leaves in first week of July 2012 in *Bt* cotton. The peak incidence depends on climatic conditions of the area, type of cotton and variety. Sitaramraju *et al.,* (2010), Soujanya *et al.,* (2010), Shivanna *et al.,* (2011), Bhute *et al.,* (2012), Shahid *et al.,* (2012) and Singh *et al.,* (2015) also revealed that the population of thrips showed positive correlation with the maximum atmospheric temperature. A positive correlation of thrips with relative humidity was reported by Shivanna *et al.,* (2011), Bhute *et al.,* (2012), Singh *et al.,* (2015). MLR analysis by Sitaramraju *et al.,* (2010) reported that all the abiotic factors together accounted for 70 per cent of total variation of thrips in *Bt* cotton.

**Whitefly :** Whitefly incidence started in the second fortnight of June, thereafter, reached its peak in the second fortnight of August during *kharif* 2015 and 2016 in *Bt* (9.50 and 9 whitefly / 3 leaves) and non *Bt* cotton (8 and 6.70 whitefly / 3 leaves), respectively. The population remained throughout the crop growth period until the second fortnight of November. The seasonal incidence was slightly higher in *Bt* cotton than in non *Bt* cotton. Whitefly population exhibited a significant positive correlation with relative humidity in both *Bt* cotton and non *Bt* cotton during *kharif* 2015 (Table :1(a) and 4 (a)). The MLR analysis indicated that the total influence of all the weather parameters was 71 ($R^2$= 0.71) and71 ($R^2$= 0.71) per cent on whitefly in *Bt* and non *Bt* cotton during *kharif* 2015 and 78 ($R^2$= 0.78) and 81 ($R^2$= 0.81) per cent on the population of whitefly in *Bt* and non *Bt* cotton during 2016. The regression equation further indicated that the relative humidity had a significant positive impact on the population of whitefly in *Bt* and non *Bt* cotton during *kharif* 2015; while, rainfall had a significant negative impact on the population of whitefly in *Bt* and non *Bt* cotton during *kharif* 2016 (Table :2,3 and 5,6).

Incidence studies by Singh *et al.,* (2015) revealed that the whitefly incidence first observed during 26$^{th}$ SMW in cotton *i.e.*, last week of June. Sitaramraju *et al.,* (2010), Soujanya *et al.,* (2010), Shera *et al.,* (2013) and Kalkal *et al.,* (2015) reported positive correlation of relative humidity with whitefly population. The rainfall has negative impact because it will wash off the whiteflies from the plant. Shera *et al.,* (2013) reported that all the parameters collectively accounted for variability in the whitefly population with $R^2$ values ranging from 0.50–0.69 during different years from 2007 to 2010.

**Mealybug :** Very low incidence was observed in both the seasons. Mealybug incidence started in the first fortnight of September (*kharif* 2015) and in the second fortnight of October (*kharif* 2016); and the

**Table 4(a).** Comparative seasonal incidence of sucking insect pests in transgenic and non transgenic cotton during *kharif* 2016

| Dates of Observation | Mean Atm. Temp. (°C) | Mean R.H. (%) | Mean Sunshine (Hrs) | Total Rainfall (mm) | Aphids / 3 leaves/plant | | Leaf hopper/ 3 leaves / plant | | Thrips / 3 leaves / plant | | Whiteflies/ 3 leaves / plant | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Bt* | Non *Bt* | *Bt* | Non *Bt* | *Bt* | Non *Bt* | *Bt* | Non *Bt* |
| 25th June | 31.38 | 55.10 | 5.57 | 31.20 | 0.50 | 0.40 | 3.60 | 3.90 | 7.20 | 5.40 | 2.04 | 2.04 |
| 10th July | 28.97 | 69.83 | 4.70 | 103.00 | 1.40 | 1.10 | 5.20 | 6.00 | 6.20 | 5.52 | 0.80 | 1.20 |
| 25th July | 27.25 | 77.80 | 2.88 | 133.80 | 1.50 | 1.10 | 2.92 | 2.40 | 8.50 | 5.80 | 1.00 | 0.90 |
| 9th August | 25.92 | 89.67 | 0.94 | 270.50 | 4.80 | 4.40 | 4.16 | 4.72 | 1.30 | 2.40 | 1.40 | 1.60 |
| 24th August | 25.66 | 80.67 | 3.19 | 95.20 | 11.00 | 13.00 | 8.00 | 6.20 | 15.00 | 15.00 | 9.00 | 6.70 |
| 8th September | 26.45 | 76.03 | 5.06 | 20.60 | 16.00 | 18.00 | 3.70 | 2.90 | 14.30 | 14.00 | 7.12 | 5.88 |
| 23rd September | 27.73 | 64.23 | 6.97 | 3.40 | 45.00 | 34.00 | 6.40 | 4.40 | 13.00 | 16.00 | 6.88 | 4.44 |
| 8th October | 27.94 | 67.30 | 5.75 | 62.40 | 38.00 | 33.00 | 4.20 | 4.36 | 8.40 | 9.40 | 2.90 | 2.40 |
| 23rd October | 25.11 | 55.37 | 8.04 | 0.00 | 28.00 | 25.00 | 1.00 | 1.10 | 1.20 | 1.10 | 0.50 | 0.80 |
| 7th November | 22.06 | 52.80 | 8.29 | 0.00 | 15.00 | 13.00 | 0.70 | 0.70 | - | - | 0.70 | 0.80 |
| 22nd November | 20.41 | 54.10 | 8.78 | 0.00 | 3.70 | 3.60 | - | - | - | - | - | - |
| 7th December | 19.75 | 55.03 | 8.80 | 0.00 | 3.00 | 3.10 | - | - | - | - | - | - |
| Coefficient of correlation (r) with mean atm. temp. (°C) | | | | | 0.15 | 0.13 | 0.66* | 0.75* | 0.58* | 0.52 | 0.32 | 0.37 |
| Coefficient of correlation (r) with R.H. (%) | | | | | -0.11 | -0.07 | 0.64* | 0.66* | 0.48 | 0.46 | 0.44 | 0.49 |
| Coefficient of correlation (r) with sunshine (Hrs)0.26 | | | | | 0.23 | -0.64* | -0.72* | -0.42 | -0.36 | -0.31 | -0.38 | |
| Coefficient of correlation (r) with total rainfall (mm) | | | | | -0.33 | -0.33 | 0.39 | 0.54 | 0.03 | 0.01 | -0.03 | 0.03 |

* Significant at 5%

**Table 4 (b).** Comparative seasonal incidence of sucking insect pests in transgenic and non transgenic cotton during *kharif* 2016

| Dates of Observation | Mean Atm. Temp. (°C) | Mean R.H. (%) | Mean Sunshine (Hrs) | Total Rainfall (mm) | Mealybug/ plant | | Red cotton bug/ plant | | Dusky cotton bug/plant | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | *Bt* | Non *Bt* | *Bt* | Non *Bt* | *Bt* | Non *Bt* |
| 25th June | 31.38 | 55.10 | 5.57 | 31.20 | - | - | - | - | - | - |
| 10th July | 28.97 | 69.83 | 4.70 | 103.00 | - | - | - | - | - | - |
| 25th July | 27.25 | 77.80 | 2.88 | 133.80 | - | - | - | - | - | - |
| 9th August | 25.92 | 89.67 | 0.94 | 270.50 | - | - | - | - | - | - |
| 24th August | 25.66 | 80.67 | 3.19 | 95.20 | - | - | - | - | - | - |
| 8th September | 26.45 | 76.03 | 5.06 | 20.60 | - | - | - | - | - | - |
| 23rd September | 27.73 | 64.23 | 6.97 | 3.40 | - | - | 2.36 | 2.04 | - | - |
| 8th October | 27.94 | 67.30 | 5.75 | 62.40 | - | - | 8.50 | 9.10 | - | - |
| 23rd October | 25.11 | 55.37 | 8.04 | 0.00 | 0.30 | 0.70 | 12.88 | 12.00 | - | - |
| 7th November | 22.06 | 52.80 | 8.29 | 0.00 | 0.10 | 1.30 | 31.00 | 28.70 | 8.30 | 7.80 |
| 22nd November | 20.41 | 54.10 | 8.78 | 0.00 | 0.50 | 2.70 | 28.00 | 25.40 | 15.68 | 8.64 |
| 7th December | 19.75 | 55.03 | 8.80 | 0.00 | 0.70 | 4.50 | 30.32 | 26.24 | 18.00 | 15.80 |
| Coefficient of correlation (r) with mean atm. temp. (°C) | | | | -0.63 | -0.88 | -0.95* | -0.93* | -0.99* | -0.78 | |
| Coefficient of correlation (r) with R.H. (%) | | | | 0.61 | 0.23 | -0.84* | -0.83* | -0.98 | -0.87 | |
| Coefficient of correlation (r) with sunshine (Hrs) | | | | | 0.78 | 0.90 | 0.83 | 0.77 | 0.98 | 0.61 |
| Coefficient of correlation (r) with total rainfall (mm) | | | | | - | - | -0.45 | -0.40 | - | - |

* Significant at 5%

population remained until the end of the crop growth period in both *Bt* and non *Bt* cotton (Table :1(b) and 4 (b)). The MLR analysis for *kharif* 2015 indicated that the total influence of all the weather parameters was 46 ($R^2$= 0.46) and 93 ($R^2$= 0.93) per cent on the population of mealybug in *Bt* and non *Bt* cotton respectively (Table: 2,3 and 5,6)

**Red cotton bug :** During *kharif* 2015, red cotton bug incidence started in the first fortnight of September and second fortnight of September and the population increased gradually; thereafter, reached its peak in the second fortnight of October (*Bt* cotton *kharif* 2015), second fortnight of November (non *Bt* cotton *kharif* 2015) and first fortnight of November (*kharif* 2016) in *Bt* and non *Bt* cotton. Red cotton bug population exhibited a significant negative correlation with mean atmospheric temperature and relative humidity during *kharif* 2016 (Table :1(b) and 4 (b)). The MLR analysis indicated that the total influence of all the weather parameters was 93 ($R^2$= 0.93) and 98 ($R^2$= 0.98) per cent on the population of red cotton bug in *Bt* and non *Bt* cotton during *kharif* 2015 and correspondingly 99 ($R^2$= 0.99) and 99 ($R^2$= 0.99) per cent during 2016. The regression equation further indicated that mean atmospheric temperature, relative humidity and sunshine hours had a significant negative impact on the population of red cotton bug in *Bt* and non *Bt* cotton only during *kharif* 2016. (Table : 2,3 and 5,6)

Similar observation was reported by Sammaiah *et al.,* (2012) that infestation started during October and continued till March in *Bt*

**Table 5.** Multiple linear regression analysis between weather parameters and pests of *Bt* cotton during *kharif* 2016

| Pests | Equation | $R^2$ |
|---|---|---|
| Aphids | $Y = - 409.28 + (4.67) X_1 + (2.73) X_2 + (20.16) X_3 + (0.09) X_4$ | 0.61 |
| Leafhoppers | $Y = - 21.65 + (0.41) X_1 + (0.21) X_2 + (0.23) X_3 + (-0.01) X_4$ | 0.71 |
| Thrips | $Y = - 26.77 + (0.55) X_1 + (0.50^*) X_2 + (-1.41) X_3 + (-0.11^*) X_4$ | 0.94 |
| Whiteflies | $Y = - 13.68 + (0.07) X_1 + (0.32) X_2 + (-0.59) X_3 + (-0.06^*) X_4$ | 0.78 |
| Red cotton bug | $Y = 444.39 + (-6.17^*) X_1 + (-1.87^*) X_2 + (-21.52^*) X_3 + (-0.22) X_4$ | 0.99 |

Note: Y – Dependent variable $X_1$ – Temperature °C (Mean) $X_2$ – Relative Humidity % (Mean)
$X_3$ – Sunshine hours $X_4$ – Total Rainfall (mm) *Significant at 5 %
# The regression equation for mealybug and duskycotton bug is not possible because of less number of observations.

**Table 6.** Multiple linear regression analysis between weather parameters and pests of non *Bt* cotton during *kharif* 2016

| Pests | Equation | $R^2$ |
|---|---|---|
| Aphids | $Y = - 315.72 + (3.44) X_1 + (2.26) X_2 + (15.14) X_3 + (0.04) X_4$ | 0.60 |
| Leafhoppers | $Y = - 21.06 + (0.46) X_1 + (0.14) X_2 + (0.47) X_3 + (0.004) X_4$ | 0.75 |
| Thrips | $Y = - 67.96 + (0.89) X_1 + (0.78^*) X_2 + (0.82) X_3 + (-0.09^*) X_4$ | 0.88 |
| Whiteflies | $Y = - 7.12 + (0.05) X_1 + (0.21) X_2 + (-0.59) X_3 + (-0.04^*) X_4$ | 0.81 |
| Red cotton bug | $Y = 426.69 + (-5.52^*) X_1 + (-1.96^*) X_2 + (-20.84^*) X_3 + (-0.19) X_4$ | 0.99 |

Note: Y – Dependent variable $X_1$ – Temperature °C (Mean) $X_2$ – Relative Humidity % (Mean)
$X_3$ – Sunshine hours $X_4$ – Total Rainfall (mm) *Significant at 5 %
# The regression equation for mealybug and dusky cotton bug is not possible because of less number of observations.

and non *Bt* cotton and a negative correlation with atmospheric temperature was reported; while, positive correlation was observed with relative humidity.

**Dusky cotton bug :** During *kharif* 2015 and 2016, incidence of dusky cotton bug started in the first fortnight of October and in the first fortnight of November; reached its peak in the second fortnight of November and in the first fortnight of December in both *Bt* and non *Bt* cotton respectively. The seasonal incidence was slightly higher in *Bt* cotton than in non *Bt* cotton. Dusky cotton bug population exhibited a significant negative correlation with mean atmospheric temperature in *Bt* cotton during *kharif* 2016 (Table :1(b) and 4 (b)). The MLR analysis indicated that the total influence of all the weather parameters were 98 ($R^2$= 0.98) and 83 ($R^2$= 0.83) per cent on the population of dusky cotton bug in *Bt* and non *Bt* cotton, respectively during *kharif* 2015. (Table : 2,3 and 5,6)

Earlier, Sammaiah *et al.,* (2012) also reported that infestation started during October *i.e.,* when bolls fully opened and continued till March in *Bt* and non *Bt* cotton and a negative correlation with mean atmospheric temperature.

## CONCLUSION

The aphid population reached its peak in the second fortnight of September during *kharif* 2015 and 2016; whereas, leafhopper, thrips and whitefly attained the peak population in the second fortnight of August. The mealybug, red and dusky cotton bugs appeared in the later part of the crop growth period in both years. The leaf hopper population evinced a significant positive correlation with relative humidity in *Bt* and non *Bt* cotton; likewise, the population of thrips (in *Bt* and non *Bt* cotton) and whitefly (*Bt* and non *Bt* cotton) showed a significant positive correlation with relative humidity. The populations of leafhopper (*Bt* and non *Bt* cotton) and thrips (*Bt* cotton) had a significant positive correlation with the mean atmospheric temperature during *kharif* 2016. Leafhopper population had a significant negative correlation with the hours of sunshine in both *Bt* and non *Bt* cotton.

## REFERENCES

**Bhute, N.K., Bhosle, B.B., Bhede, B.V and More, D.G. 2012.** Population dynamics of major sucking pests of *Bt* cotton. *Ind. J. Entomol.* **74 :** 246-52.

**Halappa, B., Patil, R.K and Guru, P.N. 2016.** Seasonal incidence of cotton leafhopper, *Amrasca biguttula biguttula* (Ishida) on *Bt* and non *Bt* cotton. *J. Entomol. Res.* (New Delhi) **40:** 243-48.

**Kalkal, D., Lal, R., Dahiya, K.K., Singh, M and Kumar, A. 2015.** Population dynamics of sucking insect pests of cotton and its correlation with abiotic factors. *Ind. J. Agric. Res.* **49:** 432-36.

**Laxman, P., Samatha, Ch and Sammaiah, Ch. 2014.** Study on infestation of sucking insect pests on *Bt*-cotton and non *Bt* cotton fields in warangal –telangana. *Int. J. Adv. Biol. Res.* **4 :** 172-77.

**Rameshbabu, S and Meghwal, M.L. 2014.** Population dynamics and monitoring of sucking pests and bollworms on *Bt* cotton in humid zone of southern Rajasthan. *The Bioscan* **9 :** 629-32.

**Sammaiah, Ch., Laxman, P. and Samatha, Ch. 2012.** Study on infestation of cotton insect stainers on *Bt* cotton and non *Bt* cotton in Warangal, Andhra Pradesh. *Int. J. Environ. Sci.* **3 :** 1155-60.

**Shahid, M.R., Farooq, J., Mahmood, A., Ilahi, F., Ria, M., Shakeel, A., Petrescu- Mag, I.V and Farooq, A. 2012.** Seasonal occurrence of sucking insect pest in cotton ecosystem of Punjab, Pakistan. *Adv. Agric. Bot.* **4 :** 26-30.

**Shera, P.S., Kumar, V and Aneja, A. 2013.** Seasonal abundance of sucking insect pests on transgenic *Bt* cotton *via-a-vis* weather parameters in Punjab, India. Acta Phytopathol. *Entomol. Hung.* **48 :** 63-74.

**Shivanna, B.K., Gangadhara Naik, B., Basavaraja, M. K., Nagaraja, R., Kalleswara Swamy, C. M and Karegowda, C. 2011.** Impact of abiotic factors on population dynamics of sucking pests in transgenic cotton ecosystem. *Int. J. Sci. Nat.* **2:** 72-74.

**Singh, H., Kaur, P and Mukherjee, J. 2015.** Impact of Weather Parameters and Plant Spacing on Population Dynamics of Sucking Pests of Cotton in South Western Punjab. *J. Agric. Phys.* **15:** 167-74.

**Sitaramaraju, S., Prasad N.V.V.S.D and Krishnaiah, P.V. 2010.** Seasonal incidence of sucking insect pests on *Bt* cotton in relation to weather parameters. *Ann. Plant Prot. Sci.* **18:** 49-52.

**Soni, R. and Dhakad, N.K. 2016.** Seasonal Incidence of Cotton JASSID, *Amrasca biguttula biguttula* (Ishida) on Trasgenic *Bt* Cotton and Their Correlation with Weather Parameters. *Int. J. Agric. Innov. Res.* **4 :** 2319-73.

**Soujanya, P.L., Prasad, N.V.V.S.D. and Rao, P.A. 2010.** Population dynamics of sucking pests and their relation to weather parameters in *Bt* staked *Bt*, non *Bt* cotton hybrids. *Trends Biosci. **3:*** 15-18.

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