CHAPTER-II
REVIEW OF LITERATURE

An attempt was made to review the available literature on “seasonal incidence, related to seasonal occurrence of these pests in relation to major abiotic factors as well as crop phenology, yield losses by this pest and effective chemical insecticide as foliar application against sucking pest of tomato”. Researches carried out on various aspects were reviewed and are presented head wise as under.

2.1 Seasonal incidence of major sucking pests of tomato

2.1.1 Whitefly, *B. tabaci*

Rafic (1999) studied the relation between day temperature and the population of *Bemisia tabaci* on tomato in Egypt. Result suggested that the heat sum model and population of *Bemisia tabaci* adults were highly correlated. The regression value indicated that for every 0.5 - 0.6°C increase in degree days, on average there was a 1 per cent increase in the infestation level of *Bemisia tabaci* adults.

Kumawat *et al.* (2000) carried out the investigation on seasonal incidence of jassid and and whitefly population on okra and their correlation with abiotic factors during *kharif*. The infestation of jassids and whiteflies started in fourth week of July and reached peak in the second and fourth weeks of September, respectively.

Chaudhari *et al.* (2001) recorded highest population density (1.68 whiteflies/plant) on tomato during mid-February and high infestation levels from mid-February to mid-March when temperature, relative humidity (RH), sunshine hour and rainfall were 17.07-22.13 °C, 65.29-72.78 per cent, 7.79-8.9 hours per day and 5 mm, respectively.

Ahsan *et al.* (2005) observed that incidence of insect pests was less in early planting tomato crop during November thereafter, the pest significantly increased in late planting. They further reported that tomato variety BARI planted in November had less infestation of insect pests which ultimately recorded higher yield.

Kharpuse and Bajpai (2006) observed appearance of whitefly during second week of January indicating its peak during last week of March in tomato field.

Anitha (2008) reported that the activity of whitefly was noticed during the fourth week of October i.e. 6.63 whitefly per 3 leaves.
Rafiq *et al.* (2008) studied population dynamics of whitefly (*B. tabaci*) for 6 years on oilseed, pulses, sugarcane, fodder and vegetable crops and reported that its population on tomato crop was present throughout the crop growing season and its maximum population (*2 0/100 cm-2*) recorded in October month in winter crop while in summer season population (*0.3/100 cm-2*) recorded in May and June.

Seasonal incidence of tomato leaf curl virus (TLCV) caused by whitefly (*B. tabaci*) was recorded on the basis of leaf curled plant at weekly interval on cultivars Kashi and Hemant. Incidence (5.33 and 3.67 % during respective years) of leaf curl virus was noticed on 49th standard week. The spread of disease gradually increased till 3rd week of January which later attained 76.00 and 77.33 per cent damage. Thereafter, incidence of disease was negligible during both the years of experimentation (Singh *et al.*, 2011).

Chakraborty (2012) observed initiation of *B. tabaci* population on tomato crop at 48th standard meteorological week (SMW). Thereafter, it further increased first slowly up to 1st SMW then steadily up to 5th SMW attaining peak at 6th SMW which continued up to about 9th SMW. Thereafter, it declined slowly then abruptly indicating significant negative influence on *B. tabaci* population. Relative humidity showed positive influence on the population.

Chavan *et al.* (2013) revealed initiation of whitefly population on tomato crop from transplanting (0.37 whiteflies/leaf) attaining peak of 6.01 whiteflies/leaf. There was significant positive correlation of whitefly with maximum temperature (*r*=0.449) and wind velocity (*r*= −0.534) and significant negative correlation with minimum temperature (*r* = −0.645, *r* = −0.599).

Sharma *et al.* (2013b) observed that weather parameters played significant role in the development of whitefly (*B. tabaci*) population on tomato. The pest population was noticed at 14th standard meteorological week which attained its peak during 22nd standard meteorological week. The correlation between whitefly and temperature (maximum and minimum) and sunshine was positive, while it was negative with relative humidity (maximum and minimum) and rainfall.

Meena and Bairwa (2014) studied that the peak incidence of whitefly (62.12 mean population/6 leaves) were observed in first week of November. The average maximum (30.3°C) and minimum temperatures (16°C) average morning (90%) and evening relative humidity (34%).
Waluniba and Alemla (2014) showed incidence of whitefly (B. tabaci) on tomato crop during 4, 7 and 9th SMWs which in turn indicated significant negative influence of maximum temperature.

Padhi et al. (2015) indicated peak population of whitefly B. tabaci on tomato crop during 7th standard week. The population exhibited negative correlation with minimum and maximum temperature, rainfall and sunshine.

Rishikesh et al. (2015) revealed that B. tabaci found during 5 to 11 November with peak between 26 February to 4 March.

### 2.1.2 Aphid, A. gossypii

Ram and Parihar (2002) revealed that aphid populations remained low on tomato during first fortnight of February which attained peak during second fortnight of February. Thereafter, the population declined in the first fortnight and consequently disappeared from second fortnight of March.

Hath and Das (2004) observed low population of aphid (A. gossypii) in the tomato field from third week of February to the last week of March. The peak population (4.47 and 6.66 aphids/5 leaves) was noticed during first week of March in cultivars Pusa Ruby and Abinash II, respectively.

Kumar et al. (2004) recorded lowest aphid population of 2.4-6.0 aphids/3 leaves. Its peak population was recorded during second week of September-fourth week of October on tomato crop.

Chakraborty (2011) reported initiation of A. gossypii population at 48th SMW in tomato field which further built up first slowly up to 52nd SMW then steadily up to 6th SMW attaining peak at 8th SMW which continued up to the 11th SMW. Maximum temperature, minimum temperature, average temperature, minimum relative humidity and sunshine had significant but negative influence on A. gossypii population While, it was positive with respect to maximum relative humidity.

More et al. (2012) monitored the population of two species of aphids (Aphis gossipii Glover and Myzus persicae Sulzer in potato crop ecosystem during rabi season. They observed that the population of A. gossipii was maximum than the population M. persicae throughout the crop growth period. Maximum number of aphids 22.55, 16.85 and 15.95 were found 45 to 65 days after planting when minimum temperature was in the range of 8.2 to 10.30 °C and maximum. Relative humidity was 98.10 to 97.20 percent.
Lanunochetla et al. (2012) recorded highest peak population of aphids (2.97/leaf) on 43th and 45th standard week of 15th September planting. Correlation of aphid population with maximum and minimum temperature, relative humidity and rainfall was positively non-significant, while maximum temperature and relative humidity showed positive correlation on potato.

Chavan et al. (2013) revealed that appearance of aphid population commenced on tomato crop from transplanting (1.35 aphids/leaf) which attained its peak (7.31 aphids/ leaf). They further reported that wind velocity was significantly and positively correlated with aphid and exhibited significant negative correlation with maximum temperature and minimum temperature.

Sharma et al. (2013b) recorded initial population of aphid (A. gossypii) on tomato during 14th standard week (4.50 aphids/plant) with peak of 24.50 aphids/plant during 22th standard week. Thereafter, there was a steady decline in aphid population. Aphid population was positive but non-significantly correlated with the maximum, minimum temperature (‘r’=0.576; 0.215) and sunshine (‘r’=0.343) but exhibited negative but non-significant correlation with relative humidity (maximum and minimum) (‘r’= −0.506; −0.381) and rainfall (‘r’= −0.613).

Shakeel et al. (2014) revealed that aphid population on tomato crop showed significant negative correlation with minimum and maximum temperature, whereas it exhibited significant positive correlation with relative humidity.

Waluniba and Alemla (2014) showed incidence of aphids (A. gossypii) on tomato at 52nd, 2nd and 4th SMWs. It showed significant negative influence by maximum temperature.

Kumawat et al. (2015) conducted a field experiment on the incidence of major sucking insect pests of chilli. They noticed that the incidence of aphid initiated during 31st SMW and continued up to the 46th SMW, thereafter, disappeared during 47th SMW. The pest population reached the peak at 35th SMW (11.93/plant). The aphid showed significant and positive correlation with mean atmospheric temperature and mean relative humidity.

Padhi et al. (2015) indicated abundance of sucking pests in tomato and their correlations with abiotic factors. They showed peak aphid population at 8th standard week exhibiting significant negative correlation with maximum temperature and sunshine hours.
Rishikesh et al. (2015) revealed that A. gossypii were recorded on the tomato crop on 22\textsuperscript{nd} October, the peak activity of A. gossypii, A. devastans, was recorded during 12\textsuperscript{th} to 18\textsuperscript{th} March, 26\textsuperscript{th} February to 4\textsuperscript{th} March, respectively. Highest mean of 11.66/6 leaves, 9.26/6 leaves was recorded for A. gossypii and A. devastans respectively.

2.1.3 Jassid, A. biguttula biguttula

Nasreen et al. (2004) reported maximum population of jassid (Amrasca biguttula biguttula; 2.43, 2.57, 3.10 and 3.63 per leaf) was recorded on Roma Super tomato.

Chavda (2006) revealed that the peak population of jassid i.e. 11.25 nymphs/leaf on okra was noticed after the 10\textsuperscript{th} week of sowing. The pest population remained active throughout Kharif season and registered significantly positive correlation with maximum temperature (r=0.5490) and significant negative correlation with minimum temperature (r= -0.5193). Similarly, jassid population had significant negative correlation with morning relative humidity (r= -0.3242) in Gujarat.

Bharadiya and Patel (2005) studied the succession of insect pests of brinjal during the kharif season and it was found that the activity of leafhopper. A. biguttula biguttula was maximum during the 3\textsuperscript{rd} week of November.

Verma et al. (2011) Studied the incidence of leafhopper, Amrasca biguttula biguttula on brinjal commenced from 6\textsuperscript{th} week after sowing i.e.second week of October (41\textsuperscript{st} standard week) with an average population level of 0.03 leafhopper/plant during 1\textsuperscript{st} year and in 2\textsuperscript{nd} year it started from second week of October (41\textsuperscript{st} standard week) with an average population level of 0.15 leafhopper/leaf. Maximum population of leafhopper was observed during February (5\textsuperscript{th} week) to March (1\textsuperscript{st} week). The leaf hopper incidence showed positive correlation with morning relative humidity.

Mathur et al. (2012) observed that the incidence of leaf hopper (Amrasca biguttula biguttula) was maximum during December, 52\textsuperscript{nd} Standard Week (SW) and minimum during March (12\textsuperscript{th} SW). Insects showed significant negative correlation with both maximum and minimum temperature and wind speed while a positive correlation with mean relative humidity and total rainfall.

Neelima et al. (2012) revealed that the cotton leafhopper, Amrasca devastans was active throughout the season and has crossed ETL. Three peaks were observed during the season on all the three entries. Correlation studies between leafhopper
population and weather parameters have shown a positive but non-significant relation with both maximum and minimum temperature and evening relative humidity; while, it was negative and non-significant with morning relative humidity and rainfall.

Dabhi and Koshiya (2014) reported that peak activity of leafhopper was found during 16th, 18th, 24th and 33rd meteorological standard week (MSW) in Kharif season. Bright sunshine hours showed significant positive impact with the population of leaf hopper.

Dahatonde et al. (2014) studied that carried out on seasonal abundance of jassid and whitefly on brinjal at Regional Horticultural Research Station Farm. NAU, Navsari, during 2011-12. The results revealed that incidence of jassid (A. biguttula bigutttda Ishida) started from November (3.20 jassid/three leaves) and reached to a peak level (22.46 jassids/three leaves) during December. Among various weather parameters, maximum, minimum and average temperature had highly significant negative influence on jassid population.

Meena and Bairwa (2014) reported that the peak incidence of leafhopper (68.24 mean population/6 leaves) were observed in second week of November on tomato.

Ghulam (2016) revealed that the mean population of jassid (A. biguttula bigutttda Ishida) was 4.30 in first week of January on tomato hybrid.

2.1.4 Thrip, T.tabaci

Brian et al. (2002) studied that the seasonal patterns of F. tritici and F. fusca capture were dissimilar among tomato fields. More F. fusca were captured between mid-May and mid-June in all regions compared with those captured between transplanting and mid-May each year. F. tritici (Lindeman) infestations are highest, between mid-May and mid-June.

Patel et al. (2008) revealed that the incidence of S. dorsalis on chilli crop commenced from first week of September and continued up to harvest of the crop. Peak activity was recorded in November (4.99 to 5.54 thrip/ leaf) and February-March (5.29 to 7.38 thrip/ leaf)

Bhute et al. (2012) reported that appearance of thrips was initiated in 31st SW (July 30-August 5) and continued up to 51th SW (Dec. 17-23) with peak population (110.10 thrips/ 3 leaves) was recorded during 40th SW (Oct. 1-7) in cotton during Kharif.
Barot et al. (2012) reported that the population dynamics of thrips, *Scirtothrips dorsalis* Hood at Main Vegetable Research Station, Anand Agricultural University, Anand (Gujarat) during the *Rabi* 2010-11. The infestation of thrips started from 1<sup>st</sup> week after transplanting i.e. last week of August (35<sup>th</sup> standard week) and remained in field till to the crop maturity (3<sup>rd</sup> week of February) in the range of 0.50 to 10.54 with an average of 4.37 thrips/twig. Thrips attained first (8.80 thrips/twig), second (5.66 thrips/twig) and third as well as the highest peak (10.54 thrips/twig) during 2<sup>nd</sup> week of November, 3<sup>rd</sup> week of December and 3<sup>rd</sup> week of February, respectively.

Verma et al. (2012) studied the seasonal incidence of *T. tabaci* infesting the garlic cultivar, Bikaner. The population density of *T. tabaci* increased with temperature. Minimum temperature negatively correlated with thrips population.

Meena et al. (2013) stated that incidence of thrips (*S. dorsalis* Hood) were appeared on the chilli crop soon after transplanting while The peak population of thrips (14.5 and 14.7/3 leaves/plant) was recorded in the first week of October and maximum temperature had positive correlation with thrips population.

Charles et al. (2013) reported that the majority of the thrips were recorded in the flowering stage of crop development.

Haider et al. (2014) reported that the thrip colonization showed negative correlation with heavy rainfall and low temperature in onion.

Pathipati et al. (2014) studied on seasonal incidence and impact of weather parameters on insect pests of chili in Andhra Pradesh. The results revealed that the infestation and severity of insect pests were highly influenced by weather parameters. Thrips population reached its peak (1.80/leaf) in the 52<sup>nd</sup> Standard Meteorological Week (SMW).

Bokan et al. (2015) studied the seasonal incidence of major sucking insect pests of chilli in relation to weather parameters and revealed that the incidence of thrips started from 35<sup>th</sup> Standard Meteorological Week (SMW). The maximum thrips population was recorded during 42<sup>nd</sup> SMW. The population of thrips was positively correlated with bright sunshine and negatively with minimum temperature, morning and evening relative humidity.

Hossain et al. (2015) revealed that the infestation of onion thrips was started from the first week of February and become gradually increased up to first week of
April than it was declined. Thrips population was positively correlated with temperature and negatively with relative humidity and rainfall.

Mandloi et al. (2015) found that major activity period of *S. dorsalis* Hood were observed during November 2012 to March 2013 with two distinct peaks 7th and 9th SW (2.08 and 1.85 thrips/6 leaves) and population of thrips had a significant positive correlation with evening relative humidity.

Saini et al. (2015) studied the seasonal incidence of major insect pests of chili and revealed that the incidence of the thrips commenced in the second week of August (32 SMW) with a mean population of 2.60/3 leaves. The population of thrips increased with the growth of the crop until it touched its peak of 10.20 thrips/3 leaves in the third week of September (38 SMW), when the prevailing mean atmospheric temperature and relative humidity were 26.15°C and 68.05 per cent, respectively; thereafter the population decreased gradually.

### 2.2. Estimation of yield losses due to sucking pests of tomato

The reduction in height of okra plants and number of leaves per plant due to the attack of jassid was observed up to 49.8 and 45.1 per cent, respectively (Rawat and Sahu, 1973).

Butani (1976) reported that the thrips (*S. dorsalis*) may cause 30 to 50 per cent crop losses in chili.

Krishnaiah (1980) reported about 40-56 per cent losses in okra due to leafhopper.

Bindra and Mahal (1981) reported that jassid caused damage right from the early seedling stage to the fruit setting stage resulting in loss of 50 per cent yield.

Zitter and Everett (1982) reported that the aphid transmitted yellowing virus reduced yield and quality of tomato. Early infection (2-3 week after transplanting) caused the greater plant stunting (8-15%) and reduction in yields (60-83%). But infection occurs as late as 5 week before harvest resulted in a 25% yield reduction.

Powar et al. (1987) reported that the brinjal sucking pest complex cause 10 to 50 per cent yield losses depending on the intensity of infestation.

Mahal *et al* (1994) reported that the seed yield decreases by 0.396 g with every unit increase in cicadellid population.

Singh and Brar (1994) reported that jassid alone can cause 32.06 to 40.84 per cent damage in okra yield.
Patel and Gupta (1998) revealed that the yield losses 60.5 to 74.3 per cent of green chili due to thrips.

Kumar et al. (2001) reported that due to thrips infestation 34 to 43 percent loss in yield of onion.

Rosaiah (2001) revealed that the infestation due to jassid, whitefly and shoot and fruit borer results in about 70-92 % loss in yield of brinjal.

Sharma and Sharma (2001) observed Jassid caused up to 63.41 % yield loss on okra.

Waiganjo et al. (2008) revealed that yield losses due to thrips may range from 18 to 60 percent in onion.

Kadri and Goud (2005) conducted a study for estimation of yield loss in onion due to onion thrips, *T. tabaci*. They reported that a maximum of 71.22 per cent loss in bulb yield was noticed in unprotected crop which was exposed for natural infestation with a mean population of 49.84 thrips per plant compared to the crop which received five insecticidal sprays and they also reported that 71.22 per cent loss in onion bulb yield could be avoided by giving five sprays of dimethoate starting from 10 days after transplanting, at 15 days interval.

Ghosh et al. (2009) evaluated the efficacy of different insecticides against thrips in chili. They recorded maximum reduction of thrips population with consequential increase in yield over control in thiamethoxam (90.1 & 54.3%) followed by acetamiprid (89.8 & 53.2%) and clothianidin (87.4 & 45.6%).

Patel et al. (2009) reported that the plots treated with difenthuiron registered highest yield (115.75 q/ha) in chili.

Diaz-Montano et al. (2011) stated that the *T. tabaci* can cause yield loss more than 50% but can be even more problematic when it transmits some viral diseases.

Mane and Kulkarni (2011) stated that average per cent loss due to brinjal pests in terms of number of fruits per plant was 40.35%. The loss in yield of brinjal due to brinjal pest complex was recorded to the tune of 23.49 per cent.

Verma et al. (2012) evaluated the efficacy of insecticides against onion thrips, *T. tabaci* on garlic and recorded highest garlic yield (172.49 q ha-l) in the treatment of imidaclorpid 17.8 SL @ 0.5 ml/1.

Sandeep and Subash (2013) reported the highest marketable fruit yield and economic returns were obtained in imidaclorpid 17.8 SL + spinosad 45 SC (259.06q/ha).
Singh et al. (2013) reported that the jassid cause yield loss ranging from 32.06 to 66.00 per cent in okra.

Binyam (2015) reported that the aphid-transmitted Potato Virus Y (PVY) is the most important viral pathogen in potato worldwide and can cause yield loss of 10-100 per cent and 39-75 per cent on tobacco.

2.3 Bio-efficacy of insecticides against major sucking pests of tomato

2.3.1 Whitefly, B. tabaci

Saradha and Nachiappan (2003) reported that diafenthiuron at 800 g a.i./ha reduced the population of whitefly to the maximum, followed by diafenthiuron at 600 g and 400 g a.i./ha on brinjal.

Ramesh and Ukey (2006) evaluated eco-friendly neonicotinoids such as imidacloprid and thiamethoxam each at 0.01% and Ha NPV at 250 LE/ha during flowering phase of the crop against jassid (A. biguttula biguttula) and whitefly (B. tabaci) infesting tomato cv. Pusa Ruby. They found imidacloprid most effective against whiteflies recording lowest population of 1.24 and 1.62 at 3 and 7 DAS.

Gupta et al. (2007) revealed that incidence and spread of the Tomato Leaf Curl Virus (TLCV) was directly correlated with whitefly population on tomato field. They also recorded that dimethoate and fenthion were significantly better in the control of whitefly and disease incidence and gave higher yield.

Muhammad et al. (2009) reported that difentiuron (Polo 500 SC) gave 38.58 per cent mortality after 7 days at 250 ml/acre against adults of B. tabaci.

Vichiter and Ramesh (2009) findings revealed that the diafenthiuron (Polo 50 WP) at 400 g a.i./ha was highly effective and significantly superior to the conventional insecticide in controlling whitefly infestation on cotton.

Raghuraman and Birah (2011) revealed that imidacloprid @ 80 g a.i./ha significantly suppressed whitefly and leafhopper populations, and consequently increased yield on okra crop. Maximum yield (508.8 kg/ha, 1188.8 kg/ha) was recorded in imidacloprid (80g a.i./ha) followed by lower dose of 40g a.i./ha during two years, respectively.

Sreekanth and Reddy (2011) evaluated six new insecticides viz., imidacloprid 200 SL, acetamiprid 20 SP, thiamethoxam 25 WG, diafenthiuron 500 SC, triazophos 40 SC and fipronil 5 SC at their field recommended doses for their efficacy against the sucking insect pests viz., aphid, leafhopper, whitefly and thrips in cotton. The
results revealed that acetamiprid, triazophos and difenthiuron provided better control of whitefly population.

Meena and Raju (2013) found fipronil 5 SC most effective insecticide for the control of whitefly and leafhopper on tomato followed by profenofos 50 EC.

Razaq et al. (2013) reported that acetamiprid and difenthiuron were the dominant insecticides to manage sucking insect pests of cotton.

Garmonyou et al. (2014) revealed that dimethoate super treated plots gave significantly lower number of \textit{B. tabaci} on tomato in first year. However in the next year, the control plots recorded significantly more aggregations of \textit{B. tabaci}.

Idris and Mandal (2014) recorded lowest whitefly population in imidacloprid 70 WS @ 10 g a.i. /ha (0.72 to 3.51 flies/leaf) followed by acetamiprid 20 SP 40 g a.i. /ha (0.98 to 3.67 whiteflies/leaf). They also showed highest tomato fruit yield (246.4 q/ha) in imidacloprid treated plots followed by acetamiprid (240.6 q/ ha).

Zala et al. (2014) reported that diafenthiuron 50 WP @ 300 g a.i./ha was found highly effective in reducing the population of aphid, jassid, thrips and whitefly in cotton followed by imidacloprid 17.8 SL @ 20 g a.i./ha.

Gosalwad et al. (2015) revealed that the insecticides imidacloprid 17.8 SL @ 20 g a.i/ha was most effective against whitefly, followed by acetamiprid 20 SP @ 15 g a.i/ha up to 25 and 45 days after transplanting.

Ali et al. (2015) reported minimum whitefly/leaf/plant (0.38, 1.25, 1.35, 1.49, 1.75 and 1.84) after 24, 48, 72 hrs, 7, 10 and 15 days, respectively in imidacloprid at 250 g/acre in cotton field.

Bharati et al. (2015) revealed that imidacloprid 17.8 SL 0.004 per cent followed by dimethoate 30 EC 0.03 per cent were the most effective insecticides in controlling brinjal whitefly.

\textbf{2.3.2 Aphid, \textit{A. gossypii}}

Morita et al. (2007) reported that flonicamid was very effective against aphids, regardless of differences in species, stages and morphs as this compound inhibited the feeding behavior of aphids within 0.5 hours of treatment and this antifeeding activity led to starvation and death.

Nderitu et al. (2008) recorded lowest aphid population in plot treated with imidacloprid (350 g L$^{-1}$) causing more than 95 per cent aphid population reduction and slightly higher yields. They also revealed that the neem products were as effective as synthetic insecticides in the management of aphids infesting okra.
Fonseca et al. (2011) carried out an experiment to evaluate the efficacy of flonicamid against *Aphis gossypii* on cotton crop and reported that foliar application was effective in control of the pest.

Xiao-Bin et al. (2011) conducted studies to manage the imidacloprid-resistant cotton aphid *Aphis gossypii* (Glover) and the results indicated that dinotefuran was the most effective insecticide against imidacloprid resistant *A. gossypii*.

Shinde et al. (2011) reported that imidacloprid 17.8 SL 0.004 per cent was the most effective treatment for the control of okra aphids.

Shivanna et al. (2011) determined the efficacy of new insecticides against sucking insect pests *viz.*, leafhopper, aphid, whitefly and thrips in cotton dimethoate 30 EC and imidacloprid 17.8 SL were most effective against aphid and dimethoate alone was most effective on leafhopper, whitefly and thrips at three days after spraying.

Ghosal et al. (2013) observed imidacloprid 17.8 SL @ 50 g a.i. ha$^{-1}$ most effective against aphid showing least aphid infestation and 84.54 per cent reduction of population over control on okra crop.

Konar et al. (2013) reported that imidacloprid @ 30 g a.i. / ha was found most effective in reducing population of aphid on okra.

### 2.3.3 *Jassid, A. biguttula biguttula*

Patil et al. (1999) studied the effect of spinosad on pest of cotton for two seasons. The result indicates that spinosad at higher dosage levels recorded lower population of leaf hopper.

Mohan and Katiyar (2000) reported that spraying of imidacloprid 200 SL was the most effective in suppressing leafhopper population in cotton.

Acharya et al. (2002) revealed that acetamiprid (20 g a.i. / ha), thiomethoxam and imidachloprid (25 g a.i. / ha) were most effective in controlling okra jassids.

Misra (2002) revealed that imidacloprid and thiomethoxam both @ 25 g a.i. per ha proved significantly superior in controlling Jassid in okra.

Gosalwad et al. (2008) revealed that the treatment of imidachloprid 17.8 SL @ 40 g a.i. / ha was found effective against sucking pest of okra, such as Jassid, aphid, whitefly and thrips and increase yield of okra fruit.

Preetha et al. (2009) revealed that the imidacloprid 17.8 SL @ 25 g a.i. / ha was found effective against jassid and whitefly in okra crop.
Among the imidacloprid formulations, imidacloprid 17.8 SL at 25 g a.i./ha was found superior against leafhoppers and this was on par with acephate 75 SP, thiamethoxam 25 WG, acetamiprid 20 SP, imidacloprid 17.8 SL at 20 g a.i./ha and imidacloprid 70 WG at 25 g a.i./ha (Honnappagouda et al., 2011).

Sujay et al. (2013) reported that the acetamiprid 20% SP resulted in the effective management of leafhopper in okra.

Ramalakshmi et al. (2012) reported difenthiuron 50% WP @ 375 g a.i./ha effective in managing cotton leafhopper.

Ahmed et al. (2014) reported that imidacloprid was safer to natural enemies and toxic for the sucking pests.

2.3.4 Thrip, *T. tabaci*

Reddy et al. (2005) reported that acetamiprid 20 SP (0.002%) and dimethoate 30 EC (0.06%) were most effective against the thrips.

Singh et al. (2005) reported that the Imidacloprid 17.8 SL @ 200 ml/ha was found most effective against thrips with highest yield of green chilli.

Patel et al. (2006) reported that Difenthiuron 50 WP at 50 and 60 g a.i./ha was found more effective than lower rates (30 and 40 g a.i./ha).

Seal et al. (2006) reported that Chlorfenapyr was the most effective in reducing the densities of *S. dorsalis* adult followed by spinosad and imidacloprid on chili.

Prasad and Ahmed (2009) reported that spinosad 45 SC tested at 100, 125, 162.5 and 200 ml ha⁻¹ was found effective against chili thrips, *S. dorsalis*. Spinosad 45 SC @ 125 ml ha⁻¹ exhibited efficacy equal to higher doses and is the optimum dose for control of thrips.

Mandal (2012) evaluated the difenthiuron (Pegasus 50 WP @ 1 g/L) followed by acetamiprid (Ekka 20 SP @ 1 g/L) at 10 days interval 30 days after transplanting 11 (DAT) of the chilli crop, was found to be superior over all other packages in terms of significantly lower thrips population count (1.87/leaf).

Manyam and Byadgi (2013) observed that imidacloprid 17.8 SL @ 0.3 ml/lit was found effective against chilli thrips.

Thania and Thomas (2013) reported that acetamiprid 20 SP @ 20 g a.i./ha along with spiromesifen 45 SC at 100 g a.i./ha were found to be effective against chilli thrips.

Vanisree et al. (2013) evaluated certain new insecticides results revealed that
spinosad 45 SC @ 0.015 per cent was found most effective in reducing the population of *S. dorsalis* as well as in increasing yields.

Varghes and Mathew (2013) has conducted experiment on the bio-efficacy of newer insecticides against the sucking pests of chili and found that acetamiprid 20 SP at 20 g a.i. /ha along with spiromesifen are found to be effective against chili thrips.

Jadhao et al. (2015) found that fipronil 5 SC @ 0.005% was the most effective to reduce the thrips population (57.3%) and it gave highest marketable green chili yield (9.98 t/ha) followed by spinosad 45 SC @ 0.018%, lambda cyhalothrin 5 EC @ 0.005% and clothianidin 50 WP g @ 0.006% by reducing 55.6, 53.7 and 51.8% and 9.18, 8.98 and 8.12 t/ha, respectively.