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***Short Communication***

# Seasonal incidence of whitefly (*Bemisia tabaci* Gennadius) and jassid (*Amrasca bigutulla bigutulla* Ishida) on transgenic cotton in south-western Punjab, India

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Cotton (*Gossypium hirsutum* L.) known as "king of fibres" is a deciduous, indeterminate, perennial plant grown commercially in about 31.8 million hectare area with the production of 24963 million bales globally (ICAC, 2018). Besides, raw lint in textile manufacturing, it also provides seeds, oil and feed for cattle. In Punjab, it occupied over 2.78 lakh hectares area with production of 12.43 lakh bales during 2016-17 (Anon., 2018). More than 1300 pest species were found to be associated with cotton crop world-wide and caused deterioration in lint quality and production losses to the tune of 10 - 40 Per cent in the non-transgenic cotton (Gahukar, 2006). In India, out of 162 insect pests attacking cotton, nine are considered as key pests resulting in 50-60 Per cent loss in seed cotton yield (Dhawan, 2004). The primary pest complex includes bollworm (BW) *viz*. American bollworm, *Helicoverpa armigera* (Hub.); spotted bollworms, *Earias insulana* (Boisd.) and *E. vitella* (Fab.); pink bollworm, *Pectinophora gossypiella* (Saund.); and the secondary pest complex includes whitefly, *Bemisia tabaci* (Gen.); jassid, *Amrasca bigutulla biguttula* (Ishida) and thrips, *Thrips tabaci* (Lind.) have been causing serious threat to the non-transgenic cotton (Dhaka and Pareek, 2007). However, the adoption of transgenic cotton in India solved the problem of bollworms to large extent, but due to changed cropping system and increase in transgenic cotton area, resulted in outbreak of the secondary pest's *viz*. whitefly, jassids and thrips incidence (Singh, 2018). Because of the unexpected variations in weather from wet towards dry conditions and indiscriminate use of conventional insecticides, the importance of whitefly and jassids as a pest of economic importance in different ecosystems has expanded. Moreover, under changed climatic conditions and with the introduction of *Bt* cotton, significance of whitefly and jassids has increased during the last 7-8 years. Keeping in view above, cotton pests surveillance were conducted during *kharif* 2016, 2017 and 2018, to assess the seasonal incidence of *B. tabaci* and *A. bigutulla biguttula* and to find out the association of these insects population fluctuations to different abiotic factors.

The field surveys were conducted throughout cotton season in the selected villages of Sangat Kalan, Maur Mandi, Bhucho Kalan, Talwandi Sabo, Naruana and Nathana blocks of south-western Punjab during *kharif* 2016, 2017 and 2018. Five villages from each block and five different fields per village surveyed and data on whitefly and jassid were recorded. Form each cotton field 10-15 plants were randomly observed for taking observations. The time for surveillance was selected before 10.00 hours in morning, keeping in view of the insect activity. The whitefly and jassids population counts were taken from fully opened 3 leaves from upper canopy. The observations on insect populations were recorded at weekly intervals from SMW 23 to SMW 43. To describe the extent of damage by these insects the Economic Threshold Levels (ETL) recommended by Punjab Agricultural University, Ludhiana was considered (Anon., 2018).

***ETL for whitefly: 18 whitefly adults/ 3 leaves***

ETL for Jassids: when leaves of upper canopy shows curling and yellowing at the margins on 50 Per cent of plants.

In order to find out the relation between whitefly and jassid incidence on *Bt* cotton to weather parameters, the agro-meteorological data for the study period were recorded at the Agrometeorological Observatory of Punjab Agricultural University, Regional Research Station, Bathinda (30°09" N, 74° 55" E and 211 m amsl) (Fig. 1).

The mean population data obtained across various standard meteorological weeks (SMW) was used to depict the seasonal incidence and dynamics of whitefly and jassids in *Bt* cotton. Data was analyzed statistically by SPSS software and simple correlation was worked out between the population of insect pests and weather parameters at 5 Per cent level of significance (Table 4).

***Seasonal incidence of B. tabaci:*** The weekly incidence and dynamics of whitefly incidence on *Bt* cotton during the *kharif* of 2016, 2017 and 2018 is presented in table 1.

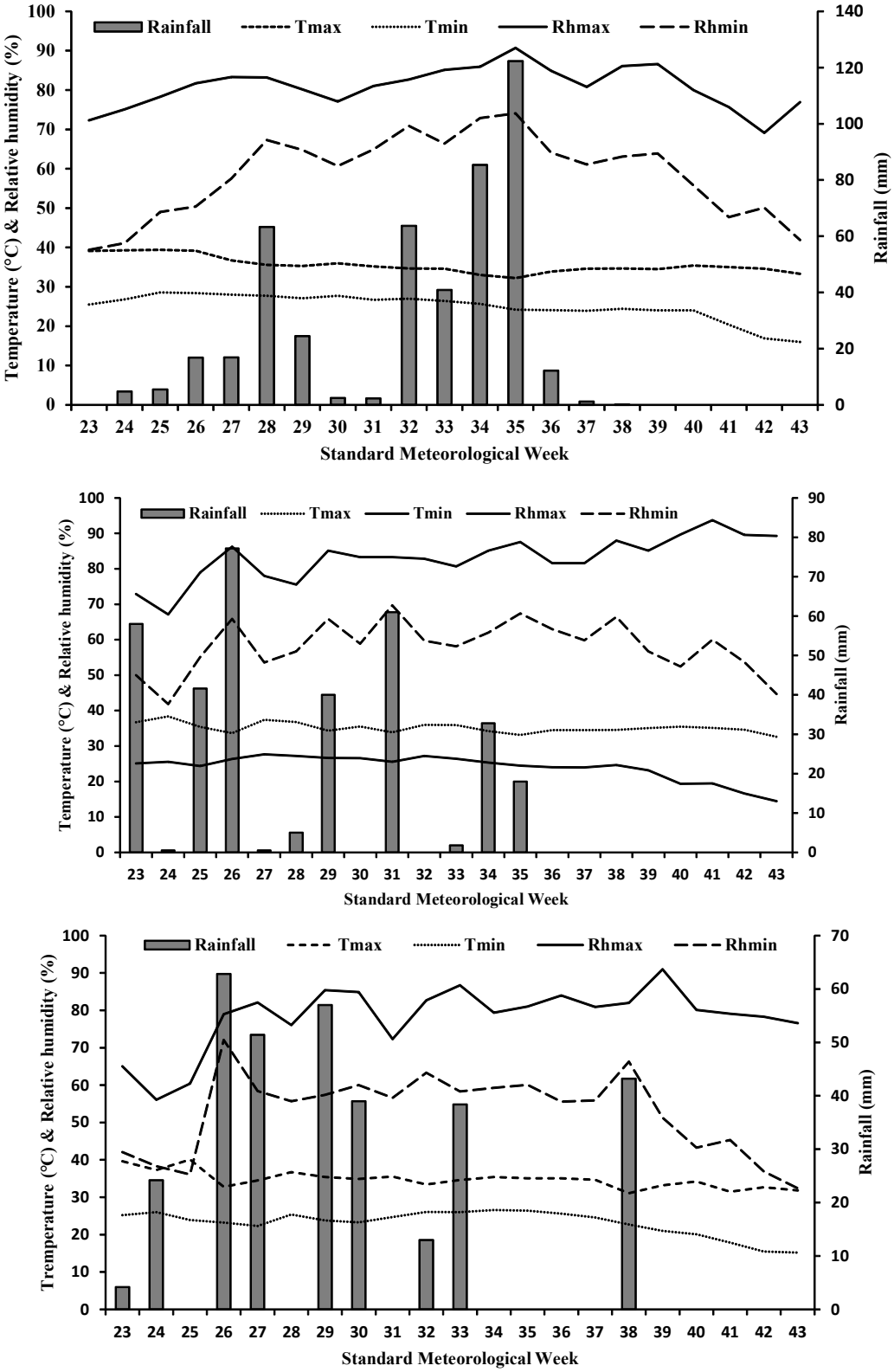


**Fig. 1:** Weather conditions during crop growing period of *Kharif* (a) 2016; (b) 2017; and (c) 2018.

**Table 1:** Seasonal incidence of *B. tabaci* on cotton during different standard meteorological weeks in south-western Punjab

| SMW | Villages visited | | | | Whitefly population range (per 3 leaves) | | | Locations above ETL | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | Total | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 |
| 23 | 13 | 19 | 11 | 43 | 0.75-6.00 | 0.00-11.40 | 0.00-0.90 | 0 | 0 | 0 |
| 24 | 11 | 13 | 10 | 34 | 1.20-10.50 | 0.96-15.09 | 0.10-1.16 | 2 | 0 | 0 |
| 25 | 12 | 17 | 10 | 39 | 0.18-19.20 | 0.33-2.46 | 0.00-1.00 | 0 | 0 | 0 |
| 26 | 14 | 14 | 11 | 39 | 0.00-22.60 | 0.90-3.99 | 0.10-4.20 | 0 | 0 | 1 |
| 27 | 11 | 20 | 9 | 40 | 0.81-32.10 | 1.47-9.60 | 0.30-1.40 | 0 | 0 | 0 |
| 28 | 17 | 27 | 8 | 52 | 0.00-30.48 | 1.02-11.49 | 0.30-1.20 | 0 | 2 | 0 |
| 29 | 15 | 31 | 21 | 67 | 0.60-30.60 | 3.18-33.39 | 0.03-2.86 | 2 | 9 | 0 |
| 30 | 14 | 35 | 34 | 83 | 1.29-21.60 | 4.08-35.70 | 0.40-4.20 | 2 | 4 | 0 |
| 31 | 17 | 37 | 28 | 82 | 0.90-12.30 | 2.01-51.45 | 0.50-3.60 | 0 | 3 | 0 |
| 32 | 21 | 34 | 25 | 80 | 0.75-10.50 | 4.20-40.77 | 0.30-3.80 | 0 | 7 | 0 |
| 33 | 23 | 38 | 18 | 79 | 2.70-19.20 | 5.34-56.40 | 0.10-2.20 | 4 | 12 | 0 |
| 34 | 25 | 39 | 28 | 92 | 1.50-23.91 | 3.51-17.61 | 0.30-3.30 | 4 | 1 | 0 |
| 35 | 16 | 11 | 23 | 50 | 0.39-69.30 | 2.52-15.66 | 0.30-3.80 | 32 | 1 | 0 |
| 36 | 13 | 36 | 25 | 74 | 3.90-69.30 | 2.70-35.40 | 0.30-2.80 | 37 | 2 | 0 |
| 37 | 19 | 15 | 18 | 52 | 3.00-41.61 | 3.21-27.60 | 0.30-3.40 | 18 | 0 | 0 |
| 38 | 12 | 13 | 15 | 40 | 3.09-37.20 | 3.67-33.68 | 0.10-3.60 | 12 | 0 | 0 |
| 39 | 14 | 14 | 18 | 46 | 0.96-18.15 | 2.61-21.23 | 0.00-2.80 | 0 | 0 | 0 |
| 40 | 13 | 14 | 19 | 46 | 1.60-11.40 | 1.67-16.47 | 0.00-2.41 | 0 | 0 | 0 |
| 41 | 18 | 16 | 21 | 55 | 1.13-8.30 | 1.23-12.45 | 0.00-2.20 | 0 | 0 | 0 |
| 42 | 22 | 14 | 16 | 52 | 0.90-7.60 | 0.96-9.87 | 0.00-1.80 | 0 | 0 | 0 |
| 43 | 19 | 12 | 15 | 46 | 0.57-6.10 | 0.56-5.43 | 0.00-0.99 | 0 | 0 | 0 |

During crop growth period *i.e.,* from SMW 23 to 43, the population of whitefly was ranged from 0.0 – 69.3, 0.0 – 56.4 and 0.0 – 4.2 adults/3 leaves for 2016, 2017 and 2018, respectively (Table 1). Throughout *kharif* 2016, location wise maximum whitefly population was observed in 36$^{th}$ SMW *i.e.* 3.9-69.3 adults/3 leaves, during which, 46.25% of total visited locations found above ETL (Table 1). Similarly, during 2017 whitefly population was peaked at 33$^{rd}$ SMW having 12 locations above ETL among 38 villages visited. Moreover, in 2018 summer season, almost all the locations visited were observed below ETL, except one location during SMW 26 (Table 1). The highest activity of whitefly was observed during SMW 33-38, 28-33 and 26during 2016, 2017 and 2018, respectively. However, the mean population of whitefly adult's during the cotton season ranged from 1.16 – 18.0, 0.84 – 17.22 and 0.63 – 3.0 adults/ 3 leaves during 2016, 2017 and 2018, respectively, whereas, the peak was observed at 36$^{th}$, 32$^{nd}$ and 30$^{th}$ SMW for the year 2016, 2017 and 2018, respectively (Fig. 2). In south western Punjab whitefly became a major threat to cotton and caused huge economic loses to farmers during *kharif* 2015 (Kataria *et al.,* 2019). The whitefly adults remain active on one or the other alternate host (crops and weeds) throughout the year and shift immediately to the cotton leaves after germination of cotton cotyledons. We have noticed the incidence of whitefly even on germinating cotyledons in the fields. During crop growing period, mean temperature was observed in the range between 24.6 – 34.0°C, 23.5 – 32.5°C and 23.5 – 32.0°C during 2016, 2017 and 2018, respectively (Fig. 1). Similarly, mean relative humidity was observed between 59.4–82.4%, 54.5–77.5% and 47.2–75.6% during 2016, 2017 and 2018, respectively (Fig. 1). It was also emphasized by Selvaraj *et al.* (2010) that maximum temperature ranged from 32°C to 35°C and minimum temperature ranged from 23°C to 26°C, morning relative humidity 84 to 93 per cent and evening relative humidity 58 to 67 per cent was favorable for multiplication of whiteflies which corroborates our findings. Although, the highest rainfall was received during

**Table 2:** Seasonal incidence of cotton jassid (*A. bigutulla bigutulla*) on cotton during different standard meteorological weeks in south-western Punjab

| SMW | Villages visited | | | | Jassid population range (per 3 leaves) | | | Locations above ETL(overall) |
|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | Total | 2016 | 2017 | 2018 | |
| 23 | 13 | 19 | 11 | 43 | 0.00-1.40 | 0.00-2.10 | 0.00-1.80 | 0 |
| 24 | 11 | 13 | 10 | 34 | 0.20-1.70 | 0.10-2.45 | 0.00-1.20 | 0 |
| 25 | 12 | 17 | 10 | 39 | 0.50-2.50 | 0.86-3.15 | 0.00-3.99 | 0 |
| 26 | 14 | 14 | 11 | 39 | 2.02-3.00 | 1.02-4.60 | 0.00-2.70 | 0 |
| 27 | 11 | 20 | 9 | 40 | 1.60-3.50 | 0.67-5.50 | 0.60-4.50 | 1 |
| 28 | 17 | 27 | 8 | 52 | 2.10-4.40 | 0.77-2.49 | 0.39-5.28 | 22 |
| 29 | 15 | 31 | 21 | 67 | 2.20-4.60 | 0.32-4.90 | 1.20-13.50 | 25 |
| 30 | 14 | 35 | 34 | 83 | 2.60-11.00 | 0.45-4.48 | 1.50-21.09 | 49 |
| 31 | 17 | 37 | 28 | 82 | 2.40-8.50 | 0.22-2.70 | 2.10-15.30 | 21 |
| 32 | 21 | 34 | 25 | 80 | 0.40-8.50 | 0.25-2.33 | 0.30-11.70 | 9 |
| 33 | 23 | 38 | 18 | 79 | 0.90-5.00 | 0.18-1.74 | 0.00-9.00 | 1 |
| 34 | 25 | 39 | 28 | 92 | 0.60-4.50 | 0.14-5.87 | 0.00-4.41 | 0 |
| 35 | 16 | 11 | 23 | 50 | 0.10-3.50 | 0.16-0.33 | 0.00-4.15 | 0 |
| 36 | 13 | 36 | 25 | 74 | 0.30-3.00 | 0.00-1.13 | 0.00-3.33 | 0 |
| 37 | 19 | 15 | 18 | 52 | 0.40-2.90 | 0.00-1.90 | 0.00-2.58 | 0 |
| 38 | 12 | 13 | 15 | 40 | 0.00-1.60 | 0.00-0.60 | 0.00-1.35 | 0 |
| 39 | 14 | 14 | 18 | 46 | 0.00-2.00 | 0.00-1.00 | 0.00-0.59 | 0 |
| 40 | 13 | 14 | 19 | 46 | 0.00-1.50 | 0.00-0.50 | 0.00-0.76 | 0 |
| 41 | 18 | 16 | 21 | 55 | 0.00-0.80 | 0.00-0.35 | 0.00-0.42 | 0 |
| 42 | 22 | 14 | 16 | 52 | 0.00 | 0.00 | 0.00 | 0 |
| 43 | 19 | 12 | 15 | 46 | 0.00 | 0.00 | 0.00 | 0 |

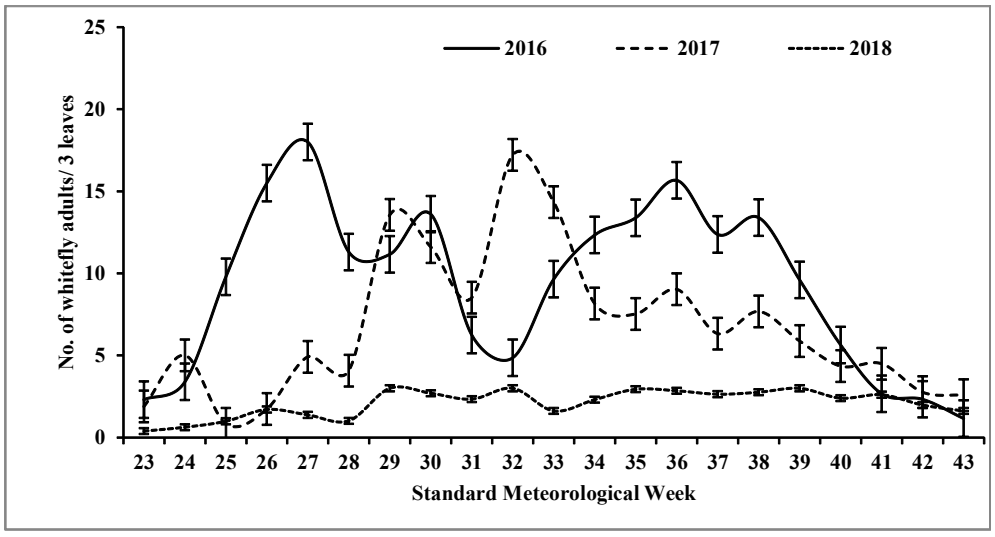


**Fig. 2:** Population dynamics of whitefly, *B. tabaci* in transgenic cotton in south-western Punjab during 2016, 2017 and 2018.

*kharif* 2016 (490.3mm) followed by 2017 (336.4mm) and 2018 (333.2mm), but due to more cloudy days, higher value of relative humidity and lesser number of sunny days, the maximum whitefly population was observed during 2016 than 2017 and 2018(Fig. 1). Kataria *et al.,* (2019) and Devi and Ram (2018**)** also reported less whitefly incidence during 2017 than 2016 in normal as well as late sown cotton crop, it may be due to improper rainfall distribution.

**Table 3:** Pearson correlation for whitefly and jassid population on cotton crop in relation to weather factors

| Variables | Tm | Tmn | RHm | RHmn | Rf | wf |
|---|---|---|---|---|---|---|
| Tmn | NS | | | | | |
| RHm | 0.53** | NS | | | | |
| RHmn | 0.31** | NS | 0.58** | | | |
| Rf | 0.26* | NS | 0.21* | 0.53** | | |
| Wf | NS | 0.25* | 0.33** | 0.46** | NS | |
| J | NS | NS | NS | 0.29* | 0.29* | NS |

Tm: maximum temperature (°C); Tmn: minimum temperature (°C); RHmn: minimum relative humidity (%); RHm: maximum relative humidity (%); and Rf: rainfall (mm); wf: whitefly adult population / 3 leaves; j: Jassid population / 3 leaves. Bold digits in the table indicate the "–" correlation; data; data followed by '*' indicates their significant correlation at $P < 0.05$ and data followed by '**' indicate their significant correlation at $P < 0.01$; NS: not significant.

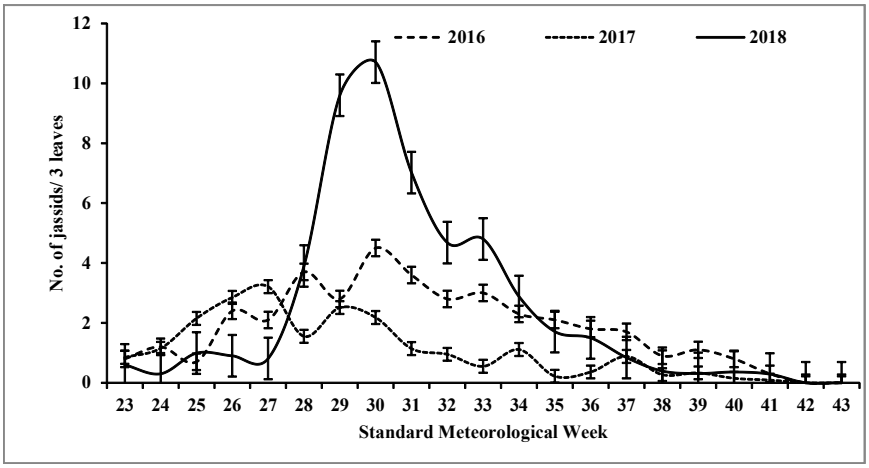


**Fig. 3:** Population dynamics of jassids, *A. bigutulla bigutulla* in transgenic cotton in south-western Punjab during 2016, 2017 and 2018.

during the *kharif* of 2016, 2017 and 2018, respectively (Table2). In general, during crop season the population of jassid was ranged between0.0 – 11.0, 0.0 – 5.87 and 0.0 – 21.1nymphs and adults/3 leavesin2016, 2017 and 2018, respectively, whereas its peak was recorded in 30th SMW (2.6 – 11.0 nymphs and adults/3 leaves), 27th SMW (0.67 – 5.5 nymphs and adults/3 leaves) and 30th SMW (1.5 – 21.0 nymphs and adults/3 leaves) during 2016, 2017 and 2018, respectively (Table 2).Moreover, it was found that mean jassid population was ranged between 0.0 – 4.5, 0.0 – 3.2 and 0.0 – 10.7 nymphs and adults/3 leaves during *kharif* of 2016, 2017 and 2018, respectively (Fig. 3). The data revealed that the peak population of jassid was noticed in 30th SMW in 2016 and 2018, whereas, in *kharif* 2017 it was maximum during 27th SMW (Fig. 3). SMW 28-32was most crucial for the management of the cotton jassid, as during this time 37.31 - 59.04 Per cent fields crossed Economic Threshold Levels for this pest. The prevalence of adults and nymphs of jassids throughout the year on one or the other host plants was already established by Boda and Ilyas (2017) was in confirmation with our observations. However, in contrast to our findings Prasad (2008) recorded that peak incidence of leaf hoppers in cotton was observed from 37th to 47th SMW which may be attributed to the crop stage and abiotic factors prevailing in their studied region.

***Correlation studies:*** The effect of weather variables on population dynamics of whitefly and jassid were analyzed in terms of correlation and presented in Table 3. The results of the study revealed that whitefly population was found to be significantly and positively correlated with minimum temperature (r=0.25) and maximum (r=0.33) and minimum(r=0.46) relative humidity, however, the maximum temperature and rainfall was found to have non-significant effect on population dynamics of this pest (Table 3). However, the jassid population was significantly and positively correlated with minimum relative humidity and rainfall (Table 3). It was very difficult to establish an exact

correlation of pest population dynamics and abiotic factors as it varies from area to area and from insect to insect. The present findings are in agreement with Selvaraj *et al.* (2010) who also observed positive correlation of whitefly with minimum temperature and maximum relative humidity. Opposite of our findings, Boda and Ilyas (2017) observed positive correlation of whitefly population with maximum temperature which could be due to the regional variation in abiotic factors and insect dynamics. Selvaraj *et al*. (2010) indicated maximum temperature negatively correlated with whitefly population. Moreover, rainfall was negatively correlated with whitefly adult population in all treatments (Mahmood *et al.*, 2002). Jassids population exhibited positive correlation with average temperature relative humidity, rainfall, rainy days and wind velocity was observed by Shitole *et al*. (2009) are in confirmation to our findings. Mohapatra (2008) reported that among the weather parameters, temperature showed a positive correlation with jassids population, but in our findings temperature has a non-significant effect on jassid population. The regression equation was also developed based on the significantly correlated abiotic factors for both the whitefly and jassids population is:

Whitefly adult/3 leaves = 0.35 (Tmn)+0.11 (RHm)+0.18 (RHmn)-13.564 (at $P < 0.05$; $R^2=0.52$ and RMSE=3.235%)

Jassid /3 leaves =0.40 (RHmn)+0.20 (Rf) – 0.83 (at $P < 0.05$; $R^2=0.34$ and RMSE=4.274%)

The information generated may be helpful in understanding the ecology of *B. tabaci* and *A. biguttula biguttula* insects in *Bt* cotton in South-western Punjab conditions which benefit in developing efficient pest management strategies against these pests. It was inferred from the present study that July and August months are very much crucial for the infestation, population buildup and further spread of whitefly and jassid in cotton. Therefore, planning and implementing Integrated Pest Management strategies during this period is must to have a healthy cotton crop.

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