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## Evaluation of insecticide sequences for integrated management of major insect pests of okra

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### Abstract

The incidence of aphids commenced at 15 days after crop emergence (DAE) and persisted for the following 15 days. Among the insecticide sequences, those containing thiamethoxam and imidacloprid provided the most effective control of aphids at 3, 7, and 14 days after spraying. Leafhopper infestation appeared during the early crop growth stage and continued up to 80 DAE, with negligible incidence thereafter. The sequence azadirachtin → imidacloprid → thiamethoxam → quinalphos → emamectin benzoate (T<sub>5</sub>) recorded the lowest leafhopper population at 3 days after spray (4.03 leafhoppers/leaf), followed by imidacloprid → azadirachtin → thiamethoxam → quinalphos → deltamethrin (T<sub>3</sub>) (4.18/leaf) and thiamethoxam → imidacloprid → azadirachtin → quinalphos → cypermethrin (T<sub>1</sub>) (4.38/leaf), all of which were statistically at par. At 7 and 14 days after spraying, T<sub>1</sub>, T<sub>3</sub>, and T<sub>5</sub> consistently maintained significantly lower leafhopper populations than the remaining treatments. Overall, insecticide sequences comprising thiamethoxam and imidacloprid proved highly effective in suppressing both aphid and leafhopper populations throughout the crop season, with T<sub>1</sub>, T<sub>3</sub>, and T<sub>5</sub> emerging as the most effective spray sequences.

**Keywords:** Okra (*Abelmoschus esculentus* L. Moench), insecticide sequence, aphid, leafhopper, sucking pests, thiamethoxam; imidacloprid, azadirachtin, integrated pest management (IPM), pest management

### Introduction

The demand of vegetables like okra is increasing day by day. Being short duration and high yielding growers get more profit per unit area. However, various problems are faced by cultivators during the crop season and one of the important limiting factors in cultivation of okra is ravages of insect pests. Okra is also known as a house of pests and disease which require special attention to combat them at proper time and in proper manner. The crop has two distinct growing stages i.e. vegetative and fruiting stages. As many as 72 species of insects have been recorded on okra (Rao and Rajendran, 2003) [26]. The problem of pests in okra is more or less similar to that of cotton crop. The major pests of okra are shoot and fruit borer and sucking pests such as aphids (*Aphis gossypii* Glover), leafhopper (*Amrasca biguttula biguttula* Ishida), whitefly (*Bemisia tabaci* Gennadius) and shoot and fruit borer (*Earias vittella* Fabricius) causes significant damage to the crop. The sucking pests usually attack right from early seedling stage to last fruit harvesting. Leafhopper attack causes the leaves to curl upward along the tip and margins and develop necrotic areas which extend over entire surface resulting in hopper burn. Nymphs and adults of aphids suck the cell sap causes reduction in vigor and photosynthesis of plants. Heavy infestation of sucking pests in early crop growth stage results in stunted growth and gradual death of the plants.

Aphids and leafhoppers are important pests in the early stage of the crop which desap the plants, make them weak and reduce the yield. Failure to control them in the initial stages was reported to cause in yield loss to the tune of 54.04 percent (Chaudhary and Dadeech, 1989) [11].

The several insecticides are being used for the control of these pests. Chemical control of insect pests is no doubt the best method of insect pest control but injudicious, indiscriminate and repeated use of same pesticide has created the problems like environmental pollution, insecticidal resistance, pesticide hazards and resurgence owing to the destruction of natural enemies besides their objectionable residues in common diets.

Pests have remarkable capacity to develop resistance to insecticides. More than 600 species of plant feeding insect pest have developed resistance to insecticides. Management of chemical insecticides resistance offers great promise as a complementary extension of integrated pest management (IPM). Insecticide resistance management (IRM) attempts to prevent or delay the development of resistance. Therefore, an experiment planned with management module constituting azadirachtin and insecticide for management of major pests on okra by avoiding repeated use of same insecticide.

### Materials and Methods

The present investigation was undertaken to evaluate the efficacy of different insecticide sequences against the major insect pests of okra under field conditions. Okra is one of the most important vegetable crops grown during the kharif season and is attacked by a complex of insect pests throughout its growth period, resulting in considerable reduction in yield and fruit quality. During the early stages of crop growth, sucking pests such as aphids (*Aphis gossypii* Glover), leafhoppers (*Amrasca biguttula biguttula* Ishida), and whiteflies (*Bemisia tabaci* Gennadius) cause significant damage by extracting plant sap, leading to curling, yellowing, stunted growth, and reduced vigour. Effective management of these pests below the economic threshold level is therefore essential for obtaining higher productivity and better quality produce. In addition to pest suppression, conservation of natural enemies is an important component of integrated pest management (IPM), which can be achieved through the judicious use of selective and eco-friendly insecticides.

The field experiment was conducted during the Kharif season of 2015-16 at the experimental farm of the Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (Dr. PDKV), Akola, to evaluate the efficacy of insecticide sequences against major insect pests of okra. The experimental material comprised okra variety 'Akola Bahar', recommended fertilizers, and insecticides including imidacloprid, thiamethoxam, azadirachtin, quinalphos, cypermethrin, deltamethrin, fenvalerate, and emamectin benzoate. The experiment was laid out in a Randomized Block Design (RBD) with six treatments replicated four times. The crop was sown in plots measuring 4.8 m × 3.6 m, maintaining a spacing of 60 cm between rows and 45 cm between plants. The recommended fertilizer dose of 50:50:0 kg N<sub>2</sub>O<sub>5</sub>:P ha<sup>-1</sup> was applied following the university recommendations. All recommended agronomic practices, except the plant protection treatments under investigation, were adopted uniformly in all the experimental plots throughout the crop growth period.

Although, many plant protection workers have recommended the several insecticides are being used for the control of these pests. Chemical control of insect pests is no doubt the best method of insect pest control but injudicious, indiscriminate and repeated use of same pesticide has created the problems like environmental pollution, insecticidal resistance, pesticide hazards and resurgence owing to the destruction of natural enemies besides their

objectionable residues in common diets. Therefore it is necessary to evaluate the insecticides sequence against major pests okra.

During the experimentation, in all five sprays were undertaken at an interval of 15 days commencing from 15 days emergence of crop. The observations on population of sucking pests particularly, aphids and leafhoppers were recorded on top, middle and bottom leaves per plant and red spider mite population on 2 sq. cm portions on top, middle and bottom of leaves per plant 3, 7 and 14 days after emergence (DAE).

### Results and Discussion

#### Effect of insecticide sequence on aphid

The incidence of aphid population was started during just before first spray i.e. 15 days after emergence (DAE) and was continued for next 15 days i.e. 30 days after emergence; but 30 DAE onwards, the aphids were not observed. Hence, only first spray data on aphids and their results are explained.

It is clear from pre-treatment data on the population (Table 1) of aphid/leaf (24 hours before spray) was found statistically non-significant.

The population of aphid data per leaf 3 days after first spray (DAFS) within the treatments was ranged between 0.22 to 4.65 and was significant. The lowest population of aphids was recorded in treatment (T<sub>3</sub>) imidacloprid 17.8 SL @ 0.25 ml/l (0.22 aphid/leaf) it was followed in (T<sub>1</sub>) thiamethoxam 25 WG @ 0.2 g/l and (T<sub>4</sub>) thiamethoxam 25 WG @ 0.2 g/l which recorded 0.25 and 0.33 aphids per leaf, respectively and all these were at par with each other. The population of aphids in these treatments were significantly minimum than population in rest of the treatments. In the treatments viz., azadirachtin 10000 ppm @ 2 ml/l (T<sub>2</sub> and T<sub>5</sub>) noted 1.24 and 1.52 aphids/leaf, respectively and these aphids were statistically lower than the aphids in the untreated control (4.65/leaf).

Data on aphid count at 7 DAFS indicated significant differences within the insecticide sequences. The lowest population of aphids were recorded in (T<sub>3</sub>) imidacloprid 17.8 SL @ 0.25 ml/l (1.55/leaf) and it was at par with aphids in (T<sub>4</sub> and T<sub>1</sub>) thiamethoxam 25 WG @ 0.2 g/l (1.73 and 1.83 aphids/leaf, respectively). The aphid population in these treatments were significantly least than the aphids in T<sub>5</sub> and T<sub>2</sub>, azadirachtin 10000 ppm @ 2 ml/l recorded (3.27 and 3.43 aphids/leaf, respectively) as well as the maximum aphid count i.e. 5.50 (untreated control). However, aphids in former two were on par to each other.

There were significant differences among the aphid population in the insecticide sequences 14 DAFS. The minimum aphids were noted in T<sub>4</sub>, thiamethoxam 25 WG @ 0.2 g/l (2.75/leaf) followed in T<sub>3</sub>, imidacloprid 17.8 SL @ 0.25 ml/l (2.80/leaf) and aphids in these two were at par to each other and with aphids in T<sub>1</sub>, thiamethoxam 25 WG 0.2 g/l @ (3.15/leaf). The rest of the sprays i.e. T<sub>5</sub> and T<sub>2</sub>, azadirachtin 10000 ppm @ 2 ml/l recorded (4.35 and 4.45/leaf, respectively) were not found effective than the T<sub>6</sub>, untreated control (5.25/leaf) for controlling aphids on okra on 14 DAFS.

**Table 1:** Population of aphids in insecticide sequence after first spray in okra during *kharif* 2015

| Tr. No.        | Spray sequence                                                                                                                                                         | Number of aphids/leaf |                  |                  |                 |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------|------------------|-----------------|
|                |                                                                                                                                                                        | 1 DBS                 | 3 DAFS           | 7 DAFS           | 14 DAFS         |
| T <sub>1</sub> | Thiamethoxam 25WG @ 0.2 g/l<br>imidacloprid 17.8 SL @ 0.25 ml/l<br>azadirachtin 10000 ppm @ 2 ml/l<br>quinalphos 25 EC @ 2 ml/l<br>cypemethrin 25 EC @ 0.3 ml/l        | 3.23<br>(1.89)**      | 0.25<br>(0.86)** | 1.83<br>(1.49)** | 3.15<br>(1.72)* |
| T <sub>2</sub> | Azadirachtin 10000 ppm @ 2 ml/l thiamethoxam 25 WG @ 0.2 g/l imidacloprid 17.8 SL @ 0.25 ml/l<br>deltamethrin 2.8 EC @ 1 ml/l<br>fenvalerate 20 EC @ 0.5 ml/l          | 2.90<br>(1.84)        | 1.24<br>(1.31)   | 3.43<br>(1.97)   | 4.45<br>(2.11)  |
| T <sub>3</sub> | Imidacloprid 17.8 SL @ 0.25 ml/l<br>azadirachtin 10000 ppm @ 2 ml/l<br>thiamethoxam 25 WG @ 0.2 g/l<br>quinalphos 25 EC @ 2 ml/l<br>deltamethrin 2.8 EC @ 1 ml/l       | 2.42<br>(1.70)        | 0.22<br>(0.84)   | 1.55<br>(1.36)   | 2.80<br>(1.67)  |
| T <sub>4</sub> | Thiamethoxam 25 WG @ 0.2 g/l<br>azadirachtin 10000 ppm @ 2 ml/l<br>deltamethrin 2.8 EC @ 1 ml/l<br>fenvalerate 20 EC @ 0.5 ml/l<br>emamectin benzoate 5% SG @ 0.3 g/l  | 2.04<br>(1.51)        | 0.33<br>(0.91)   | 1.73<br>(1.48)   | 2.75<br>(1.65)  |
| T <sub>5</sub> | Azadirachtin 10000 ppm @ 2 ml/l<br>imidacloprid 17.8 SL @ 0.25 ml/l<br>thiamethoxam 25 WG @ 0.2 g/l<br>quinalphos 25 EC @ 2 ml/l<br>emamectin benzoate 5% SG @ 0.3 g/l | 3.13<br>(1.90)        | 1.52<br>(1.40)   | 3.27<br>(1.94)   | 4.35<br>(2.09)  |
| T <sub>6</sub> | Untreated Control                                                                                                                                                      | 4.95<br>(2.33)        | 4.65<br>(2.24)   | 5.50<br>(2.45)   | 5.25<br>(2.28)  |
|                | SE (m)±                                                                                                                                                                | 0.17                  | 0.11             | 0.15             | 0.14            |
|                | CD at 5%                                                                                                                                                               | -                     | 0.34             | 0.44             | 0.44            |
|                | CV (%)                                                                                                                                                                 | 18.77                 | 17.85            | 16.67            | 15.73           |

DBS-Days before spray, DAFS-Days after first spray, \*Figures in square root transformed values, \*\*Figures  $\sqrt{x + 0.5}$  transformed value

### Effect of insecticide sequence on leafhopper

The leafhopper incidence was initiated during early crop growth and continues nearly up to 85 days after emergence. The pre treatment data on leafhopper presented in table 2 indicates that there were no significant differences among the leafhopper population within the treatments.

### Leafhopper population after first spray

All treatments were significantly superior over untreated control (Table 2) with regards to leafhopper population 3 days after first spray (DAFS). Most effective treatment was T<sub>3</sub>, imidacloprid 17.8 SL @ 0.25 ml/l (0.84 leafhoppers/leaf) followed by T<sub>1</sub> and T<sub>4</sub>, thiamethoxam 25 WG @ 0.2 g/l (0.87 and 0.88 leafhoppers/leaf, respectively) which were at par to each other. However, leafhopper in these treatments were significantly low than the leafhoppers in untreated control and in T<sub>5</sub> and T<sub>2</sub>, azadirachtin 10000 ppm @ 2 ml/l which had 1.85 and 2.05 leafhoppers/leaf, respectively being on par to each other and statistically less than leafhoppers in T<sub>6</sub>, untreated control (3.94/leaf).

Population of leafhopper recorded at 7 DAFS revealed that there were significant differences among the treatments. Lowest population was recorded in the treatment T<sub>3</sub>, imidacloprid 17.8 SL @ 0.25 ml/l (5.22 leafhoppers/leaf) followed by in treatments viz., T<sub>1</sub> and T<sub>4</sub>, thiamethoxam 25 WG @ 0.2 g/l (5.33 and 5.39 leafhoppers/leaf, respectively) which were at par to each other; these leafhopper population 7 DAFS were statistically low than in sprays with azadirachtin 10000 ppm @ 2 ml/l (T<sub>2</sub> and T<sub>5</sub>) which recorded 10.20 and 10.46 leafhoppers/leaf, respectively being on par to each other. Maximum population of

leafhopper noted in T<sub>6</sub>, untreated control (14.55/leaf).

Data on leafhopper population count at 14 DAFS indicates significant differences in leafhoppers in insecticide sequence. Minimum population of leafhopper was noted in treatment T<sub>3</sub>, imidacloprid 17.8 SL @ 0.25 ml/l (9.44 leafhoppers/leaf) followed by the 9.56 and 9.67 leafhoppers recorded respectively in T<sub>1</sub> and T<sub>4</sub>, thiamethoxam 25 WG @ 0.2 g/l, which were at par to each other; the leafhoppers in these two and in former were statistically least than the leafhoppers in rest of the treatments. The highest leafhoppers i.e. 16.87 were noted in T<sub>6</sub>, untreated control which does not differ statistically with respect to leafhopper as affected by T<sub>2</sub> and T<sub>5</sub>, azadirachtin 10000 ppm @ 2 ml/l (14.05 and 14.27/leaf, respectively) at 14DAFS.

### Leafhopper population after second spray

Unlike in first spray, leafhopper population pressure (Table 4) during second spray i.e. 30 to 45 days after emergence (DAE) was high. Leafhopper population was ranged from 3.12 to 13.44/leaf and data on leafhopper was significant 3 days after second spray (DASS). The minimum leafhopper were in T<sub>5</sub>, imidacloprid 17.8 SL @ 0.25 ml/l (3.12) closely followed in the treatments T<sub>1</sub>, imidacloprid 17.8 SL @ 0.25 ml/l and T<sub>2</sub>, thiamethoxam 25 WG @ 0.2 g/l which recorded 3.60 and 3.82 leafhoppers/leaf, respectively; however, leafhopper in this treatments does not differ statistically in T<sub>2</sub>. The leafhopper in imidacloprid 17.8 SL @ 0.25 ml/l (T<sub>5</sub> and T<sub>1</sub>) and thiamethoxam 25 WG @ 0.2 g/l (T<sub>2</sub>) spray were significantly low than leafhopper in azadirachtin 10000 ppm @ 2 ml/l (T<sub>4</sub>, 6.32 and T<sub>3</sub>, 7.22) sprays. The leafhopper population in azadirachtin 10000 ppm @ 2 ml/l spray (T<sub>3</sub>

and T<sub>4</sub>) were significantly least than leafhopper in T<sub>6</sub>, untreated control (13.44/leaf).

The leafhopper population recorded at 7 DASS in untreated plot (14.20/leaf) was higher than leafhoppers in treated plots. Minimum population (5.24 leafhoppers/leaf) was recorded in T<sub>1</sub>, imidacloprid 17.8 SL @ 0.25 ml/l and it was statistically at par with T<sub>2</sub>, thiamethoxam 25 WG @ 0.2 g/l (5.35 leafhoppers/leaf) and leafhopper in T<sub>5</sub>, imidacloprid 17.8 SL @ 0.25 ml/l (5.40/leaf) and these populations does not differ statistically with each other. Spray of azadirachtin 10000 ppm @ 2 ml/l (T<sub>4</sub>, 9.23 leafhoppers/leaf) and (T<sub>3</sub>, 9.48 leafhoppers/leaf) were preceding sprays having significantly least leafhopper than in untreated control i.e. maximum population (14.20/leaf).

The entire treated plots revealed significant differences in leafhopper population in various treatments at 14 DASS. The lowest population of leafhopper (10.10/leaf) was observed in treatment sprays T<sub>5</sub>, imidacloprid 17.8 SL @ 0.25 ml/l treatments followed in T<sub>1</sub>, imidacloprid 17.8 SL @ 0.25 ml/l and T<sub>2</sub>, thiamethoxam 25 WG @ 0.2 g/l which recorded 10.31 and 10.82/leaf, respectively being were at par with each other and significantly least than leafhopper in T<sub>4</sub> and T<sub>3</sub>, azadirachtin 10000 ppm @ 2 ml/l and T<sub>6</sub>, untreated control which had respectively 13.83, 14.45, 16.20/leaf.

#### Leafhopper population after third spray

It is evident from the table 5 that there were significant differences in leafhopper population among the various treatments 3 days after third spray (DATS). Leafhopper population was ranged from 4.52 to 14.75 leafhoppers per leaf. The spray with thiamethoxam 25 WG @ 0.2 g/l had least population 4.52 (T<sub>3</sub>) and 4.58 (T<sub>5</sub>) leafhopper per leaf which does not differ statistically than 4.60 recorded in imidacloprid 17.8 SL @ 0.25 ml/l (T<sub>2</sub>). Next effective treatments were azadirachtin 10000 ppm @ 2 ml/l (T<sub>1</sub>) deltamethrin 2.8 EC @ 1 ml/l (T<sub>4</sub>) which had 8.02 and 10.40 leafhoppers/leaf, respectively which were significantly low than untreated control (14.75/leaf). However, azadirachtin was not as effective as imidacloprid and thiamethoxam sprays.

Nearly similar was a trend 7 DATS with respect to leafhopper management. Seven days after third spray population was ranged between 5.84 to 15.60 leafhopper per leaf; minimum population (5.84/leaf) being in imidacloprid 17.8 SL @ 0.25 ml/l (T<sub>2</sub>). However, minimum population of leafhopper does not differ statistically than leafhopper in thiamethoxam 25 WG @ 0.2 g/l (T<sub>3</sub> and T<sub>5</sub>) which had 6.18 and 6.19 leafhopper per leaf, respectively. Whereas, leafhopper in imidacloprid and thiamethoxam sprays were statistically least than the leafhopper in T<sub>1</sub> azadirachtin 10000 ppm @ 2 ml/l spray which had (10.21/leaf) and T<sub>4</sub>, deltamethrin 2.8 EC @ 1 ml/l (11.68/leaf) which had significantly low leafhopper than in T<sub>6</sub>, untreated control (15.60/leaf).

The data noted on population of leafhopper 14 DATS revealed that treatment imidacloprid 17.8 SL @ 0.25 ml/l (T<sub>2</sub>) spray emerged as most effective treatment with least leafhopper (11.58/leaf) which was at par with 12.28/leaf noted in thiamethoxam 25 WG @ 0.2 g/l (T<sub>3</sub> and T<sub>5</sub>, respectively) and all these population were significantly less than leafhoppers in rest of the treatments. The treatments viz., azadirachtin 10000 ppm @ 2 ml/l (T<sub>1</sub>, 15.78 leafhoppers/leaf) and deltamethrin 2.8 EC @ 1 ml/l (16.24

leafhoppers/leaf) were not found effective than the T<sub>6</sub>, untreated control (18.47/leaf).

Fourteen days after third spray; T<sub>1</sub>, azadirachtin 10000 ppm @ 2 ml/l (15.78 leafhopper/leaf) and T<sub>4</sub>, deltamethrin 2.8 EC @ 1 ml/l (16.24 leafhoppers/leaf) which were statistically equal with leafhopper in untreated control (18.47/leaf).

#### Leafhopper population after fourth spray

The data on leafhopper population 3 days after fourth spray (DAFS) presented in table 6 revealed that all the treatments were significantly superior over untreated control. Minimum population of leafhoppers was recorded in quinalphos 25 EC @ 0.5 ml/l (T<sub>3</sub>, 5.38/leaf) followed in quinalphos 25 EC @ 0.5 ml/l (T<sub>5</sub>, 5.58 and T<sub>1</sub>, 6.02/leaf) which were at par with each other; however, it was significantly least than leafhopper in rest of the treatments. The next effective treatments were T<sub>4</sub>, fenvalerate 20 EC @ 0.5 ml/l (9.15 leafhoppers/leaf) and T<sub>2</sub>, deltamethrin 2.8 EC @ 1 ml/l (9.60 leafhoppers/leaf) which were significantly least than the leafhopper in T<sub>6</sub>, untreated control (12.55/leaf).

Population of leafhopper recorded at 7 DAFS revealed significant differences within the treatments. The lowest population of leafhoppers were observed in quinalphos 25 EC @ 0.5 ml/l sprays with 6.93 (T<sub>5</sub>), 7.07 (T<sub>3</sub>) and 7.32 (T<sub>1</sub>) leafhopper per leaf and these population counts were significantly minimum than the leafhoppers in rest of the treatments. Deltamethrin 2.8 EC @ 1 ml/l (T<sub>2</sub>) and T<sub>4</sub>, fenvalerate 20 EC @ 0.5 ml/l sprays were found effective with 10.90 and 11.02 leafhoppers/leaf, respectively as against 16.05/leaf recorded in T<sub>6</sub>, untreated control. Although, the pyrethroids viz., deltamethrin and fenvalerate were effective over untreated control, but not as good as quinalphos.

Fourteen days after fourth spray (DAFS), leafhopper population among the treatments ranged from 9.33 to 15.8/leaf. All treatments were significantly superior over untreated control. The most effective treatment was quinalphos 25 EC @ 0.5 ml/l spray which noted 9.33 (T<sub>5</sub>), 9.70 (T<sub>1</sub>), 9.87 (T<sub>3</sub>) leafhoppers/leaf and these populations were significantly least than leafhopper in T<sub>6</sub>, untreated control (15.81/leaf) as well as in deltamethrin and fenvalerate sprays. However, pyrethroids viz., deltamethrin 2.8 EC @ 1 ml/l and fenvalerate 20 EC @ 0.5 ml/l were not found effective as they registered 13.04 and 13.79 leafhoppers/leaf, respectively which does not differ statistically than 15.81 leafhoppers recorded in untreated control.

#### Leafhopper population after fifth spray

Leafhopper incidence was initiated during early crop growth and there was still leafhoppers incidence i.e. 80 days after crop emergence and 90 days onwards leafhopper supposed to disappeared. Although, there was existence of leafhopper 80 days after emergence, but at low level. The data on leafhoppers per leaf 3 and 7 days after fifth spray was non significant.

The average leafhopper data 3 and 7 days after spray presented in table 8 shows that insecticide sequences are categorized into two groups, first group as most effective sequence group which include T<sub>3</sub>, T<sub>1</sub> and T<sub>5</sub> and second next effective sequence group include T<sub>2</sub> and T<sub>4</sub>. This indicates that the sequence T<sub>3</sub>, T<sub>1</sub> and T<sub>5</sub> are most effective against 3 and 7 days after sprays.

The data on leafhopper after first, second, third, fourth, fifth spray and mean of these indicates that leafhopper population was effectively managed by the treatments sprays thiamethoxam and imidacloprid. The present findings are in agreement with findings those of Preetha *et al.*, (2009) [23] and Verma *et al.*, (2014) [30] who reported effective management of leafhopper with imidacloprid and

thiamethoxam on okra. Similarly, Raghuraman and Gupta (2006) [24], Raghuraman and Birah (2011) [25] and Begum *et al.*, (2016) [10] observed effective suppression of leafhoppers by imidacloprid. The study on okra pest control conducted by Parmar *et al.*, (2013) [20] demonstrated effective control of leafhopper with imidacloprid.

**Table 2:** Population of leafhopper per leaf in insecticide sequence in okra during *kharif* 2015

| Tr. No.        | Spray sequence                                                                                                                                                         | First Spray    |                |                 |                 | Second Spray    |                 |                 | Third Spray     |                 |                 |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                |                                                                                                                                                                        | 1 DBS          | 3 DAFS         | 7 DAFS          | 14 DAFS         | 3 DASS          | 7 DASS          | 14 DASS         | 3 DATS          | 7 DATS          | 14 DATS         |
| T <sub>1</sub> | Thiamethoxam 25WG @ 0.2 g/l<br>imidacloprid 17.8 SL @ 0.25 ml/l<br>azadirachtin 10000 ppm @ 2 ml/l<br>quinalphos 25 EC @ 2 ml/l<br>cypemethrin 25 EC @ 0.3 ml/l        | 3.85<br>(1.95) | 0.87<br>(0.93) | 5.33<br>(2.25)  | 9.56<br>(3.07)  | 3.60<br>(1.87)  | 5.24<br>(2.24)  | 10.31<br>(3.21) | 8.02<br>(2.82)  | 10.21<br>(3.18) | 15.78<br>(3.99) |
| T <sub>2</sub> | Azadirachtin 10000 ppm @ 2 ml/l thiamethoxam 25 WG @ 0.2 g/l<br>imidacloprid 17.8 SL @ 0.25 ml/l<br>deltamethrin 2.8 EC @ 1 ml/l<br>fenvalerate 20 EC @ 0.5 ml/l       | 4.67<br>(2.14) | 2.05<br>(1.41) | 10.20<br>(3.18) | 14.05<br>(3.73) | 3.82<br>(1.95)  | 5.35<br>(2.27)  | 10.82<br>(3.24) | 4.60<br>(2.13)  | 5.84<br>(2.41)  | 11.58<br>(3.36) |
| T <sub>3</sub> | Imidacloprid 17.8 SL @ 0.25 ml/l<br>azadirachtin 10000 ppm @ 2 ml/l<br>thiamethoxam 25 WG @ 0.2 g/l<br>quinalphos 25 EC @ 2 ml/l<br>deltamethrin 2.8 EC @ 1 ml/l       | 4.48<br>(2.11) | 0.84<br>(0.91) | 5.22<br>(2.23)  | 9.44<br>(3.04)  | 7.22<br>(2.67)  | 9.48<br>(3.06)  | 14.45<br>(3.80) | 4.52<br>(2.08)  | 6.18<br>(2.43)  | 12.28<br>(3.48) |
| T <sub>4</sub> | Thiamethoxam 25 WG @ 0.2 g/l<br>azadirachtin 10000 ppm @ 2 ml/l<br>deltamethrin 2.8 EC @ 1 ml/l<br>fenvalerate 20 EC @ 0.5 ml/l<br>emamectin benzoate 5% SG @ 0.3 g/l  | 4.15<br>(2.00) | 0.88<br>(0.93) | 5.39<br>(2.30)  | 9.67<br>(3.08)  | 6.32<br>(2.51)  | 9.23<br>(3.02)  | 13.83<br>(3.72) | 10.40<br>(3.22) | 11.68<br>(3.42) | 16.24<br>(4.03) |
| T <sub>5</sub> | Azadirachtin 10000 ppm @ 2 ml/l<br>imidacloprid 17.8 SL @ 0.25 ml/l<br>thiamethoxam 25 WG @ 0.2 g/l<br>quinalphos 25 EC @ 2 ml/l<br>emamectin benzoate 5% SG @ 0.3 g/l | 3.50<br>(1.85) | 1.85<br>(1.35) | 10.46<br>(3.22) | 14.27<br>(3.76) | 3.12<br>(1.73)  | 5.40<br>(2.31)  | 10.10<br>(3.15) | 4.58<br>(2.10)  | 6.19<br>(2.47)  | 12.76<br>(3.42) |
| T <sub>6</sub> | Untreated Control                                                                                                                                                      | 6.20<br>(2.47) | 3.94<br>(1.96) | 14.55<br>(3.81) | 16.87<br>(4.11) | 13.44<br>(3.66) | 14.20<br>(3.76) | 16.20<br>(4.02) | 14.75<br>(3.83) | 15.60<br>(3.96) | 18.47<br>(4.29) |
|                | SE (m)±                                                                                                                                                                | 0.17           | 0.10           | 0.20            | 0.20            | 0.15            | 0.21            | 0.17            | 0.19            | 0.17            | 0.19            |
|                | CD at 5%                                                                                                                                                               | -              | 0.31           | 0.54            | 0.60            | 0.44            | 0.63            | 0.47            | 0.59            | 0.53            | 0.40            |
|                | CV (%)                                                                                                                                                                 | 16.59          | 16.52          | 13.58           | 11.51           | 12.12           | 15.17           | 10.13           | 14.32           | 12.03           | 9.83            |

| Tr. No.        | Spray sequence                                                                                                                                                         | Fourth Spray    |                 |                 | Fifth Spray     |                  |         | Mean of total five spray |                  |                  |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|-----------------|-----------------|------------------|---------|--------------------------|------------------|------------------|
|                |                                                                                                                                                                        | 3 DAFS          | 7 DAFS          | 14 DAFS         | 3 DAFS          | 7 DAFS           | 14 DAFS | 3 DAS                    | 7 DAS            | 14 DAS           |
| T <sub>1</sub> | Thiamethoxam 25WG @ 0.2 g/l<br>imidacloprid 17.8 SL @ 0.25 ml/l<br>azadirachtin 10000 ppm @ 2 ml/l<br>quinalphos 25 EC @ 2 ml/l<br>cypemethrin 25 EC @ 0.3 ml/l        | 6.02<br>(2.43)  | 7.32<br>(2.62)  | 9.70<br>(3.11)  | 3.41<br>(1.84)* | 1.72<br>(1.41)** | -       | 4.38<br>(2.09)**         | 5.97<br>(2.44)** | 11.33<br>(3.36)* |
| T <sub>2</sub> | Azadirachtin 10000 ppm @ 2 ml/l thiamethoxam 25 WG @ 0.2 g/l<br>imidacloprid 17.8 SL @ 0.25 ml/l<br>deltamethrin 2.8 EC @ 1 ml/l<br>fenvalerate 20 EC @ 0.5 ml/l       | 9.60<br>(3.09)  | 10.90<br>(3.31) | 13.04<br>(3.61) | 5.76<br>(2.35)  | 2.74<br>(1.76)   | -       | 5.17<br>(2.27)           | 6.92<br>(2.63)   | 12.16<br>(3.48)  |
| T <sub>3</sub> | Imidacloprid 17.8 SL @ 0.25 ml/l<br>azadirachtin 10000 ppm @ 2 ml/l<br>thiamethoxam 25 WG @ 0.2 g/l<br>quinalphos 25 EC @ 2 ml/l<br>deltamethrin 2.8 EC @ 1 ml/l       | 5.38<br>(2.27)  | 7.07<br>(2.59)  | 9.87<br>(3.14)  | 2.95<br>(1.71)  | 1.76<br>(1.47)   | -       | 4.18<br>(2.04)           | 5.94<br>(2.43)   | 11.51<br>(3.39)  |
| T <sub>4</sub> | Thiamethoxam 25 WG @ 0.2 g/l<br>azadirachtin 10000 ppm @ 2 ml/l<br>deltamethrin 2.8 EC @ 1 ml/l<br>fenvalerate 20 EC @ 0.5 ml/l<br>emamectin benzoate 5% SG @ 0.3 g/l  | 9.15<br>(3.01)  | 11.02<br>(3.32) | 13.79<br>(3.71) | 4.18<br>(1.92)  | 2.05<br>(1.58)   | -       | 6.25<br>(2.49)           | 7.87<br>(2.80)   | 13.38<br>(3.66)  |
| T <sub>5</sub> | Azadirachtin 10000 ppm @ 2 ml/l<br>imidacloprid 17.8 SL @ 0.25 ml/l<br>thiamethoxam 25 WG @ 0.2 g/l<br>quinalphos 25 EC @ 2 ml/l<br>emamectin benzoate 5% SG @ 0.3 g/l | 5.58<br>(2.34)  | 6.93<br>(2.56)  | 9.33<br>(3.04)  | 5.03<br>(2.18)  | 1.95<br>(1.54)   | -       | 4.03<br>(1.99)           | 6.19<br>(2.49)   | 11.62<br>(3.40)  |
| T <sub>6</sub> | Untreated Control                                                                                                                                                      | 12.55<br>(3.65) | 16.05<br>(4.01) | 15.81<br>(3.97) | 8.50<br>(2.51)  | 3.07<br>(1.89)   | -       | 10.23<br>(3.20)          | 12.53<br>(3.54)  | 16.84<br>(4.10)  |
|                | SE (m)±                                                                                                                                                                | 0.17            | 0.23            | 0.16            | 0.24            | 0.17             |         | 0.09                     | 0.06             | 0.10             |
|                | CD at 5%                                                                                                                                                               | 0.53            | 0.64            | 0.49            | -               | -                |         | 0.27                     | 0.19             | 0.30             |
|                | CV (%)                                                                                                                                                                 | 12.55           | 14.89           | 9.45            | 23.23           | 22.18            |         | 7.75                     | 4.77             | 5.49             |

\*Figures in square root transformed values, \*\*Figures  $\sqrt{x + 0.5}$  transformed values

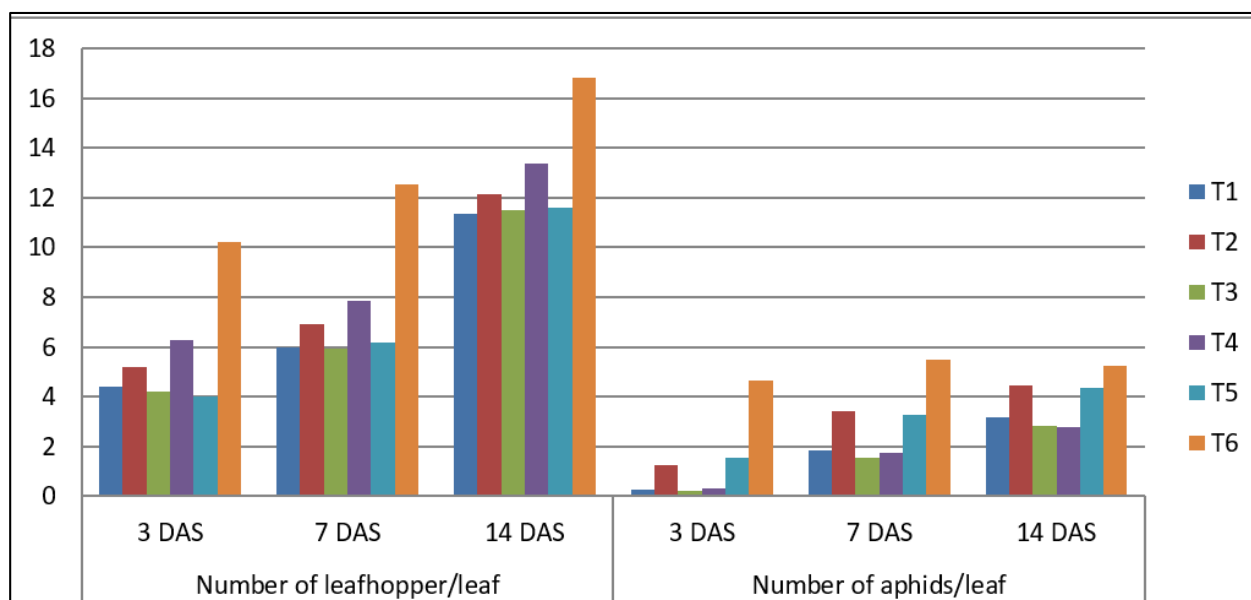


Fig 1: Mean of population of leafhopper and aphids per leaf over total five Sprays

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