# EVALUATION OF NEW INSECTICIDES AGAINST MAJOR PESTS OF OKRA, *Abelmoschus esculentus* L.

by


**RESHMA CHANDRAN**

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**THESIS**

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## DECLARATION

I, hereby declare that this thesis entitled **"EVALUATION OF NEW INSECTICIDES AGAINST MAJOR PESTS OF OKRA, *Abelmoschus esculentus* L."** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Place: Padannakkad

Date: 27/09/2019

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## CERTIFICATE

Certified that this thesis entitled **"EVALUATION OF NEW INSECTICIDES AGAINST MAJOR PESTS OF OKRA, *Abelmoschus esculentus* L."** is a record of research work done independently by Ms. Reshma Chandran under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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# *Introduction*

# 1. INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is a warm season flowering plant belonging to family Malvaceae, and cultivated throughout the tropical and subtropical warm temperate regions of the world for its edible green fruits. It is also known as ladies finger or bhindi. The immature fruits are used for making soups and curry. Apart from fruits other parts of the plant are also used for different purposes like food, bio-fuel and also have some medicinal properties (Venkenna, 2014).

Okra is one of the most important vegetables due to its nutritional value. It is the power house of valuable nutrients including vitamin A, vitamin B6, folic acid and fibre. It contains water (90 per cent), proteins (2 per cent), carbohydrates (7 per cent), minerals (phosphorus, magnesium and potassium) and vitamins (30mg/100g) (Bawa and Badrie, 2016). The nutritive value of okra is much higher than tomato, brinjal and cucurbits except bitter gourd (Nonnecke, 1989).

Okra is widely cultivated around the world with a production of 96.41 lakh tons. India ranks first in the world with a production of 60.95 lakh tons (61.9 per cent) followed by Nigeria (22.2 per cent). In India it is grown in an area of 509.02 ha with a productivity of 12.0 MT/ha. In Kerala, okra is grown in an area of 2.48 ha with a production of 34.65 MT and productivity of 13.96 MT/ha (Anon., 2018).

A number of insect pests attack the crop reducing the production and productivity. Among these, the important and the destructive ones are the shoot and fruit borer, *Earias vitella* (Fb.) (Lepidoptera: Noctuidae); gram pod borer, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae); leaf roller, *Sylepta derogata* (Fb.) (Lepidoptera: Pyralidae); leafhopper, *Amrasca biguttula biguttula* (Ishida) (Hemiptera: Cicadellidae). Other minor pests are red bug, *Dysdercus cingulatus* (F.) (Hemiptera: Pyrrhocoridae) green semilooper, *Anomis flava* Fab. (Lepidoptera: Noctuidae); semilooper caterpillar, *Xanthodes groellsi* Fsth. (Lepidoptera: Noctuidae); leaf caterpillar, *Spodoptera litura* (Lepidoptera:

Noctuidae); petiole maggot, *Melanagromyza hibisci* Spencer (Diptera: Agromyzidae); aphid, *Aphis malvae* Koch. (Hemiptera: Aphididae); flower beetle, *Mylabris pustulata* Thunb. (Coleoptera: Meloidae); and red spider mite, *Tetranychus urticae* Koch. (Tetranychidae).

One of the major pests of okra is shoot and fruit borer, *Earias vitella*, which attacks the crop during vegetative and reproductive stage. During vegetative stage, the larvae bore into the shoots and flower buds. The infested shoots droop, wither and dry up. In the reproductive stage larvae bore into the fruits and bore holes are plugged with excreta. Infested fruits become deformed and unfit for consumption. The loss in okra fruits due to the infestation of *E. vitella* ranges from 5.33 to 75.75 per cent in the field (Pareek and Bhargava, 2003).

The gram pod borer *Helicoverpa armigera* feeds on the internal content of the fruits by thrusting their head inside leaving the rest of the body outside (Venkatachalam and Ilamurugu, 2014). Damaged fruits become unfit for consumption and reduce the quality and quantity of fruits.

The nymphs and adults of leafhopper *Amrasca biguttula biguttula*, suck sap from the under surface of leaves and leaves become yellow, margins curl downwards and dry up (Venkatachalam and Ilamurugu, 2014). Severe infestation results in bronze coloured leaves which is called hopper burn symptom. The feeding activity results in stunted growth of the plants.

The leaf roller, *Sylepta derogata* is not a major pest but the larva roll the leaves and feed within and hence reduces the photosynthetic area of leaves. In severe cases it causes complete defoliation of the plant.

Though different non chemical and chemical methods are developed under the IPM strategy, these pests are still in the fields and making the cultivation difficult for farmers. Sucking pests have developed resistance to almost all conventional and synthetic insecticides and also has developed resistance to multiple classes of insecticides (Palumbo *et al.*, 2001). The shoot and fruit borer, *E. vitella* has also developed resistance against the conventional insecticides making it difficult to control (Kranthi *et al.*, 2002). As okra is a fast growing high value crop, chemical control is generally practiced for higher gains. Indiscriminate use of insecticides, leads to contamination of fruits with pesticide residues and resistance development besides ill effect on environment (Aswathi and Anand, 1983).

In order to reduce the pesticide load in fruits and environment new insecticides with different modes of action against multiple target pests having different feeding habits are combined with lower doses. Combination of two chemicals with different mode of action is the new strategy to reduce the development of resistance among insects (Kumar *et al.*, 2010). New molecules are more tissue-specific and undergo rapid degradation, leaving very less amount of residues in the environment and low risk to non-target organisms. Hence they will perform better in controlling these pests and also reduces the pesticide load (Gavkare *et al.*, 2013). Pesticide mixture has broad spectrum of activity, multiple target pest or pest species, synergistic joint action, lower quantity as well as cost, reduced application cost, saving time, less numbers of sprays, safe to farmer's health and environment (Anjabapu, 2018)

Nowadays emphasis is given for biodegradable, less persistent insecticides with lower quantity having specific activity and in this context the present study entitled "Evaluation of new insecticides against major pests of okra, *Abelmoschus esculentus* L." was undertaken with the following objectives,

- To study the efficacy of different new insecticides against major pests of okra, *viz.*, shoot and fruit borer, gram pod borer, leaf roller and leaf hopper.
- To estimate the benefit-cost ratio involved in insecticide usage in okra.

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# Review of literature

## 2. REVIEW OF LITERATURE

The available literature on efficacy of new insecticides against major pests of okra *Abelmoschus esculentus* L. and other crops are reviewed here under.

### 2.1 EFFICACY OF NEW INSECTICIDES

### 2.1.1 SHOOT AND FRUIT BORER, *Earias vitella*

Kumar *et al.* (2010) tested the efficacy of flubendiamide + thiacloprid 480 SC against cotton bollworms. In the first trail flubendiamide + thiacloprid 480 SC @ 120 g a.i./ ha (95.29 per cent reduction) showed lowest population of bollworms followed by flubendiamide 480 SC @ 60 g a.i./ha ( 93.39 per cent reduction). In the second trail, flubendiamide 480 SC recorded lowest bollworm population followed by flubendiamide + thiacloprid 480 SC @ 120 g a.i./ ha (80.00 per cent reduction).

Chatterjee and Mondal (2011) reported that larval population of okra shoot and fruit borer was reduced by spinosad (4.3 per cent) followed by flubendiamide (4.8 per cent), novaluron (5.5 per cent) and chlorantraniliprole + cypermethrin (5.6 per cent).

According to Raghunath (2011), flubendiamide 480 SC @ 0.0144 per cent significantly reduced the population of *E. vitella* (0.78 larvae/plant) in okra compared to control (1.38 larvae/plant). Flubendiamide 480 SC showed lowest shoot (8.57 per cent shoot damage) and fruit damage (1.88 per cent fruit damage). Novaluron 10 EC was less effective with 18.57 per cent shoot and 21.54 per cent fruit damage.

The lowest shoot and fruit borer infestation in okra was recorded from plots treated with thiamethoxam 25 WG @ 100 g a.i./ha as first spray and cypermethrin 25 EC @ 47 g a.i./ha (6.98 per cent infestation) as second spray at 21 days after treatment (Patel, 2013).

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Singh (2014) reported that flubendiamide 480 SC @ 100 ml/ha was superior over all the treatment with lowest shoot and fruit infestation in okra. Flubendiamide 480 SC showed more than 70 per cent reduction in the population of shoot and fruit borer larvae.

According to Venkanna (2014), rynaxypyr 20 SC, flubendiamide 480 SC and indoxacarb 14.5 SC showed more than 90 per cent reduction in the larval population of *Earias* spp. in okra. Novaluron 10 EC (90 per cent reduction) also showed significant reduction in the population of *Earias* spp.

Bajya *et al.* (2015) tested the efficacy of ampligo 150 ZC (Chlorantraniliprole 9.3 per cent+ Lambda cyhalothrin 4.6 per cent ZC) against cotton bollworms and noticed lowest square (1.58 per cent), locule (9.01 per cent) and boll (3.43 per cent) damage in plots treated with ampligo 150 ZC @ 60 g a.i./ha. It was on par with ampligo 150 ZC @ 45 and 37.5 g a.i./ha. The population of *Earias* spp. in cotton was lowest in ampligo 150 ZC @ 60 g a.i./ha (2.0 per cent).

Haider *et al.* (2015) evaluated the efficacy of insecticides against spotted bollworm (*Earias* spp.) in cotton in which lowest bollworm infestation was observed in triazophos 40 EC @ 1000 ml/acre followed by voliam flexi 300 SE (Thiamethoxam+Chlorantraniliprole) @ 80 ml/acre. The average cotton yield was highest in triazophos (2.31 and 2.44 kg) treated plots which is on par with voliam flexi (2.03 and 2.12 kg) and was superior to control (1.66 and 1.74 kg/ha).

Katti and Surpur (2015) reported that flubendiamide 480 SC @ 60 g a.i./ha significantly reduced shoot (6.20 per cent shoot damage) and fruit infestation (5.00 per cent fruit damage) by okra shoot and fruit borer.

Out of the seven insecticides tested, chlorantraniliprole 18.5 SC @ 25 g a.i./ha was superior over all the treatments with minimum shoot and fruit borer infestation in okra (7.3 per cent shoot damage and 0.2 per cent fruit damage) (Kumar, 2015).

According to Shrivastava (2016), fruit infestation was lowest in chlorantraniliprole 18.5 per cent @ 30 g a.i./ha (9.72 per cent on number basis and 9.50 per cent on weight basis) followed by thiamethoxam 25 WG @ 30 g a.i./ha (9.94 per cent on number basis and 10.05 per cent on weight basis) at 20 days after first spraying.

Deepak *et al.* (2017) noticed that flubendiamide 60 g a.i./ha significantly reduced fruit borer infestation on okra (14.40 per cent reduction on number basis and 15.90 per cent on weight basis).

According to Raju *et al.* (2017), out of seven insecticides tested against okra shoot and fruit borer *E. vitella,* emamectin benzoate 5 SG @ 15 g a.i./ha was the best treatment in reducing the shoot and fruit damage followed by spinosad 45 SC @ 75 g a.i./ha, flubendiamide 480 SG @ 60 g a.i./ha, chlorantraniliprole 20 SC @ 30 g a.i./ha and novaluron 10 EC @ 75 g a.i./ha.

According to Uchware (2017), okra shoot and fruit borer attack was lowest in carboxamide 300 SC @ 37 g a.i./ha (1.32 per cent fruit damage and 87.46 per cent population reduction ) which was at par with chlorantraniliprole 18.5 per cent SC @ 25 g a.i./ha (1.48 per cent fruit damage and 84.83 per cent population reduction).

Rambhau (2018) reported that chlorantraniliprole 8.8 per cent + thiamethoxam 17.5 per cent SC @ 150 g a.i./ha provided significant control of bollworm complex (5 per cent) in cotton with lowest locule (35.29 per cent ) and seed damage (6.66 per cent) compared to control (91.73 per cent locule damage and 63.33 per cent seed

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damage). It was followed by indoxacarb 14.5 per cent + acetamiprid 7.7 per cent SC @ 88.8 g a.i./ha (5.52), chlorantraniliprole 9.3 per cent + lambda cyhalothrin 4.6 per cent ZC @ 37.5 g a.i./ha (6.05) and flubendiamide 19.92 per cent + thiacloprid 19.92 per cent SC @ 48+48 g a.i./ha (6.35).

### 2.1.2 GRAM POD BORER, *Helicoverpa armigera*

Patil *et al.* (2007) revealed that novaluron 10 EC @ 100 g a.i./ha (1.68 larvae/m row length) recorded lowest larval population of *H. armigera* in chickpea.

Patra *et al.* (2007) reported that 100 per cent mortality of *H. armigera* in pigeon pea were recorded from plots treated with novaluron 5.25 + indoxacarb 4.5 SC @ 80 g a.i./ha and novaluron 5.25 + fipronil 4 SC @ 80 g a.i./ha.

According to Utti (2009), UP 108 (novaluron 10 EC) @ 75 g a.i./ha (62.2 per cent reduction) significantly reduced the larval population of tomato fruit borer, followed by UP 108 @ 90 g a.i./ha (58.9 per cent reduction) and novaluron 10 EC @ 75 g a.i./ha (56.25 per cent reduction) after first spray. In the second spray UP 108 @ 90 g a.i./ha (85.2 per cent) showed maximum reduction followed by UP 108 @ 75 g a.i./ha (83.2 per cent) and novaluron 10 EC (79.0 per cent).

Kuhar *et al.* (2010) reported that voliam flexi @ 7 fl oz was effective against tomato fruit borer and other lepidopteran pests with minimum fruit damage (0.0 per cent damaged fruits).

Chatterjee and Mondal (2011) revealed that lowest population of tomato fruit borer, *H. armigera* was observed in flubendiamide 20 WDG @ 60 g a.i./ha treated plots with minimum fruit damage (3.5 per cent fruit damage). Novaluron 10 EC @ 50 g a.i./ha moderately reduced the fruit infestation.

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Kumar *et al.* (2012) stated that larval population of chickpea pod borer *H. armigera* was lowest in spinosad 45 SC @ 90 g a.i./ha (62.50 per cent reduction) followed by indoxacarb 14.5 SC @ 50 g a.i./ha (60.71 per cent reduction) and novaluron 10 EC @ 100 g a.i./ha (47.91 per cent reduction).

Carneiro *et al.* (2014) conducted laboratory studies and revealed that in ingestion bioassay 100 per cent mortality of *H. armigera* was observed in larvae fed with artificial diet containing flubendiamide 480 SC @ 0.08, 0.10 and 0.12 l/ha. Chlorantraniliprole showed 100 per cent mortality at 0.10 l/ha and 95.40 per cent mortality at 0.80l/ha.

Gadhiya *et al.* (2014) reported that lowest population of *H. armigera* (0.62 larvae) and *Spodoptera litura* (0.71 larvae) in groundnut was observed in plots treated with chlorantraniliprole 20 SC @ 0.006 per cent. The treatments flubendiamide and novaluron were inferior in reducing the larval population. Percentage of leaf damaged by *H. armigera* (10.82 per cent) and *S. litura* (6.64 per cent) were reduced in chlorantraniliprole treated plots. The treatments novaluron @ 0.01 per cent and flubendiamide @ 0.014 per cent showed 13.84 and 14.88 per cent leaf infestation by *H. armigera* and 12.36 and 14.47 per cent by *S. litura* respectively. In chlorantraniliprole treated plots there was 88.89 per cent increase in the pod yield.

According to Venkanna (2014), cent per cent mortality of *H. armigera* on okra was recorded from plots treated with flubendiamide 480 SC @ 0.1ml/l. Novaluron 10 EC @ 1.0 ml/l showed 93.26 per cent larval reduction at seven days after second spray.

Yogeeswarudu and Krishna (2014) reported that novaluron 10 EC @ 1.5 ml/l (94.38 per cent reduction) significantly reduced the population of *H. armigera* on chickpea.

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Bajya *et al.* (2015) reported that ampligo 150 ZC ZC (Chlorantraniliprole 9.3 per cent+ Lambda cyhalothrin 4.6 per cent ZC) @ 60 g a.i./ha recorded lowest population of *Helicoverpa armigera* (1.30 per cent) in cotton. Higher yield of 17.59 q/ha was obtained from ampligo 150 ZC @ 60 g a.i./ha compared to untreated control (8.82 q/ha). It was on par with ampligo 45 g a.i./ha (17.10 q/ha).

Kumar and Sarada (2015) reported that novaluron 10 per cent EC @ 500 ml/ha showed 75.5 percent reduction in the population of *H. armigera* in chickpea and 71.3 percent reduction in pod damage. Highest percent reduction in population was recorded in plots treated with chlorantraniliprole 20 SC @ 150 ml/ha (93.9 per cent).

Singh *et al.* (2015) reported that flubendiamide 480 SC @ 75 ml/ha (2.33 and 2.67 larvae/five plants in first and second spray respectively) was superior over all the treatments with lowest larval population of *H. armigera* in chickpea.

Sujay *et al.* (2015) stated that population of chilli fruit borer *H. armigera* was lowest in plots treated with novaluron 10 EC @ 0.75 ml/l (0.28 larvae/plant). Novaluron 10 EC was superior over all the treatments with 6.38 per cent fruit damage compared to control (13.02 per cent fruit damage).

According to Perini *et al.* (2016) 10 days after treatment, population of *H. armigera* in soybean was reduced in plots treated with chlorfenapyr @ 240 g a.i./ha (0.1 number of larvae/$m^2$), lambda cyhalothrin + chlorantraniliprole (ampligo 50+100 SC) @ 3.7+7.5 g a.i./ha (0.3 larvae/$m^2$), flubendiamide 480 SC @ 33.6 g a.i./ha (0.3 larvae/$m^2$) and chlorantraniliprole 200 SC @ 10 g a.i./ha (0.4 larvae/$m^2$). Lambda cyhalothrin + chlorantraniliprole exhibited 92.6 per cent efficiency after chlorfenapyr (96.3 per cent).

Roshan and Jat (2016) reported that novaluron 10 EC @ 375 ml/ha + urea provided excellent control of larval population of *H. armigera* with minimum pod infestation (7.3 per cent pod damage) and highest grain yield (14.6 q/ha) in chick pea.

According to Dahe (2017), chlorantraniliprole 18.5 per cent SC @ 30 g a.i./ha (0.17 larvae/plant) reduced the population of *H. armigera* on cotton compared to control (1.35 larvae/plant).

Khamorya *et al.* (2017) conducted a study on sequential application of insecticides and reported that the lowest per cent pod damage in pigeonpea by *H. armigera* was observed in module 5, which includes chlorantraniliprole 18.5 SC @ 30 g a.i./ha - indoxacarb 15.8 EC @ 73 g a.i./ha - acetamiprid 20 SP @ 20 g a.i./ha (1.33 and 2.00 per cent) compared to untreated control (9.33 and 7.33 per cent). The same module recorded lowest grain damage (0.39 and 0.44 per cent) and maximum grain yield (1175 and 1200 kg/ha).

According to Shahiduzzaman (2017), the lowest *H. armigera* infestation in chick pea was recorded from plots treated with voliam flexi 300 SC (26.53 per cent) compared to control (37.99 per cent). The highest net income of 21625 Tk/ha and maximum B:C ratio (1: 3.39) was obtained from voliam flexi 300 SC treated plots.

Shahiduzzaman *et al.* (2017) revealed that pod borer infestation were lowest in plots treated with tracer 45 SC (4.17 per cent pod infestation) and voliam flexi 300 SC @ 0.05 per cent (6.62 per cent infestation) in mungbean. In the next year voliam flexi was superior over all the treatments with lowest pod infestation (3.61 per cent).

Akter *et al.* (2018) reported that population of tomato fruit borer was lowest in the IPM package containing mechanical control + voliam flexi 300 SC @ 0.5 ml/l + Bio neem plus 1.0 EC – Azadirachtin @ 1ml/l + pheromone trap at 10 $m^2$ distance

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(0.73 larvae/plant). Fruit infestation (1.97 per cent) was also reduced in this IPM package.

Guru and Patil (2018) evaluated the efficacy of belt expert 480 SC (flubendiamide 240 + thiacloprid 240) against fruit borers in chilli, and reported that lowest population of *H. armigera* was observed in chlorantraniliprole 20 SC 30 g a.i./ha (0.28 larvae/plant) treated plots. The next best treatments were belt expert 480 SC 120 g a.i./ha (0.36 larvae/plant) and flubendiamide 480 SC 60 g a.i./ha (0.42 larvae/plant). After second spray fruit damage was lowest in belt expert 480 SC treated plots (1.73 per cent) and there was 33.13 per cent increase in the yield compared to the untreated control. They also reported that belt expert 480 SC was effective against thrips.

Ramu *et al.* (2018) reported that chlorantraniliprole + lambda cyhalothrin 150 ZC @ 250 ml/l recorded minimum fruit damage (3.17 per cent) in soybean with 90.21 per cent reduction in the larval population. Chlorantraniliprole + lambda cyhalothrin @ 215 g a.i./ha significantly reduced the larval population of spotted pod borer *Maruca vitrata*.

### 2.1.3 LEAF ROLLER, *Sylepta derogata*

Damage caused by *S. derogata* in okra was lowest in imidacloprid 70 WDG @ 25 g a.i./ha (0.66 per cent damage/plant) treated plots followed by quinalphos 25 EC (0.79 per cent damage/plant) and thiamethoxam 25 WDG @ 25 g a.i./ha (1.06 per cent damage/plant) in first season. In the second season seed treatment with thiamethoxam 30 FS @ 3 g a.i./kg and two foliar application of imidacloprid 70 WDG @ 25 g a.i./ha recorded no incidence of damage by *S. derogata* (Jijisha, 2014).

### 2.1.4. LEAFHOPPER, *Amrasca biguttula biguttula*

Kalra *et al.* (2001) reported that thiamethoxam was four times more toxic than malathion to *A. biguttula biguttula*, and imidacloprid gave more than 80 per cent mortality of jassids at four times lower the normal concentration (0.00025per cent) in okra.

Acharya *et al.* (2002) evaluated the efficacy of newer insecticides *viz.*, acetamiprid, thiamethoxam, imidacloprid, and abamectin against okra jassid *A. biguttula biguttula.* They reported that acetamiprid @ 20 g a.i./ha, thiamethoxam and imidacloprid (both @ 25 g a.i./ha) were most effective in controlling jassids. They were also found to be safer to predatory ladybird beetles.

Sinha and Sharma (2008) reported that thiamethoxam (20 g a.i./ha), imidacloprid (20 g a.i./ha) and acetamiprid (20 g a.i./ha) were successfully controlled the population of leafhoppers in okra.

Preetha *et al.* (2009) conducted study on persistent toxicity of insecticides against leafhopper *A. biguttula biguttula* in bhindi. Imidacloprid 17.8 SL @ 50 g a.i./ha was superior over all the treatments with 100 per cent mortality of leafhopper up to 9 DAT. No leafhoppers were observed in thiamethoxam 25 WG @ 25 g a.i./ha up to 7 DAT. Thiamethoxam was persistent up to 27 days @ 25g a.i./ha with 62.85 per cent mortality of leafhoppers.

Kumar *et al.* (2010) reported that Spinosad 45 SC + imidacloprid 200 SL and indoxacarb 14.5 SC + imidacloprid 200 SL significantly reduced the population of jassids in cotton followed by flubendiamide + thiacloprid 480 SC @ 120 g a.i./ha.

Sreekanth and Reddy (2011) reported that thiamethoxam 25 WG @ 25 g a.i./ha showed 89.26 per cent mortality of leafhoppers in cotton.

Patel (2013) reported that after first spray jassid population in okra was lowest in imidacloprid 17.85 SL 100 g a.i./ha (3.66) followed by thiamethoxam 25 WG @ 100 g a.i./ha (3.87).

Harinkhere (2014) reported that out of the six insecticides tested, difenthiuron 50 WP @ 300 g a.i./ha was superior over all the treatments with lowest population of leafhoppers in okra followed by thiamethoxam 25 WG @ 25 g a.i./ha.

According to Jijisha (2014), foliar application of thiamethoxam 25 WDG @ 25 g a.i./ha (39.83 hoppers/three leaves/plant) in okra recorded lowest population of leafhopper with 78.04 per cent reduction followed by seed treatment and foliar application of thiamethoxam 30 FS @ 3 g a.i./kg + thiamethoxam 25 WDG @ 25 g a.i./ha with 44.50 hoppers and 74.20 per cent reduction in the population.

According to Kumar (2015), thiamethoxam 25 WG @ 40 g a.i./ha (1.37 mean number of jassids/leaf) recorded lowest population of leafhoppers on okra.

According to Uchware (2017), population of jassids in okra was lowest in carboxamide 300 SC @ 37 g a.i./ha (4.21 jassids/leaf) followed by chlorantraniliprole 18.5 per cent SC @ 25 g a.i./ha (4.85 jassids/leaf). Carboxamide showed 67.31 per cent reduction in the population followed by 62.40 per cent reduction in chlorantraniliprole.

According to Anjabapu (2018), buprofezin 15 per cent + acephate 35 per cent WP @ 0.125 per cent provided excellent control of brinjal leafhopper *A. biguttula biguttula.* Chlorantraniliprole 8.8 per cent + thiamethoxam 17.5 per cent SC @ 0.026 per cent, flubendiamide 19.92 per cent + thiacloprid 19.92 per cent SC @ 0.020 per cent and chlorantraniliprole 9.3 per cent + lambda cyhalothrin 4.6 per cent ZC @ 0.006 per cent showed maximum number of jassids per three leaves.

Sangamitra *et al.* (2018) revealed that flubendiamide 24 per cent + thiacloprid 24 per cent SC w/v @ 84+84 g a.i./ha (95.93 reduction reduction) showed lowest population of jassids on brinjal. The next best treatment was flubendiamide 24 per cent + thiacloprid 24 per cent SC w/v @ 72+72 a.i./ha (87.72 per cent reduction).

### 2.1.5 OTHER LEPIDOPTERAN PESTS

Kund *et al.* (2009) reported that internal damage by pepper weevil was lowest in voliam flexi WG @ 7 (2.25 mean number of fruits damaged/replication), 6 (3.25) and 4 (5.00) oz/acre. Voliam flexi also reduced the damage caused by all lepidopteran pests (2.50, 3.50 and 5.00 respectively).

Steenwyk *et al.* (2009) reported that codling moth infestation was lowest in voliam flexi 40 WG @ 6.0 oz/acre (0.3 per cent fruit infestation) treated plots but population of two spotted spider mite was highest in voliam flexi treated plots (418.3/20 leaves).

Wise *et al.* (2009) revealed that grape berry moth was significantly controlled by voliam flexi 40 WG @ 4.5 oz/acre (2 per cent cluster damage). Voliam flexi did not show any significant reduction in Japanese beetle population but it showed some anti-feedant properties.

Davis *et al.* (2010) reported that voliam flexi @ 0.128 (100 per cent control) and 0.10 (99 per cent control) lb/acre significantly reduced the population of soybean loopers.

According to Palumbo (2010) population of larvae of diamond back moth (0.0 larvae/10 plants) and cabbage looper (0.0 larvae/ 10 plants) were lowest in voliam flexi @ 6 oz/acre treated plots.

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Chatterjee and Mondal (2011) evaluated the efficacy of insecticides against lepidopteran pests revealed that spinosad (9.4 per cent), flubendiamide (10.1 per cent) and novaluron (10.4 per cent) were the best treatments against brinjal shoot and fruit borer. Diamond back moth population on cabbage was reduced by flubendiamide (91.0 per cent reduction) followed by spinosad (89.2 per cent) and novaluron (87.9 per cent).

Goebel *et al.* (2011) revealed that moth borer attack in sugarcane was reduced by ampligo 150 ZC (chlorantraniliprole 100 g/l + lambda cyhalothrin 50 g/l). The percentage of stalk damaged by top borer (3.8 per cent), stem borer (50.2 per cent) and internode borer (4.6 per cent) was lowest in ampligo treated plots. Ampligo 150 ZC was superior over all the treatments with lowest crop loss. It was the best treatment with maximum stalk height (288.9 cm), stalk diameter (2.74 cm), weight (2.33 kg/stalk) and sucrose content (10.6 t/ha). Ampligo showed lowest fibre content (9.2 per cent) which increases with the intensity of damage.

Kuhar *et al.* (2011) revealed that voliam flexi @ 7 oz/acre significantly reduced tomato fruit damage with 5 per cent lepidopteran fruit damage, 0.0 Beet army worm larvae/10 plants and 0.0 Colorado potato beetle larvae/10 plants.

Rucker and Hamilton (2011) reported that all the treatments reduced oriental fruit moth damage. Voliam flexi 40WG @ 7 oz/acre also significantly reduced oriental fruit moth damage (1.0 per cent fruit damage).

Stansly and Kostyk (2011a) revealed that coragen 20 SC @ 5 oz/acre was superior over all the treatments with 100 per cent mortality of southern army worm larvae with no fruit damage in tomato. Voliam flexi 5 oz/acre recorded 0.9 per cent fruit damage.

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Stansly and Kostyk (2011b) reported that coragen 20 SC @ 3.5 oz/acre and voliam flexi @ 7.0 oz/acre recorded 100 per cent mortality of pickle worm larvae/squash flower.

Akin and Howard (2012) evaluated the efficacy of insecticides against loopers in soybean, revealed that voliam flexi 40 WG @ 0.07 lb/acre reduced the population of loopers significantly at 8 DAT (1.3 loopers/25 sweeps).

Braham *et al.* (2012) evaluated the efficacy of novel insecticides against *Tuta absoluta* in toato and revealed that in greenhouse the larval population was reduced by spinosad 240 SC @ 60 ml/hectolitre (34.3 per cent), tutafort 150 ml/hectolitre (28.1 per cent) and ampligo 150 ZS @ 30 ml/hectolitre (27.4 per cent). In laboratory highest percentage of larval mortality was observed in challenger (66.0 per cent) and ampligo (61.2 per cent).

According to Chand (2012), *Spodoptera litura* infestation in soybean was reduced by alika 247 ZC @ 33 g a.i./ha and alika 247 ZC @ 27.5 g a.i./ha after first (0.20 and 1.19 larvae/m row length) and second spray respectively (0.26 and 0.73 larvae/m row length). These treatments also reduced the population of Green semilooper, Bihar hairy caterpillar and Stem fly in soybean.

Rajavel *et al.* (2013) revealed that chlorantraniliprole 20 SC @ 60 g a.i./ha (21.32 per cent shoot damage and 4.99 per cent fruit damage) and 50 g a.i./ha (22.18 per cent shoot damage and 5.43 per cent fruit damage) recorded lowest shoot and fruit damage by brinjal shoot and fruit borer.

Mahata *et al.* (2014) reported that in brinjal, lowest shoot damage was observed in flubendiamide 20 WG @ 30 g a.i./ha (2.65 per cent) treated plots. It was on par with chlorantraniliprole 18.5 SC @ 27.25 g a.i./ha (2.77 per cent). The maximum shoot infestation was recorded in control (8.37 per cent) it was on par with thiamethoxam 25 WG (6.62 per cent). Fruit damage was lowest in flubendiamide @ 30 g a.i./ha (14.07 per cent) and chlorantraniliprole @ 27.25 g a.i./ha (15.33 per cent) treated plots. The next best treatments were flubendiamide @ 20 g a.i./ha (15.85 per cent), chlorantraniliprole @ 18.5 g a.i./ha (16.78 per cent). Relatively highest damage was recorded in thiamethoxam 25 WG (26.75 per cent), flubendiamide 20 WG + thiamethoxam 25 WG (20.56 per cent) and novaluron 10 EC (18.78 per cent).

According to Ayalew (2015), chlorantraniliprole treated plots recorded minimum fruit infestation (2-6 per cent fruit damage) and leaf damage by *Tuta absoluta* in tomato. Ampligo treated plots showed highest marketable yield (18.4 t/ha) and total yield (31.9 t/ha).

Grigolli *et al.* (2015) reported that lowest larval population of *Maruca vitrata* in soybean was observed on plots treated with chlorpyriphos @ 480 g a.i./ha (0.60), teflubenzuron @ 15 g a.i./ha (0.80), chlorantraniliprole + lambda cyhalothrin @ 10.0+5.0 g a.i./ha (1.00) and flubendiamide @ 33.6 g a.i./ha (1.00). Percentage of damaged plant was lowest in chlorpyriphos (5.40) and it was on par with teflubenzuron (7.20) and chlorantraniliprole + lambda cyhalothrin (9.40).

According to Hossain (2015), pod borer infestation was minimum in plots treated with voliam flexi 300 SC @ 0.5 ml/l (1.02 per cent). Percentage of defoliation (5.33 per cent) by flea beetle was also lowest in voliam flexi 300 SC.

Nikam *et al.* (2015) revealed that novaluron 10 per cent EC showed highest $LC_{50}$ value (0.00763 per cent), which indicates it was less toxic to diamond back moth larvae in cabbage compared to other treatments.

Venkataiah *et al.* (2015) reported that lowest larval population of *Spodoptera litura,* was observed in plots treated with flubendiamide 480 SC @ 150 ml/ha (1.33 larvae). The next best treatments were chlorantaniliprole 20 SC @ 125 ml/ha (2.50 larvae) and novaluron 10EC @ 500 ml/ha (3.33 larvae). The percent defoliation was reduced in flubendiamide 480 SC (9.67 per cent/10 plants) followed by chlorantraniliprole 20 SC (13.50 per cent defoliation) and novaluron 10 EC (16.50 per cent defoliation) against maximum defoliation in untreated control (53.50 per cent defoliation). Flubendiamide recorded maximum dry grain yield (2650 and 2100 kg/ha) and it was on par with chlorantraniliprole (2500 and 1983 kg/ha) and novaluron (2267 and 1958 kg/ha).

Kushwaha and Painkra (2016) evaluated the efficacy of insecticides against brinjal shoot and fruit borer, revealed that lowest shoot and fruit damage was recorded from plots treated with chlorantraniliprole 20 SC @ 0.006 per cent (4.884 shoot damage and 4.713 fruit damage) followed by flubendiamide 39.35 per cent SC @ 0.01 per cent (5.183 shoot damage and 5.185 fruit damage).

Pawar *et al.* (2016) conducted field studies against brinjal shoot and fruit borer showed that chlorantraniliprole 18.5 SC @ 37 g a.i./ha treated plots recorded minimum fruit infestation (9.33 per cent fruit damage on number basis) and highest marketable fruit yield (350.67 q/ha).

Chaudhari *et al.* (2017) screened new insecticides against major pests of rice and revealed that the population of gall midge was lowest in flubendiamide + thiacloprid @ 250 ml/ha (belt - expert 480 SC) (10.31 per cent silver shoot). Flubendiamide 480 SC @ 50 ml/ha recorded lowest percentage of dead heart (1.45 per cent). White ear head was lowest in dinotefuran 20 SG @ 200 g/ha (3.64 per cent), which was on par with flubendiamide + thiacloprid (3.72 per cent). Lowest

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leaf folder damage was recorded in flubendiamide + thiacloprid (2.13 per cent) treated plots.

Roy *et al.* (2017) reported that flubendiamide 24 per cent + thiacloprid 24 per cent SC @ 175 ml/ha (72.02 per cent reduction in first spray and 79.99 per cent reduction in second spray) and chlorantraniliprole 10 per cent + thiamethoxam 20 per cent SC @ 180 ml/ha (73.40 per cent reduction in first spray and 77.91 per cent reduction in second spray) significantly reduced the larval population of *Maruca testulalais* on cowpea. 60.68 per cent reduction in the pod damage in chlorantraniliprole + thiamethoxam and 60.35 per cent reduction in flubendiamide + thiacloprid.

Sen *et al.* (2017) evaluated the efficacy of ampligo 150 ZC, against brinjal shoot and fruit borer. Among the treatments lowest percentage of shoot damage was observed in ampligo 150 ZC @ 35 (1.26 per cent) and 28 g a.i./ha (1.59 per cent). Chlorantraniliprole 18.5 SC also showed lowest shoot infestation (3.76 per cent) compared to control (21.53 per cent). The same trend was followed in fruit damage, it was lowest in ampligo @ 35 g a.i./ha (2.49 per cent). It was on par with ampligo @ 28 g a.i./ha (2.97 per cent) and chlorantraniliprole 18.5 SC (3.32 per cent). Relatively higher yield was obtained from all the treatments, ampligo 150 ZC @ 30 g a.i./ha was superior over all the treatments with 150.88 q/ha yield.

Swami *et al.* (2017) reported that lowest larval population of pod borer in pigeon pea was observed in chlorantraniliprole 9.6 per cent + lambda cyhalothrin 4.6 per cent @ 300 ml/ha during 2011 (91.86 per cent reduction) and 2012 (89.14 per cent). It was followed by chlorantraniliprole 9.6 per cent + lambda cyhalothrin 4.6 per cent @ 200 and 250 ml/ha.

According to Anjabapu (2018), chlorantraniliprole 9.3 per cent + lambda cyhalothrin 4.6 per cent ZC @ 0.006 per cent (1.41 per cent infestation), flubendiamide 19.92 per cent + thiacloprid 19.92 per cent SC @ 0.020 per cent (1.46 per cent) and chlorantraniliprole 8.8 per cent + thiamethoxam 17.5 per cent SC @ 0.026 per cent (2.04 per cent) were effective against brinjal shoot and fruit borer.

Franeta *et al.* (2018) reported that activity of antioxidative enzyme CAT was lowest in larvae collected from plots treated with chlorantraniliprole + lambda cyhalothrin (ampligo ZC) @ 200 ml/ha. It induces oxidative stress in European corn borer.

Ramu *et al.* (2018) revealed that lowest larval population of *Maruca vitrata* was observed on plots treated with flubendiamide 24 per cent + thiacloprid 24-48 per cent SC @ 2ml/l (84.45 per cent reduction). Novaluron 10 EC @ 1.0 ml/l also reduced pod borer damage in blackgram.

Rohokale *et al.* (2018) stated that brinjal fruit borer damage was lowest in chlorantraniliprole 8.8 per cent + thiamethoxam 17.5 per cent SC @ 0.026 per cent (8.70 per cent fruit infestation) followed by flubendiamide 19.92 per cent + thiacloprid 19.92 per cent SC @ 0.020 per cent (8.95 per cent) and chlorantraniliprole 9.3 per cent+ lambda cyhalothrin 4.6 per cent ZC @ 0.006 per cent (9.34 per cent). Percent shoot damage was reduced by flubendiamide 19.92 per cent + thiacloprid 19.92 per cent SC (3.07 per cent), chlorantraniliprole 9.3 per cent + lambda cyhalothrin 4.6 per cent ZC (3.18 per cent) and chlorantraniliprole 8.8 per cent + thiamethoxam 17.5 per cent SC (3.38 per cent).

Sangamitra *et al.* (2018) reported that brinjal shoot and fruit borer damage was lowest in flubendiamide 24 per cent + thiacloprid 24 per cent SC @ 84+84 g a.i./ha (96.62 per cent reduction in shoot damage and 98.25 per cent reduction in fruit

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damage). It was followed by flubendiamide 24 per cent + thiacloprid 24 per cent SC @ 72+72 g a.i./ha with 88.98 per cent reduction in shoot damage and 88.90 per cent reduction in fruit damage.

### 2.1.6 OTHER SUCKING PESTS

According to Palumbo (2011), voliam flexi @ 7 oz/acre significantly reduced the population of green peach aphid in cabbage.

Wise *et al.* (2012) reported that all the treatments *viz.*, rimon 0.83 EC, HGW86 10 SE, endigo 2.06 ZC, endigo 2.71 ZC, actara 25 WDG and bexar 15 SC significantly reduced the population of cherry fruit fly and drosophila fruit fly. Voliam flexi 40 WG @ 7 oz/acre also showed significant reduction in the population cherry fruit fly and drosophila fruit fly.

Sridhar and Sharma (2013) evaluated the efficacy of alika 247 against pests of soybean and revealed that alika 247 ZC @ 22, 27.5 and 33 g a.i./ha showed no incidence of damage by stem fly and girdle beetle. Alika 247 ZC @ 27.5 and 33 g a.i./ha were effective against semiloopers.

Stansly *et al.* (2013) reported that voliam flexi + 435 oil @ 5 (0.00 adults and 14.3 nymphs) and 7 (0.08 adults and 1.89 nymphs) oz + 2 per cent significantly reduced the population of Asian citrus psyllid nymphs and adults. It also reduced citrus leaf miner larvae up to 24 DAT (0.46 and 0.38 larvae/three leaves respectively).

Cardwell and Scott (2014a) reported that voliam flexi @ 7 oz/acre + omni 6E oil @ 0.50 per cent and actara @ 5.5 oz/acre + omni 6E oil @ 0.50 per cent were the best treatments with 100 per cent mortality of fuller rose beetle with 0.0 per cent leaf damage at 14 DAT.

Cardwell and Scott (2014b) reported that voliam flexi mixed with omni oil 6 E @ 7 oz + 0.50 per cent, significantly reduced the population of citricola scale from 0.65 to 0.05 nymphs per five leaves and 0.33 to 0.08 adult females per five twigs compared to untreated control (4.13 nymphs and 0.88 adult females) in citrus.

Stansly *et al.* (2014) reported that voliam flexi @ 7 oz + activator 90 @ 0.5 per cent provided excellent control of Asian citrus psyllid nymphs (0.00 live nymphs /shoot) at 17 DAT and adults (0.03 adults/sample) at 48 DAT. Also reduced the population of citrus leaf miner (0.23 larvae/shoot) at 24 DAT.

According to Alam *et al.* (2017), population of whitefly in beans were lowest in plots treated admire 200 SL @ 0.5 ml/l (4.18 at vegetative stage and 2.13 at reproductive stage) and voliam flexi @ 1.0 ml/l (5.22 at vegetative stage and 3.90 at reproductive stage). Pod borer infestation was also lowest in admire 200 SL followed by voliam flexi.

Belay *et al.* (2017) conducted greenhouse trails and reported that 100 per cent mortality of adults, nymphs and eggs of *Tetranychus urticae* in potato were observed in chlorantraniliprole + lambda cyhalothrin (Ampligo 150 ZC) @ 300 ml/ha, profenofos @ 1.0 l/ha and paraffin oil 2.5 per cent/ha. In laboratory evaluation, ampligo, profenofos, paraffin oil and amitraz showed 99 per cent mortality of mites in both leaf disc spray and leaf disc dip bioassay.

Kumar *et al.* (2017) reported that thiamethoxam @ 280.2 g a.i./ha (87 per cent mortality of larvae and 80 per cent mortality of adults) and thiamethoxam + chlorantraniliprole @ 420.3 g a.i./ha (72.8 per cent mortality of larvae and 72.8 per cent mortality of adults) significantly reduced the population of adult and larval *Scirtothrips dorsalis*.

Roy *et al.* (2017) revealed that 77.30 per cent reduction of nymphs and adults of *Aphis craccivora* was observed in flubendiamide 24 per cent + thiacloprid 24 per cent SC @ 175 ml/ha followed by 72.43 per cent reduction in chlorantraniliprole 10 per cent + thiamethoxam 20 per cent SC @ 180 ml/ha.

Samanta *et al.* (2017) evaluated the efficacy of alika 247 ZC against major pests of tea revealed that alika 247 ZC @ 33 g a.i./ha reduced the population of thrips (98.42 and 98.54 per cent reduction), semilooper (99.15 and 99.48 per cent reduction) and shoot infestation by tea mosquito bug (2.64 and1.78 per cent) in first location. The same trend was followed in second location with 98.98 and 99.20 per cent reduction in thrips and population of semilooper was reduced to 96.75 and 98.62 per cent. Shoot infestation was reduced to 2.38 and 1.79 per cent compared to untreated control (10.26 and 7.31 per cent).

Reddy *et al.* (2018) evaluated the efficacy of insecticide mixtures and revealed that chlorantraniliprole 8.8 per cent + thiamethoxam 17.5 per cent SC (voliam flexi) @ 150 g a.i./ha was superior over all the treatments in reducing the population of pod bug *Riptortus pedestris* (0.6 bugs/plant). The next best treatments were thiamethoxam 12.6 per cent + lambda cyhalothrin 9.5 per cent ZC (Alika 247) @ 27.5 g a.i./ha (1.33 bugs/plant) and tank mixed formulation of chlorantraniliprole 18.5 SC + thiamethoxam 25 WG (1.67 bugs/plant). Volium flexi 150 g a.i./ha, alika 27.5 g a.i./ha, thiamethoxam 30 g a.i./ha and tank mixed formulation of chlorantraniliprole 18.5 SC + thiamethoxam 25 WG were the best treatments with zero aphid population against highest population in the control (211.67 aphids).

# Material and methods

# 3. MATERIALS AND METHODS

Experiment on 'Evaluation of new insecticides against major pests of okra, *Abelmoschus esculentus* L.' was conducted at College of Agriculture, Padannakkad, in two seasons during 2018-19 with an objective 'to study the efficacy of different new insecticides against major pests of okra, *viz.*, shoot and fruit borer, gram pod borer, leaf roller and leafhopper'. The materials used and methods adopted during the research work were discussed here.

## 3.1 LOCATION OF THE EXPERIMENT

The entire research work was carried out in the farm of RARS Pilicode sub centre, Karuvachery, Kasargod during first season from September to December 2018 and second season from January to April 2019.

## 3.2 EXPERIMENTAL MATERIAL

The experimental material selected for research work was okra variety, Varsha Uphar developed by Haryana Agricultural University, Hisar. Seeds were purchased from College of Agriculture, Vellayani.

## 3.3 DETAILS OF THE EXPERIMENT

The experiment was laid out in Randomized Block Design with 8 treatments and 3 replications. In this experiment seven insecticides were evaluated along with an untreated control as detailed in table 1.

First four treatments were ready mix formulation of new insecticide mixtures having different modes of action. Treatments $T_6$ and $T_7$ were used as standard check.

**Table 1. Details of treatments**

| Treatments | | Trade name | Dose (ml/l or g/l) |
|---|---|---|---|
| $T_1$ | Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | Voliam flexi | 0.7 ml/l |
| $T_2$ | Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | Ampligo | 0.4 ml/l |
| $T_3$ | Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | Alika | 0.5 ml/l |
| $T_4$ | Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | Belt expert | 0.4 ml/l |
| $T_5$ | Novaluron 10 EC | Pedestal | 2.0 ml/l |
| $T_6$ | Chlorantraniliprole 18.5 SC (check) | Coragen | 0.3 ml/l |
| $T_7$ | Thiamethoxam 25 WG (check) | Actara | 0.3 g/l |
| $T_8$ | Absolute control | Water spray alone | |

**3.4 FIELD PREPARATION**

Crop : Okra

Variety : Varsha Uphar

Experimental design : RBD

Number of treatments : 8

Number of replications : 3

Total area : 3.6 cent

Area of a single plot : 1.6 x 0.85 m

Seed rate : 8.5 kg/ha

Spacing : 60 x 45 cm

Field experiment was conducted to evaluate the efficacy of insecticides. The experiment was conducted in the farm of RARS Pilicode sub centre, Karuvachery during rabi season of 2018 and summer season of 2019. After the land preparation 24 beds were prepared and lime was applied on the same day. Farm yard manure (FYM) along with recommended dose of fertilizers was applied prior to sowing.

### 3.5 RAISING OF CROP

Seeds were soaked in the water for 12 hrs before sowing. Seeds were sown by dibbling 2-3 seeds/hole at a spacing of 60 x 45 cm. 10 days after sowing thinning and gap filling was done so that six plants/plot was maintained. Fertilizer application and other cultural practices were followed as per recommendations in KAU, Package of Practices Recommendations: Crops 2016 (KAU, POP) except for plant protection measures. Irrigation and weeding were done whenever necessary. Treatments were applied one at vegetative and one at reproductive stage after the incidence of pests.

### 3.5 METHOD OF APPLICATION

Treatments were applied by diluting with water at recommended doses. Absolute control was maintained by spraying with water. Treatments were applied as foliar spray, by using a hand sprayer of one litre capacity in the respective plots of field at 30 and 60 days after sowing. Spraying was done in the morning hours to avoid drift from one plot to other and plastic screens were placed around each plot at the time of spraying.

Treatments were applied one at vegetative stage and one at reproductive stage after the incidence of pest infestation. Damage by different pests was recorded at 7 and 14 days after spraying. Population of leafhopper was recorded at 1, 3, 5, 7 and 14 days after treatment. Fruits were harvested at two days interval and number and weight of healthy and damaged fruits were recorded.

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**Plate 1. Experimental plot**

**(1a) Field preparation**

**(1b) Field view - 30 days after sowing**

**(1c) Field view – 45 days after sowing**

## 3.7 OBSERVATIONS MADE ON INSECT PESTS

Observations were recorded from six plants and its average was taken. Precount was recorded 24 hrs before spraying. Damage symptoms were recorded at 7 and 14 days after spraying and population count was recorded at 1,3,5,7, and 14 DAS.

### 3.7.1 Shoot and fruit borer, *Earias vitella*

To study the efficacy of treatments against shoot and fruit borer, *E. vitella*, 7 and 14 DAT total number of shoots and number of damaged shoots was counted. Shoot damage was expressed in per cent.

$$\text{Damaged shoots (\%)} = \frac{\text{Number of shoots damaged}}{\text{Total number of shoots}} \times 100$$

Total number of fruits along with infested fruits was harvested and per cent fruit damage was worked out.

$$\text{Damaged Fruits (\%)} = \frac{\text{Number of fruits damaged}}{\text{Total number of fruits}} \times 100$$

### 3.7.2 Gram pod borer, *Helicoverpa armigera*

To assess the damage caused by gram pod borer, *H. armigera,* total number of fruits and number of damaged fruits from each replication was recorded and expressed as per cent fruit damaged by gram pod borer.

$$\text{Damaged fruits (\%)} = \frac{\text{Number of fruits damaged}}{\text{Total Number of fruits}} \times 100$$

### 3.7.3 Leaf roller, *Sylepta derogata*

Efficacy against leaf roller, *S. derogata* was evaluated by recording the damage symptoms at 7 and 14 DAT. The damage was assessed by counting total number of leaves and number of leaves damaged and per cent values were worked out.

$$\text{Damaged leaves (\%)} = \frac{\text{Number of leaves damaged}}{\text{Total number of leaves}} \times 100$$

### 3.7.4 Population of leafhopper, *Amrasca biguttula biguttula*

The population of leafhopper, *A. biguttula biguttula* was taken by visual counting of adults and nymphs on upper, middle and lower leaves and from the recorded observations, average number of leafhopper per plant was calculated.

## 3.8 BIOMETRIC OBSERVATION

Fruits were harvested at two days interval. Length of the fruit in centimeter was measured using a scale at each picking and its mean value was recorded.

## 3.9 YIELD COMPONENTS

Fresh weight of fruit (g/plant) and marketable yield (g/plant) were recorded from each replication during each picking. Based on yield cost of plant protection and benefit - cost ratio was calculated.

## 3.10 STATISTICAL ANALYSIS

The data recorded from field experiment was tabulated and statistical analysis was performed using analysis of variance (ANOVA). Square root transformation was worked out for population of leafhopper. Whereas, the data on per cent shoot, fruit and leaf damage were transformed to arc sine. Yield parameters were analysed without any transformation. Pooled analysis of two season's data was also conducted.

# Results

# 4. RESULTS

Field experiments were conducted at farm of RARS Pilicode sub centre, Karuvachery in two seasons during 2018-19. The efficacy of new insecticides like voliam flexi, alika, ampligo, belt-expert, novaluron, chlorantraniliprole and thiamethoxam were evaluated against major pests of okra *viz.,* shoot and fruit borer, *Earias vitella* (Fb.), gram pod borer, *Helicoverpa armigera* (Hubner), leaf roller, *Sylepta derogata* (Fb.) and leaf hopper, *Amrasca biguttula biguttula* (Ishida). The data recorded were tabulated and statistical analysis was performed.

Results of the studies conducted on efficacy against major pests, biometric obervation and yield components are presented below.

## 4.1 Efficacy of new insecticides against shoot and fruit borer, *Earias vitella*

An experiment was conducted to evaluate the efficacy of new insecticides against okra shoot and fruit borer during rabi season (September to December 2018) and summer season (January to April 2019). Each treatment was evaluated in terms of per cent shoot and fruit damage. The observations were recorded at 7 and 14 days and the data were statistically analyzed and are presented in the table 2, 3, 4 and 5.

### 4.1.1 Percentage of shoot damaged by *E. vitella* during rabi season from September 2018 to December 2018

The percentage of shoot damaged by shoot and fruit borer larvae was taken at seven and fourteen days after spraying during September to December 2018. The analyzed data is presented in Table 2.

**First spray:**

Seven days after first spray, no incidence of shoot damage was observed in $T_1$ and $T_6$ (0.0%) as against maximum shoot damage of 77.77 per cent in untreated control. $T_7$ and $T_3$ recorded 61.75 per cent and 51.21 per cent shoot damage respectively. Less shoot damage was noticed in plots treated with $T_5$ (9.65 per cent) and $T_2$ (22.04 per cent). $T_4$ recorded significantly high shoot damage than from $T_5$ and $T_2$ with 35.35 per cent shoot damage. Fourteen days after spraying there was an increase in the shoot damage in $T_8$ (82.05 per cent) followed by $T_7$ (63.01 per cent) and $T_3$ (52.24 per cent). No shoot damage was noticed in plots treated with $T_1$ and $T_6$. Less damage was recorded in $T_5$ (4.11 per cent) followed by $T_2$ (7.39 per cent). $T_4$ was significantly different from $T_5$ and $T_2$ with 31.80 per cent shoot damage.

**Second spray:**

After seven days of second spraying no shoot damage was noticed in $T_1$ which was on par with $T_6$. Maximum shoot damage was recorded in $T_8$ (83.55 per cent), followed by $T_7$ (63.81 per cent) and $T_3$ (52.88 per cent). Less shoot damage was observed in $T_5$ (17.26 per cent) followed by $T_2$ (17.26 per cent). $T_4$ was significantly inferior from other treatments with 33.76 per cent shoot damage. After 14 days of treatment shoot damage was less in $T_5$ (3.25 per cent), $T_2$ (7.99 per cent), $T_4$ (27.60 per cent) and $T_3$ (47.86 per cent). Whereas shoot damage increased in both $T_8$ (84.64 per cent) and $T_7$ (64.19 per cent).

### 4.1.2 Percentage of shoot damaged by *E.vitella* during summer season from January 2019 to April 2019

The per cent shoot damage caused by okra shoot and fruit borer was recorded during rabi season from January to April 2019 at 7 and 14 days after treatment. Analyzed data is presented in Table 3.

**First spray:**

Seven days after treatment no shoot damage was reported in $T_1$, it was on par with $T_6$ as against maximum damage was observed in $T_8$ (81.56 per cent). It was followed by $T_7$ (58.89 per cent), $T_3$ (49.87 per cent) and $T_4$ (40.45 per cent).

**Table 2. Percentage of shoot damaged by *Earias vitella* in okra treated with different insecticides during rabi season from September 2018 to December 2018**

| Treatments | Mean shoot damaged per plant (%)* | | | | |
|---|---|---|---|---|---|
| | | First spray | | Second spray | |
| | 1 DBT | 7 DAT | 14 DAT | 7 DAT | 14 DAT |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 68.40 | 0.00 (0.59) | 0.00 (0.59) | 0.00 (0.59) | 0.00 (0.59) |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 65.50 | 22.04 (27.93) | 7.39 (15.55) | 17.26 (24.37) | 7.99 (16.37) |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 64.72 | 51.21 (45.69) | 52.24 (46.28) | 52.88 (46.66) | 47.86 (43.77) |
| $T_4$ - Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 67.52 | 35.35 (36.45) | 31.80 (34.31) | 33.76 (35.52) | 27.60 (31.69) |
| $T_5$ - Novaluron 10 EC | 67.18 | 9.65 (17.98) | 4.11 (11.53) | 9.34 (17.59) | 3.25 (10.29) |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 64.26 | 0.00 (0.59) | 0.00 (0.59) | 0.00 (0.59) | 0.00 (0.59) |
| $T_7$ - Thiamethoxam 25 WG (check) | 60.78 | 61.75 (51.81) | 63.01 (52.56) | 63.81 (53.05) | 64.19 (53.28) |
| $T_8$ - Absolute control | 70.16 | 77.77 (61.97) | 82.05 (64.97) | 83.55 (66.18) | 84.64 (67.11) |
| C.D. (0.05%) | | 3.70 | 3.52 | 4.52 | 3.95 |

Figures in parenthesis are arc sine transformed values.

*Mean of 6 plants from 3 replications

DAT- Days after treatment, DBT- Day before treatment

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$T_5$ recorded 21.61 per cent shoot damage which was not significantly different from $T_2$ (24.48 per cent). After fourteen days of treatment application no shoot damage was found in $T_1$ and $T_6$. There was a gradual increase in the shoot damage in $T_8$ (83.29 per cent) and $T_7$ (59.01 per cent). $T_3$ and $T_4$ recorded significantly higher shoot damage of 49.10 and 37.81 per cent respectively. In $T_5$ and $T_2$ damage per cent decreased to 17.19 and 19.28 per cent respectively.

**Second spray:**

Seven days after spraying $T_1$ and $T_6$ were on par with each other with no shoot damage. Maximum shoot damage was observed in $T_8$ (77.54 per cent). $T_7$ and $T_3$ recorded 46.98 and 38.24 per cent shoot damage respectively. Shoot damage was absent in $T_1$ which was not significantly different from $T_6$. Less damage was reported in $T_5$ (8.00 per cent) and $T_2$ (16.78 per cent). The same trend was followed after fourteen days of spraying. Shoot damage was reduced to 6.62, 14.06, 20.45 and 37.96 per cent in $T_5$, $T_2$, $T_4$ and $T_3$ respectively. They are significantly different from each other. The highest shoot damage was record in $T_8$ (74.79 per cent) and $T_7$ was significantly different from $T_8$ with 47.33 per cent shoot damage.

**4.1.3 Pooled analysis of per cent shoot damage for two seasons**

The results of rabi (September to December 2018) and summer (January to April 2019) season's data on shoot damage was pooled and analyzed to find out the overall effect of treatments and it was shown in table 4.

**First spray:**

The pooled data of shoot damage revealed that treatments $T_1$, $T_2$, $T_5$ and $T_6$ significantly reduced shoot infestation compared to control at 7 DAT and 14 DAT.

**Table 3. Percentage of shoot damaged by *Earias vitella* in okra treated with different insecticides during summer season from January 2019 to April 2019**

| Treatments | Mean shoot damaged per plant (%)* | | | | |
|---|---|---|---|---|---|
| | 1 DBT | First spray | | Second spray | |
| | | 7 DAT | 14 DAT | 7 DAT | 14 DAT |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 75.2 | 0.00 (0.59) | 0.00 (0.59) | 0.00 (0.59) | 0.00 (0.59) |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 71.66 | 24.48 (29.62) | 19.28 (25.94) | 16.78 (24.17) | 14.06 (22.00) |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 60.16 | 49.87 (44.92) | 49.10 (44.48) | 38.24 (38.19) | 37.96 (38.03) |
| $T_4$ -Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 78.15 | 40.45 (39.48) | 37.81 (37.94) | 22.83 (28.53) | 20.45 (26.88) |
| $T_5$ - Novaluron 10 EC | 73.5 | 21.61 (27.64) | 17.19 (24.49) | 8.00 (16.37) | 6.62 (14.85) |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 67.18 | 0.00 (0.59) | 0.00 (0.59) | 0.00 (0.59) | 0.00 (0.59) |
| $T_7$ - Thiamethoxam 25 WG (check) | 63.09 | 58.89 (50.15) | 59.01 (50.19) | 46.98 (43.27) | 47.33 (43.48) |
| $T_8$ - Absolute control | 78.29 | 81.56 (64.17) | 83.29 (65.97) | 77.54 (62.02) | 74.79 (59.98) |
| C.D. (0.05%) | | 4.21 | 3.02 | 4.28 | 3.27 |

Figures in parenthesis are arc sine transformed values.

*Mean of 6 plants from 3 replications

DAT- Days after treatment, DBT- Day before treatment

**Plate 2. Shoot infestation by okra shoot and fruit borer, *Earias vitella***

**(2a)**

**(2b)**

**(2c)**

**(a), (b) and (c) Shoots damaged by *Earias vitella***

Shoot damage was not oberved in $T_1$ and $T_6$ at 7 DAT and 14 DAT and they were on par with each other. Maximum shoot damage was recorded from $T_8$ (79.67 and 8267 per cent at 7 and 14 DAT respectively). Treatments $T_3$, $T_4$ and $T_7$ not showed any significant reduction in shoot damage.

**Second spray:**

Pooled data on shoot damage at 7 and 14 days after treatment revealed that no shoot damage was oberved in $T_1$ and $T_6$ and they were on par with each other. Followed by $T_5$ (7.94 and 4.93 per cent at 7 and 14 DAT respectively) and $T_2$ (15.29 and 11.03 per cent at 7 and 14 DAT respectively) significantly reduced shoot infestation compared to control. $T_2$ and $T_4$ were found on par with each other at 7 DAT. Maximum shoot damage was recorded in $T_8$ (82.45 and 79.72 per cent at 7 and 14 DAT respectively). Treatments $T_3$ and $T_7$ not showed any significant reduction in shoot damage.

**4.1.4 Percentage of fruits damaged by *Earias vitella* during rabi season from September 2018 to December 2018**

The fruits infested by okra shoot and fruit borer were taken at seven and fourteen DAT on number basis during rabi season from September 2018 to December 2018. The analyzed data is presented in Table 5.

**Second spray:**

Seven days after second spray no fruit infestation was recorded from $T_1$ and $T_6$, they were statistically on par.$T_5$ (7.91 per cent) recorded less fruit infestation among other treatments except $T_1$ and $T_6$. $T_8$ (89.03 per cent) recorded highest fruit infestation followed by $T_7$ (67.98 per cent) and $T_3$ (51.49 per cent). $T_2$ and $T_4$ recorded 13.79 and 30.98 per cent damage respectively.

**Table 4. Pooled analysis of per cent shoot damage in okra treated with different insecticides**

| Treatments | Mean shoot damaged per plant (%)* | | | |
|---|---|---|---|---|
| | First spray | | Second spray | |
| | 7 DAT | 14 DAT | 7 DAT | 14 DAT |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 0.00 | 0.00 | 0.00 | 0.00 |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 23.26 | 13.34 | 15.29 | 11.03 |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 50.54 | 50.67 | 44.87 | 42.91 |
| $T_4$ -Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 37.90 | 34.80 | 26.91 | 24.02 |
| $T_5$ - Novaluron 10 EC | 15.63 | 10.65 | 7.94 | 4.93 |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 0.00 | 0.00 | 0.00 | 0.00 |
| $T_7$ - Thiamethoxam 25 WG (check) | 60.32 | 61.01 | 57.48 | 55.77 |
| $T_8$ - Absolute control | 79.67 | 82.67 | 82.45 | 79.72 |
| C.D. (0.05%) | 6.79 | 9.44 | 12.07 | 11.37 |

DAT- Days after treatment, DBT- Day before treatment

*Mean of 6 plants from 3 replications

Data recorded after fourteen days of treatment revealed that no fruit infestation was recorded from $T_1$ and $T_6$ and an increase in the fruit infestation was noticed in $T_8$ (91.16 per cent) compared to other treatments. Fruit infestation was reduced in $T_5$ (3.04 per cent), $T_2$ (8.38 per cent), $T_4$ (27.45 per cent) and $T_3$ (48.72 per cent). Only a slight decrease was noticed in $T_7$ (67.49 per cent).

### 4.1.5 Percentage of fruits damaged by *Earias vitella* during summer season from January 2019 to April 2019

The per cent of fruits infested by okra shoot and fruit borer during summer season from January 2019 to April 2019 is presented in table 5.

**Second spray:**

Seven days after treatment application $T_1$ and $T_6$ showed non-significant difference with no fruit infestation. Second lowest infestation was observed in $T_2$ having 13.70 per cent fruit infestation. It was found on par with $T_5$ (15.35 per cent). Treatment $T_8$ (85.47 per cent) showed maximum per cent fruit infestation. It was followed by $T_7$ (63.81 per cent) and $T_3$ (52.88 per cent). Fourteen days after treatment in all treatments fruit infestation were reduced except $T_8$ (87.41 per cent) and $T_3$ (39.09 per cent). No fruit damage was found in $T_6$ and $T_1$. $T_5$ recorded second lowest fruit damage (8.86 per cent) which was found on par with $T_2$ having 9.34 percent fruit damage. Fruit infestation was also reduced in $T_4$ (21.10 per cent) and $T_7$ (58.53 per cent).

### 4.1.6 Pooled analysis of per cent fruit damage for two seasons

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**Table 5. Percentage of fruits damaged by *Earias vitella* in okra treated with different insecticides during rabi season (September to December 2018) and summer season (January to April 2019)**

| Treatments | Mean fruits damaged per plant (%)* | | | | | |
|---|---|---|---|---|---|---|
| | Rabi season | | | Summer season | | |
| | 1 DBT | 7 DAT | 14 DAT | 1 DBT | 7 DAT | 14 DAT |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 70.87 | 0.00 (0.59) | 0.00 (0.59) | 73.02 | 0.00 (0.59) | 0.00 (0.59) |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 65.27 | 13.79 (21.73) | 8.38 (16.78) | 75.28 | 13.70 (21.70) | 9.34 (17.78) |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 60.21 | 51.49 (45.86) | 48.72 (44.27) | 67.18 | 39.75 (39.02) | 39.09 (38.70) |
| $T_4$ -Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 74.56 | 30.98 (33.82) | 27.45 (31.54) | 63.09 | 31.52 (33.98) | 21.10 (26.96) |
| $T_5$ - Novaluron 10 EC | 69.42 | 7.91 (16.30) | 3.04 (10.01) | 74.52 | 15.35 (23.00) | 8.86 (17.29) |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 65.97 | 0.00 (0.59) | 0.00 (0.59) | 71.66 | 0.00 (0.59) | 0.00 (0.59) |
| $T_7$ - Thiamethoxam 25 WG (check) | 68.80 | 67.98 (55.56) | 67.49 (55.26) | 68.72 | 59.18 (50.32) | 58.53 (49.91) |
| $T_8$ - Absolute control | 75.89 | 89.03 (70.78) | 91.16 (72.87) | 79.5 | 85.47 (67.63) | 87.41 (69.29) |
| C.D. (0.05%) | | 2.99 | 3.49 | | 4.99 | 4.65 |

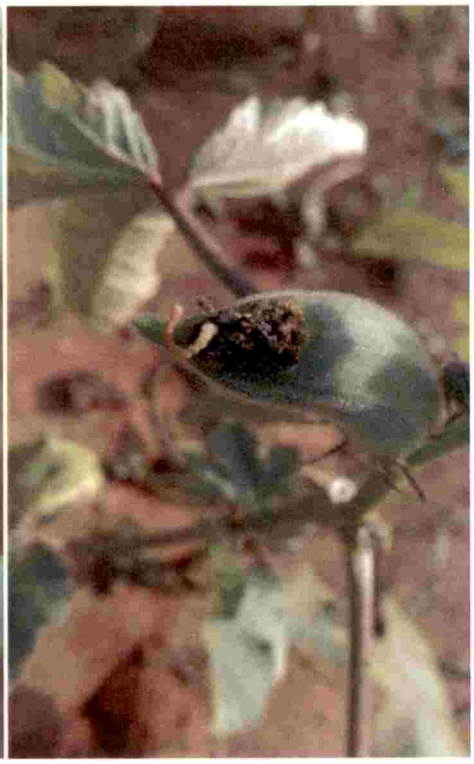
Figures in parenthesis are arc sine transformed values.

*Mean of 6 plants from 3 replications

DAT- Days after treatment, DBT- Day before treatment

**Plate 3. Fruit infestation by *Earias vitella***

**(3a) Holes made by the larvae**



**(3b) Holes are plugged with excreta**

**(3c) Fruit damaged by *Earias vitella***

The results of rabi (September to December 2018) and summer (January to April 2019) season's data on fruit infestation was pooled and analyzed to find out the overall effect of treatments and it was shown in table 6.

The pooled data of shoot damage revealed that treatments $T_1$, $T_2$, $T_5$ and $T_6$ significantly reduced the fruit infestation compared to control at 7 and 14 days after treatment. No fruit infestation was oberved in $T_1$ and $T_6$ at 7 and 14 days after treatment and they were on par with each other. Fruit infestation was highest in $T_8$ (87.25 and 89.28 per cent at 7 and 14 DAT respectively). Treatments $T_3$, $T_4$ and $T_7$ not showed any significant reduction in fruit infestation.

### 4.2 Efficacy of new insecticides against gram pod borer, *Helicoverpa armigera*

There was no incidence of *H. armigera* on fruits during rabi season and negligible amount was noticed during summer season. Hence it was not statistically analyzed.

### 4.3 Efficacy of new insecticides against leaf roller, *Sylepta derogata*

Incidence of leaf roller was very low during both the season while during reproductive stage of the crop there was no incidence of leaf roller.

#### 4.3.1 Percentage of leaf damaged by leaf roller, *Sylepta derogata* during 2018-19

Percentage of leaf damaged by leaf roller was assessed by counting the total number of leaves and damaged leaves during rabi season (September to December 2018) and summer season (January to April 2019). Observations were taken at seven and fourteen days after treatment. Statistically analyzed data is shown in table 7.

**First season:**

Data obtained from seven days after treatment revealed that treatments $T_1$ and $T_6$ were found significantly superior to other treatments with 0.0 per cent leaf damage

**Table 6. Pooled analysis of percentage of fruits damaged in okra treated with different insecticides**

| Treatments | Mean fruits damaged per plant (%) * | |
|---|---|---|
| | 7 DAT | 14 DAT |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 0.00 | 0.00 |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 13.75 | 8.86 |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 45.62 | 43.91 |
| $T_4$ -Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 31.25 | 24.28 |
| $T_5$ - Novaluron 10 EC | 11.63 | 5.95 |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 0.00 | 0.00 |
| $T_7$ - Thiamethoxam 25 WG (check) | 63.58 | 63.01 |
| $T_8$ - Absolute control | 87.25 | 89.28 |
| C.D. (0.05%) | 8.67 | 7.78 |

DAT- Days after treatment, DBT- Day before treatment

*Mean of 6 plants from 3 replications

**Table 7. Percentage of leaf damaged by leaf roller, *Sylepta derogata* in okra treated with different insecticides during rabi season (September to December 2018) and summer season (January to April 2019)**

| Treatments | Mean leaves damaged per plant (%) * | | | | | |
|---|---|---|---|---|---|---|
| | Rabi season | | | Summer season | | |
| | 1 DBT | 7 DAT | 14 DAT | 1 DBT | 7 DAT | 14 DAT |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 64.85 | 0.00 (0.59) | 0.00 (0.59) | 57.21 | 0.00 (0.59) | 0.00 (0.59) |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 73.40 | 8.98 (17.44) | 5.15 (13.12) | 56.40 | 4.99 (12.78) | 2.14 (8.37) |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 67.54 | 37.05 (37.48) | 37.01 (37.45) | 50.35 | 37.13 (37.54) | 36.01 (36.87) |
| $T_4$ -Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 60.16 | 22.68 (28.44) | 19.22 (25.97) | 53.09 | 12.92 (20.85) | 8.65 (17.11) |
| $T_5$ - Novaluron 10 EC | 63.09 | 5.23 (13.09) | 2.28 (8.69) | 55.72 | 2.22 (8.21) | 1.31 (6.53) |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 62.50 | 0.00 (0.59) | 0.00 (0.59) | 51.18 | 0.39 (2.46) | 0.00 (0.59) |
| $T_7$ - Thiamethoxam 25 WG (check) | 62.98 | 52.83 (46.93) | 54.27 (47.45) | 50.91 | 48.39 (44.07) | 53.07 (46.77) |
| $T_8$ - Absolute control | 68.72 | 85.09 (67.36) | 87.57 (69.37) | 59.37 | 63.00 (52.62) | 66.29 (54.51) |
| C.D. (0.05%) | | 2.44 | 2.09 | | 5.56 | 1.73 |

Figures in parenthesis are arc sine transformed values.

*Mean of 6 plants from 3 replications

DAT- Days after treatment, DBT- Day before treatment

against maximum leaf damage in $T_8$ (85.09 per cent). It was followed by $T_7$ (52.83 per cent) and $T_3$ (37.05 per cent) and they were significantly different. Less damage was obtained from $T_5$ (5.23 per cent) and $T_2$ (8.98 per cent). It was followed by $T_4$ with 22.68 per cent leaf damage by leaf roller which showed significant difference with all other treatments.

After fourteen days of spraying all the treatments except $T_8$ (87.57 per cent) and $T_7$ (54.27 per cent) showed significant reduction in leaf damage. No damage was recorded from $T_1$ and $T_6$ and they were statistically on par with each other. Leaf damage was reduced in plots treated with $T_5$ (2.28 per cent), $T_2$ (5.15 per cent), $T_4$ (19.22 per cent) and $T_3$ (37.01 per cent).

**Second season:**

Data obtained from seven days after treatment showed that lowest leaf damage was recorded from $T_1$ (0.0 per cent) which was on par with $T_6$ having 0.39 per cent leaf damage. $T_5$ showed non-significant difference with $T_2$ having 2.22 and 4.99 per cent leaf damage respectively. It was followed by $T_4$ (12.92 per cent). The highest leaf damage was observed in $T_8$ (63.00 per cent) followed by $T_7$ (48.39 per cent) and $T_3$ (37.13 per cent).

After fourteen days there was a significant reduction in leaf damage in all treatments except $T_8$ (66.29 per cent) and $T_7$ (53.07 per cent). Treatments *viz.*, $T_1$ (0.0 per cent), $T_6$ (0.0 per cent), $T_5$ (1.31 per cent), $T_2$ (2.14 per cent), $T_4$ (8.65 per cent) and $T_3$ (36.01 per cent) reduced leaf damage after fourteen days after treatment. $T_1$ was found on par with $T_6$.

**4.3.2 Pooled analysis of percentage of leaves damaged for two seasons**

**Plate 4. Leaves damaged by leaf roller, *Sylepta derogata***


(4a) and (4b) Leaf rolls made by the larvae

(4c) Larvae of *S. derogata*

(4d) Leaf rolls

The results of rabi (September to December 2018) and summer (January to April 2019) season's data on leaf damage was pooled and analyzed to find out the overall effect of treatments and it was shown in table 8.

The pooled data of leaf damage revealed that no leaf damage was oberved in $T_1$ and $T_6$ at seven days after treatment and they were on par with each other. Highest leaf damage was observed in $T_8$ (74.04 per cent). Treatments $T_3$ and $T_7$ not showed any significant reduction in fruit infestation. $T_5$ (3.72 per cent) and $T_2$ (6.99 per cent) were on par with each other with less leaf damage followed by $T_4$ (17.80 per cent).

The pooled data of leaf damage at fourteen days after treatment revealed that no leaf damage was oberved in $T_1$ and $T_6$ and they were on par with each other. Highest leaf damage was observed in $T_8$ (76.93 per cent). Treatments $T_3$ and $T_7$ not showed any significant reduction in fruit infestation. $T_5$ (1.79 per cent) and $T_2$ (3.64 per cent) were on par with each other with less leaf damage followed by $T_4$ (13.94 per cent).

### 4.4 Efficacy of new insecticides against leafhopper, *Amrasca biguttula biguttula*

The effect of different treatments on population of leafhopper was tested during rabi season (September to December 2018) and summer season (January to April 2019) to find out their efficacy. Population of leafhopper was taken by visual counting of nymphs and adults from leaves and statistically analyzed data is shown in table 9, 10, 11 and 12.

### 4.4.1 Effect of first spray of treatments on population of leafhopper, *Amrasca biguttula biguttula* during rabi season from September 2018 to December 2018

Efficacy of different treatments was evaluated after first spray of treatments at vegetative stage of okra during rabi season from September 2018 to December 2018. Population of adults and nymphs were recorded at 1,3,5,7 and 14 days after treatment. Statistically analyzed data is presented in table 9.

**Table 8. Pooled analysis of percentage of leaves damaged in okra treated with different insecticides**

| Treatments | Mean leaves damaged per plant (%)* | |
|---|---|---|
| | 7 DAT | 14 DAT |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 0.00 | 0.00 |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 6.99 | 3.64 |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 37.09 | 36.51 |
| $T_4$ -Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 17.80 | 13.94 |
| $T_5$ - Novaluron 10 EC | 3.72 | 1.79 |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 0.19 | 0.00 |
| $T_7$ - Thiamethoxam 25 WG (check) | 50.61 | 53.67 |
| $T_8$ - Absolute control | 74.04 | 76.93 |
| C.D. (0.05%) | 10.93 | 10.89 |

*Mean of 6 plants from 3 replications, DAT- Days after treatment

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Data obtained one day before spraying showed that there was a non-significant difference among all the treatments. The population of leafhopper ranged from 4.0 to 4.83 leafhopper/plant.

One day after first spray, the lowest population of leafhopper was observed in $T_1$ (0.61 leafhopper/plant). It was found on par with $T_7$ having 0.89 leafhopper/plant. $T_3$ showed significant difference fro other treatments with 1.66 leafhopper/plant. The highest number of leafhopper was recorded in $T_8$ (6.54 leafhopper/plant). It was followed by $T_2$ with 5.11 leafhopper/plant. The treatments $T_6$, $T_4$ and $T_5$ were found on par with each other having 4.11, 3.55 and 3.99 leafhopper/plant respectively.

Three days after first spray, number of leafhopper was significantly reduced by treatments $T_1$ (0.05 leafhopper/plant), $T_7$ (0.05 leafhopper/plant) and $T_3$ (1.49 leafhopper/plant). $T_1$ and $T_7$ were found on par with each other. The maximum population observed in $T_8$ (6.65 leafhopper/plant). It was followed by $T_2$ with 5.16 leafhopper/plant. Treatments *viz.*, $T_4$, $T_5$ and $T_6$ showed non-significant difference with each other having 3.71, 3.99 and 4.11 leafhopper/plant respectively.

Five days after first spraying, no leafhoppers were observed in $T_1$ and $T_7$. It was followed by $T_3$ with 0.05 leafhopper/plant. The treatments $T_1$, $T_7$ and $T_3$ were statistically on par with each other. Maximum number of leafhopper was found on $T_8$ having 6.94 leafhopper/plant. It was followed by $T_2$ having 5.44 leafhopper/plant There was an increase in the population of leafhopper in $T_6$ (3.94 leafhopper/plant), $T_4$ (4.05 leafhopper/plant) and $T_5$ (4.10 leafhopper/plant) and they showed non-significant difference with each other.

Seven days after first treatment revealed that $T_1$, $T_3$ and $T_7$ treated plots recorded no incidence of leafhopper and found on par with each other. Whereas maximum population was recorded in $T_8$ (6.87 leafhopper/plant). $T_2$ was significantly different from all other treatments with 5.44 leafhopper/plant. Treatments $T_6$, $T_4$ and $T_5$ were found on par with each other having 3.99, 4.05 and

**Table 9. Effect of first spray of treatments on population of leafhopper, *Amrasca biguttula biguttula* in okra treated with different insecticides during rabi season from September 2018 to December 2018**

| Treatments | *Mean number of leafhopper population per plant (nymphs and adults) | | | | | |
|---|---|---|---|---|---|---|
| | 1 DBS | Days after first spray | | | | |
| | | 1 DAS | 3 DAS | 5 DAS | 7 DAS | 14 DAS |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 4.00 (1.99) | 0.61 (0.72) | 0.05 (0.74) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 4.66 (2.16) | 5.11 (2.25) | 5.16 (2.37) | 5.44 (2.43) | 5.44 (2.43) | 5.83 (2.52) |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 4.16 (2.04) | 1.66 (1.27) | 1.49 (1.46) | 0.05 (0.74) | 0.00 (0.70) | 0.27 (0.87) |
| $T_4$ - Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 4.33 (2.09) | 3.55 (1.89) | 3.71 (2.06) | 4.05 (2.13) | 4.05 (2.13) | 4.49 (2.24) |
| $T_5$ - Novaluron 10 EC | 4.66 (2.15) | 3.99 (1.98) | 3.99 (2.10) | 4.10 (2.14) | 4.28 (2.17) | 4.66 (2.28) |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 4.50 (2.12) | 4.11 (2.01) | 4.11 (2.13) | 3.94 (2.11) | 3.99 (2.11) | 4.22 (2.18) |
| $T_7$ - Thiamethoxam 25 WG (check) | 4.16 (2.03) | 0.89 (0.90) | 0.05 (0.74) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) |
| $T_8$ - Absolute control | 4.83 (2.19) | 6.54 (2.56) | 6.65 (2.68) | 6.94 (2.73) | 6.87 (2.71) | 7.22 (2.77) |
| C.D. (0.05%) | | 0.28 | 0.22 | 0.22 | 0.20 | 0.11 |

Figures in parentheses are $\sqrt{x+1}$ transformed values

*Mean of 6 plants from 3 replications

DBS- Day before spray; DAS- Days after spray

4.28 leafhopper/plant. Fourteen days after first treatment showed that there was a gradual increase in the population of leafhopper in all the treatments except $T_1$ and $T_7$. Treatment $T_3$ was significantly different from all other treatments having 0.27 leafhopper/plant. The highest population of leafhopper was observed in $T_8$ (7.22 leafhopper/plant) followed by $T_2$ (5.83 leafhopper/plant). A slight increase in the population of leafhopper was recorded in $T_6$ (4.22 leafhopper/plant), $T_4$ (4.49 leafhopper/plant) and $T_5$ (4.66 leafhopper/plant) and they were found on par with each other.

### 4.4.2 Effect of second spray of treatments on population of leafhopper, *Amrasca biguttula biguttula* during rabi season from September 2018 to December 2018

Effect of different treatments on the population of leafhopper at reproductive stage of okra during rabi season from September 2018 to December 2018 is presented in table 10.

Results obtained one day before second spray showed that there was narrow difference between the treatments. One day after second spray revealed that the population of leafhopper was drastically reduced in all the treatments except $T_8$ (61.88 leafhopper/plant). The lowest population of leafhopper was recorded in $T_7$ (7.44 leafhopper/plant) which was on par with $T_1$ having 7.55 leafhopper/plant. $T_3$ was significantly different from all other treatments with 16.38 leafhopper/plant. Treatment $T_5$ showed non-significant difference with $T_4$ having 30.77 and 36.77 leafhopper/plant respectively. Treatments $T_4$, $T_2$ and $T_6$ were on par with 36.77, 39.72 and 40.94 leafhopper/plant respectively.

Three days after second spray, treatments $T_1$ (1.66 leafhopper/plant) and $T_7$ (1.55 leafhopper/plant) showed lowest leafhopper population. They were found on par with each other. It was followed by $T_3$ with 9.48 leafhopper/plant. The population of leafhopper was slightly increased in treatments $T_5$ (31.05 leafhopper/plant), $T_4$ (38.33 leafhopper/plant), $T_2$ (42.05 leafhopper/plant) and $T_6$

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(42.28 leafhopper/plant). $T_4$ and $T_5$ were found on par with each other. $T_4$, $T_2$ and $T_6$ also showed non-significant difference with each other. The highest population was recorded in $T_8$ (65.38 leafhopper/plant). Five days after second spray, highest population of leafhopper was observed in $T_8$ (63.22 leafhopper/plant). Treatments *viz.*, $T_2$, $T_6$, $T_4$ and $T_5$ showed non-significant difference with each other having 43.33, 39.99, 39.88 and 37.66 leafhopper/plant respectively. Whereas no incidence of leafhopper was observed in $T_1$, $T_7$ and $T_3$ and they were found on par with each other.

The data obtained seven days after second spray revealed that there was a gradual increase in the population of leafhopper in all the treatments except $T_1$, $T_7$ and $T_3$, which showed no incidence of leafhopper. The treatments $T_5$, $T_6$ and $T_4$ were found on par with each other having 38.72, 40.55 and 40.89 leafhopper/plant. Treatments $T_6$ and $T_4$ showed non-significant difference with $T_2$ (43.47 leafhopper/plant).

Fourteen days after second spray, treatments $T_8$, $T_2$, $T_6$, $T_4$, $T_5$ and $T_3$ showed an increase in the population of leafhopper with 68.22, 46.83, 45.22, 43.49, 41.17 and 1.38 leafhopper/plant respectively. $T_5$ was found on par with $T_4$. Treatments $T_2$, $T_6$ and $T_4$ showed non-significant difference with each other. Maximum population was recorded in $T_8$. Whereas minimum population of leafhopper was observed in $T_1$ and $T_7$, in which no incidence of leafhopper was observed.

**4.4.3 Effect of first spray of treatments on population of leafhopper, *Amrasca biguttula biguttula* during summer season from January 2019 to April 2019**

Efficacy of different treatments on the population of leafhopper was tested at vegetative stage of okra during summer season from January 2019 to April 2019. The data on population of leaf hopper is presented in table 11.

**Table 10. Effect of second spray of treatments on population of leafhopper, *Amrasca biguttula biguttula* in okra treated with different insecticides during rabi season from September 2018 to December 2018**

| Treatments | *Mean number of leafhopper population per plant (nymphs and adults) | | | | | |
|---|---|---|---|---|---|---|
| | | Days after second spray | | | | |
| | 1 DBS | 1 DAS | 3 DAS | 5 DAS | 7 DAS | 14 DAS |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 58.50 ( 7.65) | 7.55 (2.75) | 1.66 (1.25) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 56.88 (7.55) | 39.72 (6.29) | 42.05 (6.49) | 43.33 (6.61) | 43.47 (6.62) | 46.83 (6.87) |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 59.50 (7.71) | 16.38 (4.02) | 9.48 (3.07) | 0.00 (0.70) | 0.00 (0.70) | 1.38 (1.35) |
| $T_4$ - Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 56.74 (7.53) | 36.77 (6.05) | 38.33 (6.19) | 39.88 (6.34) | 40.89 (6.42) | 43.49 (6.64) |
| $T_5$ - Novaluron 10 EC | 50.16 (7.09) | 30.77 (5.55) | 31.05 (5.57) | 37.66 (6.18) | 38.72 (6.26) | 41.17 (6.45) |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 56.89 (7.54) | 40.94 (6.39) | 42.28 (6.49) | 39.99 (6.34) | 40.55 (6.40) | 45.22 (6.75) |
| $T_7$ - Thiamethoxam 25 WG (check) | 57.10 (7.55) | 7.44 (2.72) | 1.55 (1.13) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) |
| $T_8$ - Absolute control | 58.83 (7.67) | 61.88 (7.86) | 65.38 (8.08) | 63.22 (7.98) | 64.19 (8.04) | 68.22 (8.29) |
| C.D. (0.05%) | | 0.71 | 0.67 | 0.59 | 0.27 | 0.25 |

Figures in parentheses are $\sqrt{x+1}$ transformed values,

*Mean of 6 plants from 3 replications

DBS- Day before spray; DAS- Days after spray

A pre count was taken one day before first spray indicates that treatments showed non-significant difference with each other.

Results obtained one day after first spray revealed that lowest population of leafhopper was observed in $T_1$ (0.49 leafhopper/plant). It was followed by $T_7$ and $T_3$ with 1.22 and 1.16 leafhopper/plant respectively. Treatment $T_1$ was found on par with $T_7$. $T_3$ was significantly different from all other treatments. Highest population of leafhopper was observed in $T_8$ with 3.38 leafhopper/plant. Treatments $T_4$ (1.94 leafhopper/plant), $T_2$ (2.10 leafhopper/plant) and $T_6$ (2.27 leafhopper/plant) were found on par with each other and $T_5$ (2.66 leafhopper/plant) was on par with $T_6$ and $T_2$.

Three days after first spray there was a slight decrease in the population of leafhopper in $T_1$ (0.21 leafhopper/plant), $T_7$ (0.27 leafhopper/plant) and $T_3$ (0.77 leafhopper/plant). $T_1$ and $T_7$ were found on par with each other. $T_3$ was significantly different from all other treatments. The lowest population was recorded in $T_1$. Whereas highest population was recorded in $T_8$ (4.27 leafhopper/plant). It was followed by $T_5$ having 3.16 leafhopper/plant. Treatments $T_5$ was found on par with $T_2$ (2.55 leafhopper/plant), $T_6$ (2.49 leafhopper/plant) and $T_4$ (2.44 leafhopper/plant).

Five days after first spray, treatments $T_2$ (2.27 leafhopper/plant) and $T_4$ (2.22 leafhopper/plant) exhibited a slight decrease in the population of leafhopper. Treatment $T_5$ was found on par with $T_6$ (3.10 leafhopper/plant) and $T_2$ was found on par with $T_4$. Treatments $T_1$, $T_3$ and $T_7$ showed significant reduction in the population of leafhopper, they were on par with no incidence of leafhopper. Treatment $T_8$ showed maximum number of leafhopper (4.27 leafhopper/plant).

Seven days after first spray, treatments $T_1$, $T_7$ and $T_3$ recorded no incidence of leafhopper and showed non-significant difference with each other. Rest of the treatments showed an increase in the population of leafhoppers. Treatments $T_4$ and

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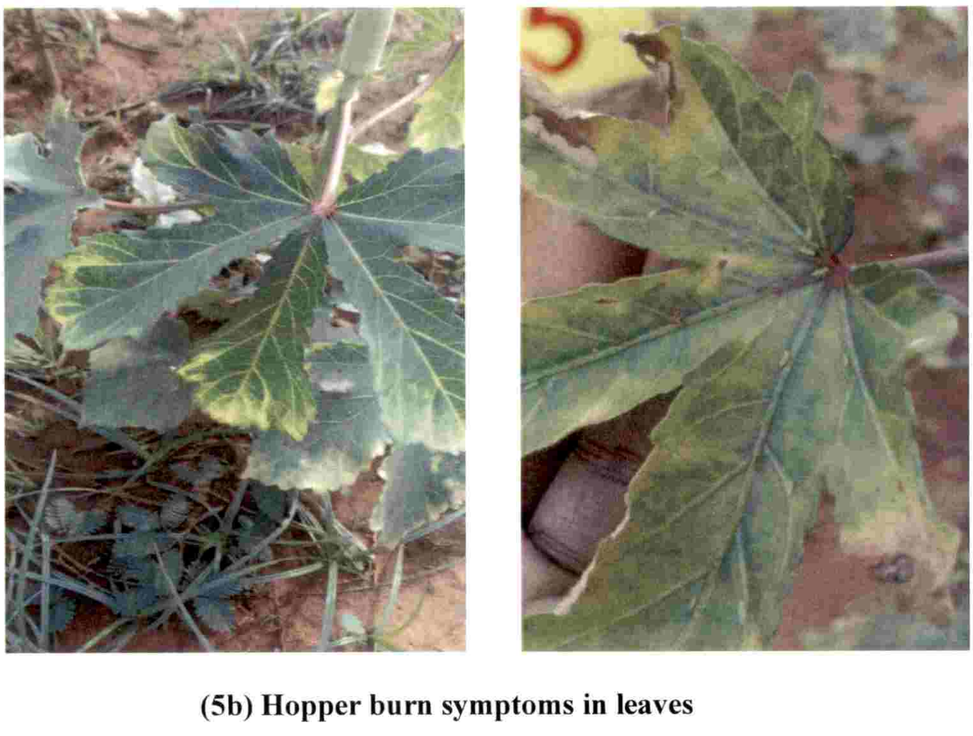
**Plate 5. Incidence of leafhoppers in okra**

**(5a) Adults and nymphs of leafhopper in okra**



**(5b) Hopper burn symptoms in leaves**

$T_2$ showed non-significant difference with each other having 2.49 and 2.66 leafhopper/plant respectively. Whereas $T_5$ was found on par with $T_6$ with 3.49 and3.21 leafhopper/plant respectively. The number of leafhopper was highest in $T_8$ (4.60 leafhopper/plant).

Fourteen days after first spray, all the treatments except $T_1$ and $T_7$ exhibited a gradual increase in the population of leafhoppers. Treatments $T_1$ and $T_7$ were statistically on par with no incidence of leafhopper. $T_3$ was found on par with $T_1$ and $T_7$ with 0.22 leafhopper/plant. The treatment $T_8$ showed a gradual increase in the population from first to fourteen days after treatment. It was ranged from 3.38 to 5.05 leafhopper/plant. It was followed by $T_6$, $T_5$ and $T_2$. $T_6$ (3.94 leafhopper/plant) and $T_5$ (3.88 leafhopper/plant) were on par with each other. Also $T_2$ (3.16 leafhopper/plant) was found on par with $T_4$ (2.66 leafhopper/plant).

#### 4.4.4 Effect of second spray of treatments on population of leafhopper, *Amrasca biguttula biguttula* during summer season from January 2019 to April 2019

A study was conducted to evaluate the efficacy of different treatments on the population of leafhopper during summer season from January 2019 to April 2019. Treatments were applied at the reproductive stage of the crop. The results obtained from the study are presented in table 12.

The population at fourteen days after first spray was taken as the pre count of second spray. The results obtained one day after second spray showed that $T_1$ and $T_7$ recorded no incidence of leafhoppers and showed non-significant difference with each other. Population of leafhopper was high in $T_8$ (4.61 leafhopper/plant). It was followed by $T_6$ and $T_5$ with 3.28 and 3.22 leafhopper/plant respectively. Treatments $T_6$, $T_5$ and $T_2$ were found on par with each other and $T_2$ (2.55 leafhopper/plant), $T_4$ (2.38 leafhopper/plant) and $T_3$ (1.94 leafhopper/plant) were also found on par with each other.

**Table 11. Effect of first spray of treatments on population of leafhopper, *Amrasca biguttula biguttula* in okra treated with different insecticides during summer season from January 2019 to April 2019**

| Treatments | *Mean number of leafhopper population per plant (nymphs and adults) | | | | | |
|---|---|---|---|---|---|---|
| | | Days after first spray | | | | |
| | 1 DBS | 1 DAS | 3 DAS | 5 DAS | 7 DAS | 14 DAS |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 2.66 (1.64) | 0.49 (0.69) | 0.21 (0.45) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 2.83 (1.68) | 2.10 (1.44) | 2.55 (1.59) | 2.27 (1.66) | 2.66 (1.78) | 3.16 (1.92) |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 2.50 (1.59) | 1.16 (1.05) | 0.77 (0.85) | 0.00 (0.70) | 0.00 (0.70) | 0.22 (0.84) |
| $T_4$ - Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 2.16 (1.48) | 1.94 (1.39) | 2.44 (1.56) | 2.22 (1.64) | 2.49 (1.73) | 2.66 (1.78) |
| $T_5$ - Novaluron 10 EC | 2.33 (1.52) | 2.66 (1.63) | 3.16 (1.77) | 3.38 (1.97) | 3.49 (1.99) | 3.88 (2.09) |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 1.83 (1.35) | 2.27 (1.47) | 2.49 (1.57) | 3.10 (1.89) | 3.21 (1.93) | 3.94 (2.11) |
| $T_7$ - Thiamethoxam 25 WG (check) | 2.00 (1.41) | 1.22 (0.69) | 0.27 (0.51) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) |
| $T_8$ - Absolute control | 2.83 (1.68) | 3.38 (1.91) | 4.27 (2.06) | 4.27 (2.18) | 4.60 (2.25) | 5.05 (2.35) |
| C.D. (0.05%) | | 0.20 | 0.24 | 0.12 | 0.14 | 0.16 |

Figures in parentheses are $\sqrt{x+1}$ transformed values

*Mean of 6 plants fro 3 replications

DBS- Day before spray; DAS- Days after spray

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Three days after second spray treatments also showed that plots treated with $T_1$ and $T_7$ recorded no hoppers and $T_3$ significantly reduced the population of leafhopper (1.22 leafhopper/plant). $T_1$ and $T_7$ were found on par with each other and $T_3$ was significantly different from all other treatments. Treatments *viz.*, $T_5$, $T_6$, $T_2$ and $T_4$ were on par with 3.44, 3.28, 2.72 and 2.61 leafhopper/plant respectively. The population was highest in $T_8$ (4.77 leafhopper/plant).

Five days after second spray, treatments $T_1$, $T_7$ and $T_3$ showed no incidence of leafhoppers and they were on par with each other. Maximum population was recorded from $T_8$ (5.22 leafhopper/plant) followed by $T_5$ (3.99 leafhopper/plant) and $T_6$ (3.55 leafhopper/plant) in which $T_5$ and $T_6$ were found on par with each other. $T_4$ (2.49 leafhopper/plant) showed non-significant difference with $T_2$ (2.49 leafhopper/plant).

Seven days after second spray, treatments $T_8$ (5.27 leafhopper/plant), $T_5$ (4.05 leafhopper/plant), $T_6$ (3.94 leafhopper/plant), $T_4$ (3.33 leafhopper/plant) and $T_2$ (2.99 leafhopper/plant) showed an increase in the population of leafhopper. Among these highest population was recorded in $T_8$. $T_5$ was found on par with $T_6$. Treatments $T_4$ and $T_2$ showed significant difference with all other treatments. $T_1$, $T_7$ and $T_3$ were on par with no incidence of leafhopper.

There was a gradual increase in the population of leafhopper at fourteen days after second spray. No incidence of leafhopper was observed in $T_1$ and $T_7$. The second lowest population was recorded in $T_3$ (1.05 leafhopper/plant) which was significantly different from all other treatments. There was an increase in the population in $T_8$ (5.61 leafhopper/plant), $T_5$ (4.33 leafhopper/plant), $T_6$ (4.33 leafhopper/plant), $T_4$ (3.88 leafhopper/plant) and $T_2$ (3.44 leafhopper/plant). Highest population was recorded in $T_8$. Treatments $T_5$, $T_6$, $T_4$ and $T_2$ were on par with each other.

**Table 12. Effect of second spray of treatments on population of leafhopper, *Amrasca biguttula biguttula* in okra treated with different insecticides during summer season from January 2019 to April 2019**

| Treatments | *Mean number of leafhopper population per plant (nymphs and adults) | | | | | |
|---|---|---|---|---|---|---|
| | | Days after second spray | | | | |
| | 1 DBS | 1 DAS | 3 DAS | 5 DAS | 7 DAS | 14 DAS |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 3.16 (1.92) | 2.55 (1.58) | 2.72 (1.65) | 2.49 (1.73) | 2.99 (1.86) | 3.44 (1.97) |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 0.22 (0.84) | 1.94 (1.37) | 1.22 (1.10) | 0.00 (0.70) | 0.00 (0.70) | 1.05 (1.22) |
| $T_4$ - Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 2.66 (1.78) | 2.38 (1.53) | 2.61 (1.60) | 2.49 (1.73) | 3.33 (1.95) | 3.88 (2.09) |
| $T_5$ - Novaluron 10 EC | 3.88 (2.09) | 3.22 (1.78) | 3.44 (1.86) | 3.99 (2.12) | 4.05 (2.14) | 4.33 (2.19) |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 3.94 (2.11) | 3.28 (1.79) | 3.28 (1.79) | 3.55 (2.01) | 3.94 (2.11) | 4.33 (2.19) |
| $T_7$ - Thiamethoxam 25 WG (check) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) | 0.00 (0.70) |
| $T_8$ - Absolute control | 5.05 (2.35) | 4.61 (2.14) | 4.77 (2.18) | 5.22 (2.39) | 5.27 (2.41) | 5.61 (2.48) |
| C.D. (0.05%) | | 0.22 | 0.26 | 0.14 | 0.08 | 0.27 |

Figures in parentheses are $\sqrt{x+1}$ transformed values

*Mean of 6 plants from 3 replications

DBS- Day before spray; DAS- Days after spray

**Table 13. Pooled analysis of population of leafhopper in okra treated with different insecticides**

| Treatments | *Mean number of leafhopper population per plant (nymphs and adults) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | First spray | | | | | Second spray | | | | |
| | 1 DAS | 3 DAS | 5 DAS | 7 DAS | 14 DAS | 1 DAS | 3 DAS | 5 DAS | 7 DAS | 14 DAS |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 0.55 | 0.13 | 0.03 | 0.00 | 0.00 | 4.44 | 1.16 | 0.00 | 0.00 | 0.00 |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 3.61 | 3.85 | 3.72 | 4.05 | 4.49 | 21.13 | 22.38 | 22.91 | 23.23 | 25.13 |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 1.41 | 1.13 | 0.75 | 0.00 | 0.24 | 9.16 | 5.35 | 0.00 | 0.00 | 1.22 |
| $T_4$ - Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 2.74 | 3.07 | 2.95 | 3.27 | 3.58 | 19.58 | 20.47 | 21.19 | 22.11 | 23.69 |
| $T_5$ - Novaluron 10 EC | 3.33 | 3.58 | 3.69 | 3.89 | 4.27 | 16.99 | 17.24 | 20.83 | 21.39 | 22.75 |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 3.19 | 3.30 | 3.61 | 3.61 | 4.08 | 22.11 | 22.78 | 21.77 | 22.24 | 24.77 |
| $T_7$ - Thiamethoxam 25 WG (check) | 1.05 | 0.16 | 0.03 | 0.00 | 0.00 | 4.44 | 0.99 | 0.00 | 0.00 | 0.00 |
| $T_8$ - Absolute control | 4.96 | 5.46 | 5.46 | 5.74 | 6.13 | 33.24 | 35.08 | 34.22 | 34.73 | 36.91 |
| C.D. (0.05%) | 1.84 | 1.52 | 1.49 | 1.56 | 1.58 | 25.76 | 30.95 | 32.70 | 33.03 | 35.25 |

DAS- Days after spray, *Mean of 6 plants from 3 replications

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### 4.4.5 Pooled analysis of population of leafhopper for two seasons

**First spray:**

The results of two season's pooled data on population of leafhopper revealed that one day after first spray lowest population of leafhopper was recorded in $T_1$ (0.55 leafhopper/plant). It was on par with $T_7$ (1.05 leafhopper/plant) and $T_3$ (1.41 leafhopper/plant). Treatments $T_2$, $T_5$, $T_6$ and $T_4$ were less effective against population of leafhopper and they were on par with each other. Highest population was recorded in $T_8$ with 4.96 leafhopper/plant.

Three days after first spray population of leafhopper was reduced to 0.13 leafhopper/plant in $T_1$. It was on par with $T_7$ (0.16 leafhopper/plant) and $T_3$ (1.13

leafhopper/plant). Maximum population was observed in $T_8$ (5.46 leafhopper/plant). Treatments $T_2$, $T_5$, $T_6$ and $T_4$ were less effective against population of leafhopper and they were on par with each other.

Five days after first spray lowest population of leafhopper was recorded in $T_1$ (0.03 leafhopper/plant). $T_7$ (0.03 leafhopper/plant) and $T_3$ (0.75 leafhopper/plant) were on par with $T_1$. Treatments $T_2$, $T_5$, $T_6$ and $T_4$ were less effective against population of leafhopper and they were on par with each other. Maximum population was observed in $T_8$ (5.46 leafhopper/plant).

Seven days after first spray no leafhoppers were recorded in plots treated with $T_1$, $T_7$ and $T_3$ and were on par with each other. Significant higher population was recorded from $T_2$, $T_5$, $T_6$ and $T_4$ and they were on par with each other. Highest population was recorded in $T_8$ with 5.74 leafhopper/plant.

Fourteen days after first spray revealed that no leafhoppers were recorded in plots treated with $T_1$ and $T_7$. $T_3$ showed a slight increase in the population of leafhopper and it was on par with $T_1$ and $T_7$. Significant higher population was recorded from $T_2$, $T_5$, $T_6$ and $T_4$ and they were on par with each other. Population of leafhopper was increased to Maximum in $T_8$ with 6.13 leafhopper/plant.

**Second spray:**

Pooled data on population of leafhopper after second spray revealed that one day after spray lowest population of leafhopper was recorded in $T_1$ (4.44 leafhopper/plant) and $T_7$ (4.44 leafhopper/plant). It was followed by $T_3$ (9.16 leafhopper/plant). $T_1$, $T_7$ and $T_3$ were on par with each other. Significantly high population was observed in $T_2$, $T_5$, $T_6$ and $T_4$. Maximum population was observed in $T_8$ (33.24 leafhopper/plant).

Three days after spray population of leafhopper was reduced to 1.16 leafhopper/plant in $T_1$ and 0.99 leafhopper/plant in $T_7$ and they were on par with each other. Significant reduction in the population was observed in $T_3$ (5.35 leafhopper/plant). Significantly higher population was recorded from $T_2$, $T_5$, $T_6$ and $T_4$ and they were on par with each other. Highest population was recorded in $T_8$ with 35.08 leafhopper/plant.

Five days after sspray no leafhoppers were recorded in plots treated with $T_1$, $T_7$ and $T_3$ and were on par with each other. The population was increased in $T_2$, $T_5$, $T_6$ and $T_4$ and showed non-significant difference with each other. Maximum population was observed in $T_8$ (34.22 leafhopper/plant).

Seven days after spray also no leafhoppers were recorded in plots treated with $T_1$, $T_7$ and $T_3$ and were on par with each other. Maximum population was observed in $T_8$ (34.73 leafhopper/plant). Significantly higher population was recorded from $T_2$, $T_5$, $T_6$ and $T_4$ and they were on par with each other.

Fourteen days after spray revealed that no leafhoppers were recorded in plots treated with $T_1$ and $T_7$. $T_3$ (1.22 leafhopper/plant) showed a slight increase in the population of leafhopper and it was on par with $T_1$ and $T_7$. Significantly higher population was recorded from $T_2$, $T_5$, $T_6$ and $T_4$ and they were on par with each other. Population of leafhopper was increased to maximum in $T_8$ with 36.91 leafhopper/plant.

## 4.5 BIOMETRIC OBSERVATIONS

### 4.5.1 Length of fruits measured from the yield obtained during rabi season from September 2018 to December 2018

The length of fruits was taken from the fruits harvested per treatment during rabi season from September 2018 to December 2018. From this data average length of the fruit was calculated and statistical analysis was performed. Results obtained are presented in table 14.

Observations recorded on fruit length during rabi season revealed that $T_1$ (14.85 cm) recorded significantly higher fruit length and minimum fruit length was observed in $T_8$ (10.13 cm). It was followed by $T_7$ (11.33 cm) and $T_3$ (11.66 cm) and they were on par with each other and $T_3$ was found on par with $T_4$ (12.00 cm). $T_6$ and $T_2$ showed non-significant difference with each other having 13.68 and13.24 cm respectively and $T_2$ was found on par with $T_5$ (12.66 cm).

### 4.5.2 Length of fruits measured from the yield obtained during summer season from January 2019 to April 2019

The length of fruits was taken from the fruits harvested per treatment during summer season from January 2019 to April 2019. From this data average length of the fruit was calculated and statistical analysis was performed. Results obtained are presented in table 14.

Observations recorded on fruit length during summer season showed that the significantly higher fruit length was observed in $T_1$ (15.99 cm) followed by $T_6$ (14.89 cm), $T_2$ (14.44 cm) and $T_5$ (13.93). Treatments $T_4$ and $T_3$ were found on par with

**Plate 6. Healthy and damaged fruits**


(6a) Healthy fruits

(6b) Damaged fruits

each other. Minimum fruit length was observed in $T_8$ (11.80 cm) followed by $T_7$ (12.66 cm).

**4.6 Yield attributes of okra taken during rabi (september to december 2018) and summer season (january to april 2019)**

**4.6.1 Assessment of yield components like fresh weight, total yield and marketable yield obtained during rabi season from September 2018 to December 2018**

During each harvest the fresh weight of the fruits were recorded. The total number of harvests made during rabi season was eight. From this data total yield and marketable yield were calculated. The results obtained are statistically analyzed and presented in table 15.

Data obtained from first harvest revealed that treatments were significantly different from each other. Significantly maximum fresh weight was recorded in $T_1$ (55.80 g per plant). It was followed by $T_6$ (51.00 g per plant), $T_2$ (49.00 g per plant) and $T_5$ (46.50 g per plant). $T_4$ and $T_7$ recorded yield of 38.90 and 32.50 g per plant respectively. Minimum yield was observed in $T_8$ (16.40 g per plant) followed by $T_3$ (27.50 g per plant).

After second harvest, treatment $T_1$ recorded highest yield of 58.50 g per plant followed by, $T_6$ (56.50 g per plant) and $T_2$ (52.10 g per plant). Treatment $T_8$ recorded lowest yield with 34.10 g per plant. $T_7$ (40.00 g per plant) was found on par with $T_3$ (38.82 g per plant). Treatments $T_5$ and $T_4$ with yield 49.74 and 46.50 g per plant respectively.

The yield obtained from third harvest revealed that maximum fresh weight of fruits was recorded from $T_1$ (79.90 g per plant). It was followed by $T_6$ (66.80 g per

**Table 14. Mean length of fruits per treatment taken in okra treated with different insecticides during rabi season (September to December 2018) and summer season (January to April 2019)**

| Treatment | Mean fruit length per plant (cm) | |
|---|---|---|
| | Rabi season | Summer season |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 14.85 | 15.99 |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 13.24 | 14.44 |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 11.66 | 13.22 |
| $T_4$ - Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 12.00 | 13.31 |
| $T_5$ - Novaluron 10 EC | 12.66 | 13.93 |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 13.68 | 14.89 |
| $T_7$ - Thiamethoxam 25 WG (check) | 11.33 | 12.66 |
| $T_8$ - Absolute control | 10.13 | 11.80 |
| C.D. (0.05%) | 0.67 | 0.39 |

plant) and $T_2$ (65.60 g per plant). The yield obtained from third harvest revealed that maximum fresh weight of fruits recorded from $T_1$ (79.90 g per plant). It was followed by $T_6$ (66.80 g per plant) and $T_2$ (65.60 g per plant). Treatments $T_5$, $T_4$, $T_7$ and $T_3$ recorded 59.33, 55.89, 44.00 and 43.00 g per plant respectively. Minimum yield of 26.29 g per plant was observed in $T_8$.

After fourth harvest lowest yield was observed in $T_8$ (31.33 g per plant). Treatments $T_7$ and $T_3$ were found on par with each other having 35.66 and 35.50 g per plant respectively. Highest yield was recorded in $T_1$ (49.66 g per plant) followed by $T_6$ (47.50 g per plant) and $T_2$ (43.16 g per plant). $T_4$ showed non-significant difference with $T_5$ having 39.83 and 40.50 g per plant respectively.

The data obtained from fifth harvest revealed that $T_1$ (52.50 g per plant) exhibited highest yield and it was on par with $T_6$ (39.06 g per plant). Treatments $T_2$ (48.22 g per plant) and $T_5$ (46.35 g per plant) were found on par with each other and also $T_5$ was on par with $T_4$ (45.50 g per plant). The lowest yield was obtained from $T_8$ (34.50 g per plant) followed by $T_7$ (39.06 g per plant) and $T_3$ (39.64 g per plant). $T_7$ and $T_3$ were found on par with each other.

After sixth harvest treatment $T_1$ (39.50 g per plant) recorded maximum yield followed by $T_6$ (38.33 g per plant). $T_1$ was found on par with $T_6$. Treatments $T_2$ and $T_5$ were on par with each other with 35.66 and 34.50 g per plant respectively. Minimum yield was recorded from $T_8$ (29.50 g per plant). It was followed by $T_3$ with 27.66 g per plant. $T_7$ and $T_4$ with yield 38.33 and 30.19 g per plant and they found on par with each other.

After seventh harvest treatment $T_1$ exhibited maximum yield of 45.50 g per plant whereas minimum yield was recorded from $T_8$ (31.50 g per plant). $T_8$ was found on par with $T_3$ with yield 33.50 g per plant. $T_7$ was significantly different from all other treatments with yield of 35.84 g per plant. Treatments $T_5$ and $T_4$ were on par with yield of 39.66 and 38.21 g per plant respectively. $T_6$ and $T_2$ with yield of 43.20 and 40.66 g per plant and $T_2$ was found on par with $T_5$.

After eighth harvest, lowest yield was recorded from $T_8$ (69.50 g per plant) and it was significantly different from all other treatments. It was followed by $T_3$, $T_7$ and $T_4$ with yield of 74.50, 75.83 and 76.16 g per plant respectively and was on par with each other. Also $T_4$ was found on par with $T_5$ (80.50 g per plant). $T_1$ was significantly different from all the treatments with maximum yield of 88.50 g per plant. It was followed by treatments $T_6$ (86.16 g per plant), $T_2$ (81.19 g per plant) and $T_5$ (80.50 g per plant) and they were found on par with each other.

From the data obtained on fresh weight of the fruits, total yield was calculated and the results revealed that highest yield was recorded from $T_1$ (469.86 g per plant) and it was significantly different from all the treatments. It was followed by $T_6$ with yield 415.59 g per plant. Treatments $T_2$ and $T_5$ were found on par with each other with yield 415.59 and 397.08 g per plant respectively. Treatment $T_8$ recorded lowest yield of 268.62 g per plant. $T_7$ and $T_3$ recorded yield of 332.40 and 415.59 g per plant and they were found on par with each other. $T_4$ was significantly different from all the treatments with yield 371.18 g per plant.

Results obtained from marketable yield revealed that treatment $T_1$ (442.87 g per plant) exhibited maximum yield and $T_8$ (106.63 g per plant) recorded minimum yield. Treatments $T_6$, $T_5$, $T_2$, $T_4$, $T_7$ and $T_3$ with marketable yield of 405.99, 375.36, 369.55, 262.76, 207.27 and 189.74 g per plant respectively. Treatments $T_5$ and $T_2$ were found on par with each other.

**4.6.2 Assessment of yield components like fresh weight, total yield and marketable yield obtained during summer season from January 2019 to April 2019**

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**Table 15. Effect of treatments on the yield attributes of okra treated with different insecticides during rabi season from September 2018 to December 2018**

| Treatments | Mean fresh weight of fruits (g/plant) | | | | | | | | Total yield (g/plant) | Marketable yield (g/plant) |
|---|---|---|---|---|---|---|---|---|---|---|
| | First harvest | Second harvest | Third harvest | Fourth harvest | Fifth harvest | Sixth harvest | Seventh harvest | Eighth harvest | Total | Total |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 55.80 | 58.50 | 79.90 | 49.66 | 52.50 | 39.50 | 45.50 | 88.50 | 469.86 | 442.87 |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 49.00 | 52.10 | 65.60 | 43.16 | 48.22 | 35.66 | 40.66 | 81.19 | 415.59 | 369.55 |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 27.50 | 38.82 | 43.00 | 35.50 | 39.64 | 27.66 | 33.50 | 74.50 | 320.12 | 189.74 |
| $T_4$ - Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 38.90 | 46.50 | 55.89 | 39.83 | 45.50 | 30.19 | 38.21 | 76.16 | 371.18 | 262.76 |
| $T_5$ - Novaluron 10 EC | 46.50 | 49.74 | 59.33 | 40.50 | 46.35 | 34.50 | 39.66 | 80.50 | 397.08 | 375.36 |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 51.00 | 56.50 | 66.80 | 47.50 | 50.50 | 38.33 | 43.20 | 86.16 | 439.99 | 405.99 |
| $T_7$ - Thiamethoxam 25 WG (check) | 32.50 | 40.00 | 44.00 | 35.66 | 39.06 | 29.51 | 35.84 | 75.83 | 332.40 | 207.27 |
| $T_8$ - Absolute control | 16.40 | 34.10 | 26.29 | 31.33 | 34.50 | 25.00 | 31.50 | 69.50 | 268.62 | 106.63 |
| C.D. (0.05%) | 1.97 | 1.96 | 2.12 | 0.13 | 2.13 | 1.39 | 2.02 | 4.54 | 18.95 | 15.49 |

Fresh weight of the fruits was recorded at each harvest during summer season from January to April 2019. Eight harvests were made during summer season. From the fresh weight of fruits total yield and marketable yield were calculated. The results obtained are statistically analyzed and presented in table 16.

After first harvest, $T_1$ recorded maximum yield of 60.90 g per plant. It was followed by $T_6$ (60.30 g per plant), $T_5$ (57.50 g per plant) and $T_2$ (56.70 g per plant). $T_1$ and $T_6$ were at par with each other and $T_5$ was found on par with $T_2$. $T_8$ recorded lowest yield of 42.50 g per plant. Treatments $T_4$, $T_7$ and $T_3$ with yield of 51.30, 47.80 and 45.10 g per plant respectively.

Data on second harvest revealed that maximum yield was recorded from $T_1$ (73.30 g per plant) whereas minimum yield of 40.23 g per plant was recorded from $T_8$. Treatments $T_6$ , $T_2$, $T_5$, $T_4$, $T_7$ and $T_3$ recorded yield of 64.85, 60.91, 58.75, 54.17, 47.00 and 44.43 g per plant respectively. $T_5$ and $T_2$ showed non-significant difference with each other.

After third harvest, highest fresh weight of fruits was recorded from $T_1$ (85.41 g per plant) and lowest yield was recorded from $T_8$ (40.00 g per plant). It was followed by $T_3$ with yield of 47.21 g per plant. Treatments $T_4$ and $T_7$ were on par with each other with the yield of 55.83 and 54.50 g per plant respectively. $T_5$ was significantly different from all the treatments with yield of 75.28 g per plant and $T_6$ (80.08 g per plant) was found on par with $T_2$ (79.33 g per plant).

Data obtained from fourth harvest revealed that, treatment $T_1$ showed highest yield of 75.00 g per plant. Treatments $T_6$, $T_5$, $T_2$ and $T_4$ with yield 69.31, 60.10, 55.00 and 49.10 g per plant respectively. Treatments $T_3$ (45.00 g per plant) and $T_7$ (43.72 g per plant) were found on par with each other. Minimum yield was recorded from $T_8$ (25.00 g per plant).

After fifth harvest, treatment $T_1$ showed maximum yield of 87.30 g per plant followed by $T_2$ (83.10 g per plant) and $T_6$ (82.20 g per plant). $T_2$ and $T_6$ were found on par with each other. The lowest yield was recorded from $T_8$ with yield of 55.90 g per plant. $T_3$ was found on par with $T_7$ with yield 65.90 and 68.40 g per plant respectively. Treatments $T_4$ (72.70 g per plant) and $T_5$ (77.70 g per plant) were significantly different from all the treatments.

After sixth harvest, $T_1$ (66.80 g per plant) recorded maximum yield and $T_8$ (40.10 g per plant) recorded minimum yield. Second highest yield was recorded from $T_6$ (59.10 g per plant). $T_5$ and $T_2$ were found on par with each other with yield of 56.20 and 55.00 g per plant respectively. Treatments $T_4$, $T_7$ and $T_3$ with yield of 50.00, 46.80 and 43.30 g per plant respectively.

Data recorded after seventh harvest revealed that $T_1$ recorded maximum yield of 80.50 g per plant, which was on par with $T_6$ with the yield of 59.50 g per plant. The lowest yield was observed in $T_8$ (53.26 g per plant). Treatment $T_6$ was found on par with $T_2$ (75.65 g per plant) and $T_2$ was found on par with $T_5$ (73.83 g per plant). Treatments $T_7$ and $T_3$ were on par with each other with yield of 62.51 and 60.00 g per plant respectively. $T_4$ was significantly different from all other treatments with yield of 68.50 g per plant.

After eighth harvest maximum yield was recorded in $T_1$ (65.10 g per plant) whereas minimum yield was recorded in $T_8$ (36.50 g per plant). $T_6$ was significantly different from all the treatments with yield 59.50 g per plant. Treatments $T_4$, $T_7$ and $T_3$ recorded yield of 49.50, 46.33 and 41.20 g per plant respectively. $T_5$ (53.61 g per plant) was found on par with $T_2$ (54.91 g per plant).

Results obtained from total yield revealed that maximum yield was observed in $T_1$ (594.31 g per plant) followed by $T_6$ (584.13 g per plant) and they were on par with each other. $T_2$ was found on par with $T_5$ with yield 520.00 and 512.97 g per plant.

**Table 16. Effect of treatments on the yield attributes of okra treated with different insecticides during summer season from January 2019 to April 2019**

| Treatments | Mean fresh weight of fruits (g/plant) | | | | | | | | Total yield (g/plant) | Marketable yield (g/plant) |
|---|---|---|---|---|---|---|---|---|---|---|
| | First harvest | Second harvest | Third harvest | Fourth harvest | Fifth harvest | Sixth harvest | Seventh harvest | Eighth harvest | Total | Total |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 60.90 | 73.30 | 85.41 | 75.00 | 87.30 | 66.80 | 80.50 | 65.10 | 594.31 | 571.87 |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 56.70 | 60.91 | 79.33 | 55.00 | 83.10 | 55.00 | 75.65 | 54.91 | 520.00 | 461.24 |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 45.10 | 44.43 | 47.21 | 45.00 | 65.90 | 43.30 | 60.00 | 41.20 | 392.14 | 237.56 |
| $T_4$ - Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 51.30 | 54.17 | 55.83 | 49.10 | 72.70 | 50.00 | 68.50 | 49.50 | 451.10 | 332.42 |
| $T_5$ - Novaluron 10 EC | 57.50 | 58.75 | 75.28 | 60.10 | 77.70 | 56.20 | 73.83 | 53.61 | 512.97 | 450.90 |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 60.30 | 64.85 | 80.08 | 69.31 | 82.20 | 59.10 | 78.10 | 59.50 | 584.13 | 545.71 |
| $T_7$ - Thiamethoxam 25 WG (check) | 47.80 | 47.00 | 54.50 | 43.72 | 68.40 | 46.80 | 62.51 | 46.33 | 417.06 | 290.56 |
| $T_8$ - Absolute control | 42.50 | 40.23 | 40.00 | 25.00 | 55.90 | 40.10 | 53.26 | 36.50 | 333.49 | 139.16 |
| C.D. (0.05%) | 2.41 | 2.39 | 3.04 | 3.18 | 2.99 | 2.06 | 3.38 | 3.02 | 25.13 | 9.53 |

Minimum yield was recorded from $T_8$ and it was 333.49 g per plant. $T_4$ was significantly different from all the treatments with yield of 451.10 g per plant. $T_7$ and $T_3$ were on par with each other with yield of 417.06 and 392.14 g per plant respectively.

Results on marketable yield showed that highest yield was recorded in $T_1$ (571.87 g per plant). It was followed by $T_6$ with yield of 545.71 g per plant. $T_5$ was found on par with $T_2$ recorded 450.90 and 461.24 g per plant. Treatments $T_4$ (332.42 g per plant), $T_7$ (290.56 g per plant) and $T_3$ (237.56 g per plant) showed significant difference with each other.

## 4.7 ECONOMIC ANALYSIS

### 4.7.1 Economics of cultivation of okra during rabi season from September 2018 to December 2018

The economics of production of okra during rabi season from September 2018 to December 2018 was calculated. The result obtained is presented in table 17.

The results obtained after economic analysis revealed that maximum net income was obtained from $T_1$ (Rs. 192330.54). It was followed by $T_6$ (Rs. 164087.05), $T_5$ (Rs. 139748.22) and $T_2$ (Rs. 137844.02). Also high benefit-cost ratio was obtained from these treatments. $T_1$ was recorded high benefit-cost ratio which means an amount of Rs. 2.42 was obtained for every one rupee invested. Treatment $T_8$ recorded lowest net returns of Rs. 0.59. Second highest net returns was recorded from $T_6$ (Rs. 2.20) followed by $T_2$ (Rs. 2.01) and $T_5$ (Rs. 2.01).

### 4.7.2 Economics of cultivation of okra during summer season from January 2019 to April 2019

**Table 17. Economics of cultivation of okra treated with different insecticides during rabi season from September 2018 to December 2018**

| Treatments | Economics of okra | | | | | |
|---|---|---|---|---|---|---|
| | **Production cost excluding insecticides (Rs./ha)** | **Cost of insecticides (Rs./ha)** | **Total expenditure (Rs./ha)** | **Gross income (Rs./ha)** | **Net income (Rs./ha)** | **B : C ratio** |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 133795.98 | 1925.00 | 135720.98 | 328051.52 | 192330.54 | 2.42 |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 133795.98 | 2100.00 | 135895.98 | 273740.00 | 137844.02 | 2.01 |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 133795.98 | 781.25 | 134577.23 | 140548.00 | 5970.77 | 1.04 |
| $T_4$ - Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 133795.98 | 2520.00 | 136315.98 | 194636.80 | 58320.82 | 1.43 |
| $T_5$ - Novaluron 10 EC | 133795.98 | 4500.00 | 138295.98 | 278044.20 | 139748.22 | 2.01 |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 133795.98 | 2850.00 | 136645.98 | 300733.03 | 164087.05 | 2.20 |
| $T_7$ - Thiamethoxam 25 WG (check) | 133795.98 | 840.00 | 134635.98 | 153533.20 | 18897.22 | 1.14 |
| $T_8$ - Absolute control | 133795.98 | 0.00 | 133795.98 | 78985.10 | -54810.88 | 0.59 |

**Table 18. Economics of cultivation of okra treated with different insecticides during summer season from January 2019 to April 2019**

| Treatments | Economics of okra | | | | | |
|---|---|---|---|---|---|---|
| | Production cost excluding insecticides (Rs./ha) | Cost of insecticides (Rs./ha) | Total expenditure (Rs./ha) | Gross income (Rs./ha) | Net income (Rs./ha) | B : C ratio |
| $T_1$ - Chlorantraniliprole 8.8% + Thiamethoxam 17.5% SC | 133795.98 | 1925.00 | 135720.98 | 423606.9 | 287885.92 | 3.12 |
| $T_2$ - Lambda cyhalothrin 4.6% + Chlorantraniliprole 9.3% ZC | 133795.98 | 2100.00 | 135895.98 | 341658.9 | 205762.92 | 2.51 |
| $T_3$ - Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC | 133795.98 | 781.25 | 134577.23 | 175970.2 | 41392.97 | 1.31 |
| $T_4$ - Flubendiamide 19.92% w/w + Thiacloprid 19.92% w/w | 133795.98 | 2520.00 | 136315.98 | 246236.8 | 109920.82 | 1.81 |
| $T_5$ - Novaluron 10 EC | 133795.98 | 4500.00 | 138295.98 | 333999.7 | 195703.72 | 2.41 |
| $T_6$ - Chlorantraniliprole 18.5 SC (check) | 133795.98 | 2850.00 | 136645.98 | 404229.2 | 267583.22 | 2.90 |
| $T_7$ - Thiamethoxam 25 WG (check) | 133795.98 | 840.00 | 134635.98 | 215229.4 | 80593.42 | 1.59 |
| $T_8$ - Absolute control | 133795.98 | 0.00 | 133795.98 | 103081.4 | -30714.58 | 0.77 |

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The economics of production of okra during rabi season from September 2018 to December 2018 was calculated. The result obtained is presented in table 18.

The results obtained after economic analysis revealed that maximum net income was obtained from $T_1$ (Rs. 287885.92). It was followed by $T_6$ (Rs. 267583.22), $T_2$ (Rs. 205762.92 R) and $T_5$ (Rs. 195703.72). Also high benefit-cost ratio was obtained from these treatments. $T_1$ recorded high benefit-cost ratio which means an amount of Rs. 3.12 was obtained for every one rupee invested. Treatment $T_8$ recorded lowest net returns of Rs. 0.77. Second highest net returns was recorded from $T_6$ (Rs. 2.90) followed by $T_2$ (Rs. 2.51) and $T_5$ (Rs. 2.41).

# Discussion

# 5. DISCUSSION

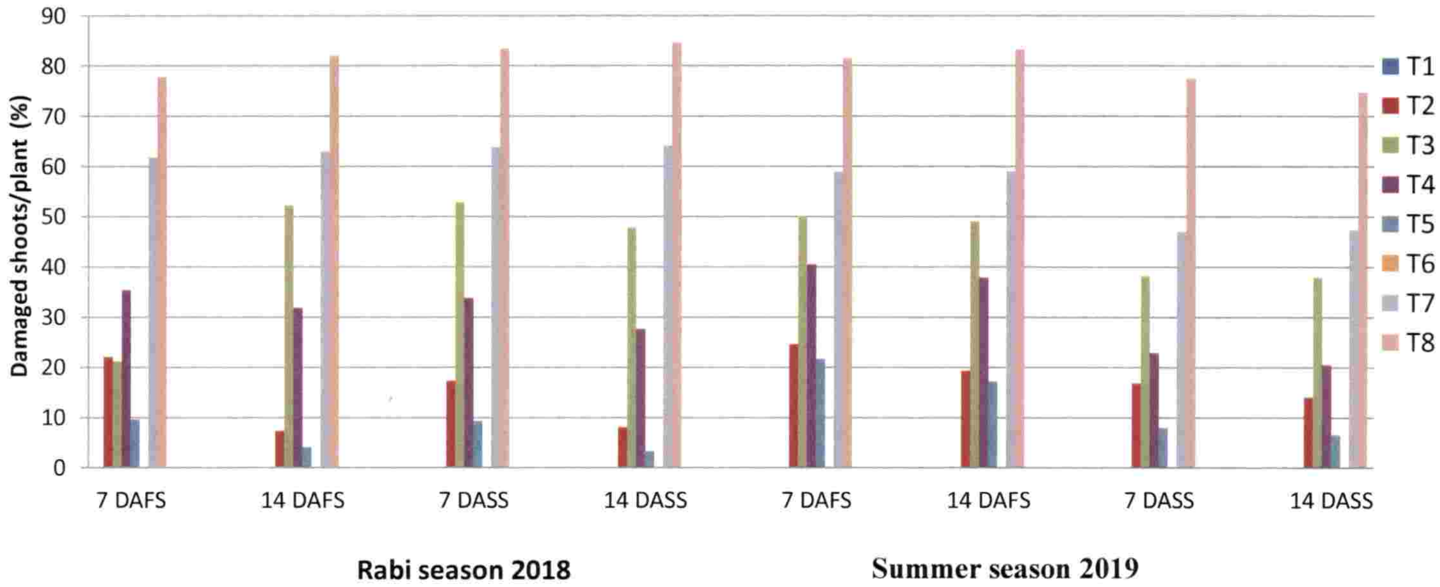
Field experiments were conducted on the topic 'Evaluation of new insecticides against major pests of okra, *Abelmoschus esculentus* L.' during rabi season (September to December 2018) and summer season (January to April 2019). The findings of the study are discussed in this chapter.

## 5.1 EFFICACY OF NEW INSECTICIDES AGAINST MAJOR PESTS OF OKRA

### 5.1.1 Effect of new insecticides against okra shoot and fruit borer, *Earias vitella* during rabi (September to December 2018) and summer season (January to April 2019)

Results obtained from the study concluded that Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC (Voliam flexi) @ 0.7 ml/l of water was very effective against okra shoot and fruit borer larvae during both rabi and summer season from September to December 2018 and January to April 2019 respectively (Fig 1 and 2). The efficacy of the same in tomato was reported by Kuhar *et al.* (2011) in which Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC @ 7 oz/acre significantly reduced fruit damage in tomato. In present study Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC showed non-significant difference with Chlorantraniliprole 18.5 SC @ 0.3 ml/l of water (Check). Similar findings were reported by Rambhau (2018) in cotton where in Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC was effective against *E. vitella* and it recorded lowest seed, locule and fruiting body damage. The present study was in line with Hossain (2015) who reported that pod borer infestation was minimum in plots treated with Voliam flexi 300 SC @ 0.5 ml/l of water. Kumar (2015) reported that Chlorantraniliprole 18.5 SC @ 25 g a.i./ha significantly reduced the percentage of shoot and fruit damage in okra

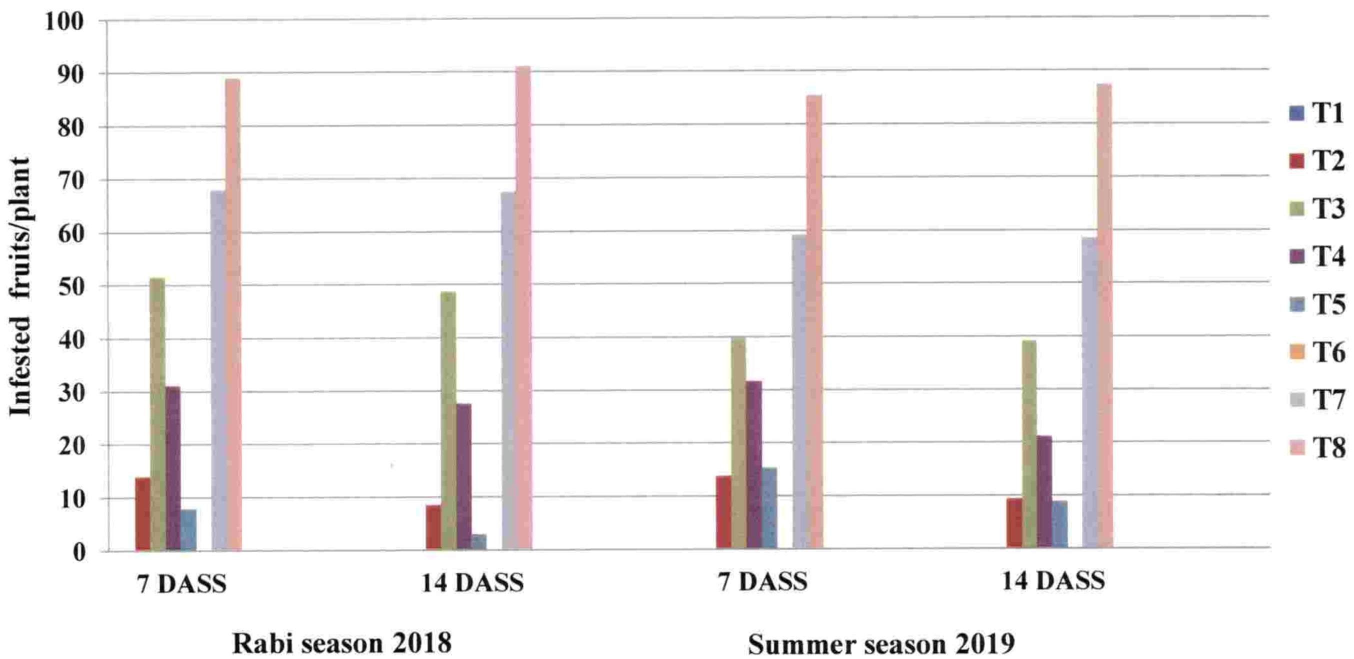
**Fig 1. Damaged shoots per plant (%) during rabi (September to December 2018) and summer season (January to April 2019)**




DAFS – Days after first spray, DASS – Days after second spray

$T_1$: Chlorantraniliprole 8.8%+thiamethoxam 17.5% SC (Voliam flexi®) @ 0.7ml/l; $T_2$: Lambda cyhalothrin 4.6%+chlorantraniliprole 9.3% ZC (Ampligo®) @ 0.4 ml/l; $T_3$: Thiamethoxam 12.6%+ lambda cyhalothrin 9.5% ZC (Alika®) @ 0.5 ml/l; $T_4$: Flubendiamide 19.92% w/w+ thiacloprid 19.92% w/w (Belt-expert®) @ 0.4ml/l; $T_5$: Novaluron 10 EC @ 2ml/l; $T_6$: Chlorantraniliprole 18.5 SC @ 0.3 ml/l (check); $T_7$: Thiamethoxam 25 WG @ 0.3g/l (check); $T_8$: Absolute control.

Fig.2. Infested fruits per plant during rabi (September to December 2018) and summer season (January to April 2019)




DASS – Days after second spray

$T_1$: Chlorantraniliprole 8.8%+thiamethoxam 17.5% SC (Voliam flexi®) @ 0.7ml/l; $T_2$: Lambda cyhalothrin 4.6%+chlorantraniliprole 9.3% ZC (Ampligo®) @ 0.4 ml/l; $T_3$: Thiamethoxam 12.6%+ lambda cyhalothrin 9.5% ZC (Alika®) @ 0.5 ml/l; $T_4$: Flubendiamide 19.92% w/w+ thiacloprid 19.92% w/w (Belt-expert®) @ 0.4ml/l; $T_5$: Novaluron 10 EC @ 2ml/l; $T_6$: Chlorantraniliprole 18.5 SC @ 0.3 ml/l (check); $T_7$: Thiamethoxam 25 WG @ 0.3g/l (check); $T_8$: Absolute control

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In the present investigation after Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC and Chlorantraniliprole, Novaluron 10 EC @ 2 ml/l and Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC (Ampligo ) @ 0.4 ml/l of water were found to be effective against okra shoot and fruit borer larvae. They significantly reduced shoot damage fourteen days after first and second spray during rabi season. Rambhau (2018) reported that and Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC was on par with Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC, which significantly reduced the fruiting body damage in cotton. According to Anjabapu (2018), shoot damage in brinjal was significantly reduced by and Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC and it was on par with Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC and fruit damage was lowest in Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC. Similar findings were reported by Bajya *et al.* (2015) that Ampligo 150 ZC @ 60 g a.i./ha, 45 g a.i./ha and 37.5 g a.i./ha were effective against *Earias* spp in cotton.

In the present study during summer season after Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC and Chlorantraniliprole 18.5 SC, Novaluron 10 EC recorded lowest shoot damage at seven and fourteen days after treatment. This result was in line with the findings of Patil *et al.* (2007) that Novaluron 10 EC @ 1.0 ml/l significantly reduced the pod borer damage in black gram.

No fruit infestation was observed in plots treated with Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC at seven and fourteen days after treatment during both rabi and summer season. It was on par with the standard check Chlorantraniliprole 18.5 SC. The next best treatment was Novaluron 10 EC, which significantly reduced fruit infestation during both rabi and summer season. Similar findings were reported by Shahiduzzaman (2017) where in Volium flexi 300 SC significantly reduced the pod borer damage in chickpea. Rohokale *et al.* (2018) also reported similar finding that brinjal shoot and fruit borer damage was lowest in Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC.

Pooled data also revealed that Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC significantly reduced the percentage of shoot and fruit damage during both season. It was followed by Chlorantraniliprole 18.5 SC, Novaluron 10 EC and Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC.

Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC (Voliam flexi) is a ready mix formulation of Chlorantraniliprole 8.8 per cent and Thiamethoxam 17.5 per cent. In this mixture Chlorantraniliprole is a ryanodine receptor modulator, which means it interrupts the balance of calcium channels and disrupts proper muscle function in insects. It is highly specific to insect ryanodine receptors. Thus it is safe to natural enemies and mammals. The findings of Braham *et al.* (2012) that Chlorantraniliprole is a stomach poison results in the death of the insect and very specific to target species which includes Lepidopteran pests, reconfirmed the present study.

### 5.1.2 Effect of new insecticides against leaf roller, *Sylepta derogata* during rabi (September to December 2018) and summer season (January to April 2019)

Results obtained from efficacy of new insecticides against leaf roller concluded that the combination insecticide, Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC @ 0.7 ml/l of water was the best treatment which significantly reduced the leaf damage in both rabi and summer season (Fig 3). The check Chlorantraniliprole 18.5 SC, also showed no incidence of leaf roller in rabi season and showed no significant difference with Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC during summer season. Similar result was reported by Davis *et al.* (2010) that Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC @ 0.128 and 0.10 Ib/acre exhibited 100 per cent reduction in the population of soybean loopers. Akin and Howard (2012) reported that Voliam flexi 40 WG @ 0.07 lb/acre reduced the population of soybean loopers significantly at 8 DAT.

In the present study next best treatments were Novaluron 10 EC and and Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC, showed a gradual decrease in the leaf roller damage during both rabi and summer season. This statement was supported by Sen *et al.* (2017) who stated that Ampligo 150 ZC @ 28-35 g a.i./ha recorded lowest shoot and fruit damage in brinjal which is in line with the present study. Grigolli *et al.* (2015) reported that damage caused by *Maruca vitrata* in soybean was significantly reduced by and Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC. Baskaran *et al.* (2012) reporetd that Ampligo 150 ZC @ 250 ml/l was effective against *Helicoverpa armigera* and recorded lowest fruit damage (3.17 per cent) was in line with the above results.

Pooled analysis of two season's data revealed that Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC significantly reduced the percentage of shoot and fruit daage during both season. It was followed by Chlorantraniliprole 18.5 SC, Novaluron 10 EC and Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC.

### 5.1.3 Effect of new insecticides on population of leafhopper, *Amrasca biguttula biguttula* during rabi (September to December 2018) and summer season (January to April 2019)

During rabi season, population of leafhopper was high and plants showed hopper burn symptoms. The number of leafhopper was significantly reduced by Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC during rabi and summer season (Fig 4 and 5). It was on par with standard check Thiamethoxam 25 WG @ 0.3 g/l of water. Five days after treatment, both the treatments recorded no incidence of leafhopper up to fourteen days after treatment. Present study is supported by Kumar *et al.* (2017) who reported that Thiamethoxam and

Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC significantly reduced the population of adults and larvae of thrips, *Scirtothrips dorsalis*. Similar results were reported by Jijisha (2014) that seed treatment and foliar application with Thiamethoxam effectively reduced the population of leafhopper in okra up to 50 DAS. Kumar (2015) reported that Thiamethoxam 25 WG @ 40 g a.i./ha recorded lowest population of jassids in okra. After Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC and Thiamethoxam, the next best treatment was Thiamethoxam 12.6 per cent + Lamda cyhalothrin 9.5 per cent ZC (Alika) @ 0.5ml/l of water which significantly reduced the population of leafhopper.

Seven days after first spray, no leafhoppers were reported from plots treated with Thiamethoxam 12.6 per cent + Lamda cyhalothrin 9.5 per cent ZC and a slight increase in the population was observed fourteen days after treatment during rabi season. After second spray, Thiamethoxam 12.6 per cent + Lamda cyhalothrin 9.5 per cent ZC recorded no incidence of leafhoppers at five and seven days after spraying and there was a gradual increase in the population was noticed fourteen days after treatment. The same trend was followed during summer season that Thiamethoxam 12.6 per cent + Lamda cyhalothrin 9.5 per cent ZC treated plots recorded no leafhoppers at five and seven days after spraying and thereafter a slight increase in the population was observed. This is in line with the report of Birla (2013) that Thiamethoxam 12.6 per cent + Lambda cyhalothrin 9.5 per cent ZC @ 27.5 g a.i./ha significantly reduced the population of jassids and whiteflies in soybean. Chand (2012) reported that Alika 247 ZC @ 27.5g a.i./h significantly reduced the damage caused by *Spodoptera litura* in soybean and recorded high yield. Reddy *et al.* (2018) reported that Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC @ 150 g a.i./ha was superior over all the treatments in reducing the population of sucking pests of cowpea, it was followed by Alika 247 ZC also substantiated the present study.

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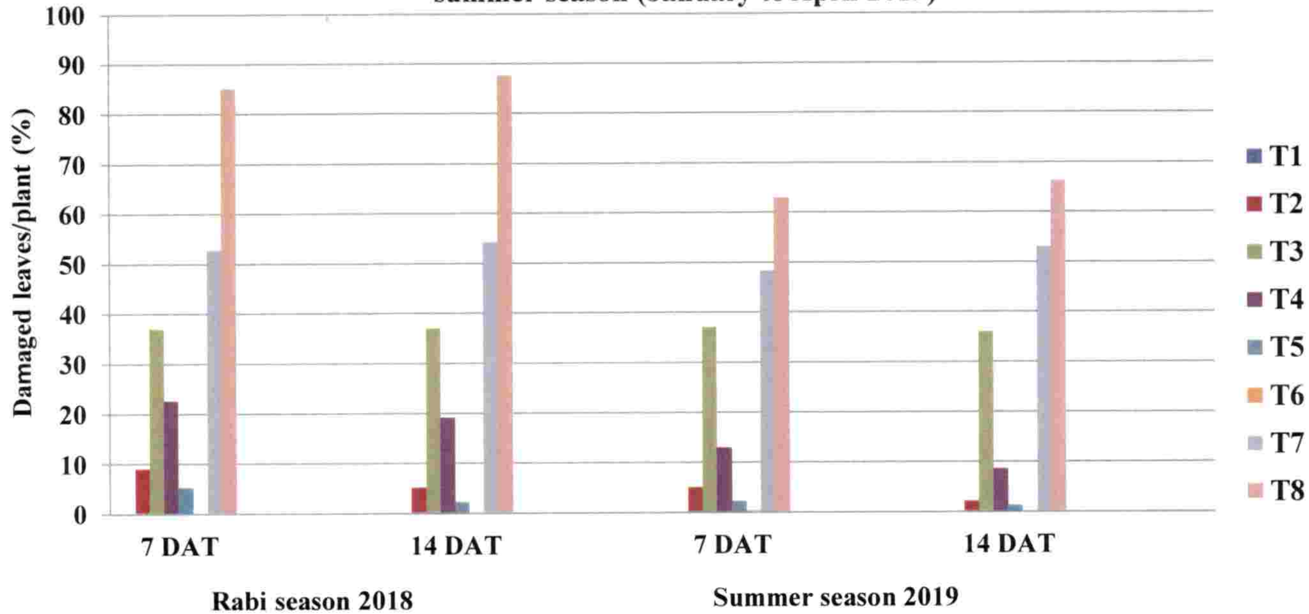
Fig 3. Damaged leaves per plant (%)during rabi (September to December 2018) and summer season (January to April 2019)




DAT – Days after treatment $T_1$: Chlorantraniliprole 8.8%+thiamethoxam 17.5% SC (Voliam flexi®) @ 0.7ml/l; $T_2$: Lambda cyhalothrin 4.6%+chlorantraniliprole 9.3% ZC (Ampligo®) @ 0.4 ml/l; $T_3$: Thiamethoxam 12.6%+ lambda cyhalothrin 9.5% ZC (Alika®) @ 0.5 ml/l; $T_4$: Flubendiamide 19.92% w/w+ thiacloprid 19.92% w/w (Belt-expert®) @ 0.4ml/l; $T_5$: Novaluron 10 EC @ 2ml/l; $T_6$: Chlorantraniliprole 18.5 SC @ 0.3 ml/l (check); $T_7$: Thiamethoxam 25 WG @ 0.3g/l (check); $T_8$: Absolute control

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Pooled analysis of the population of leafhopper after first and second spray also concluded that Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC was effective against leafhoppers followed by Thiamethoxam 25 WG and Thiamethoxam 12.6 per cent + Lamda cyhalothrin 9.5 per cent ZC.

Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC (Voliam flexi) is a ready mix formulation of Chlorantraniliprole 8.8 per cent and Thiamethoxam 17.5 per cent. It is having systemic and contact action. In this combination Thiamethoxam is a nicotinic acetylcholine receptor agonist, which interact with acetylcholine binding site of the insect and causes excitation, paralysis and death of the insect. It affects insect nerve system and comparatively safe to vertebrates. The report of Jijisha (2014) that Thiamethoxam is a potent agonist which selectively acts on the target site, nicotinic acetylcholine receptors (nAChRs) of insects and it is widely used against sucking pests reinforced the present study. Also Chlorantraniliprole in the combination is a ryanodine receptor modulator, which means it interrupts the balance of calcium channels and disrupts proper muscle function in insects. It is highly specific to insect ryanodine receptors. Thus it is safe to natural enemies and mammals.

## 5.2 BIOMETRIC OBSERVATIONS

### 5.2.1 Length of fruits measured from the yield obtained during rabi (September to December 2018) and summer season (January to April 2019)

Length of the fruits was taken at each harvest to find out the effect of treatments on fruits. Significant difference in the fruit length was observed between treatments. Maximum fruit length was obtained from Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC treated plots during rabi and summer season. In rabi season it was 14.85 cm and 15.99 cm in summer season (Fig 6). It was followed by Chlorantraniliprole 18.5 SC (13.68 and 14.89 cm during rabi and summer season respectively) and Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent

ZC (13.24 and 14.44 cm during rabi and summer season respectively). The lowest fruit length was obtained from absolute control, which were 10.13 and 11.80 cm during rabi and summer season respectively. Present study is in line with the study of Akter *et al.* (2018) who reported that in tomato the IPM module with Voliam flexi 300 SC @ 0.5 ml/l recorded longest plant (99.54 cm) with maximum number of branches (19.40), maximum number of flowers (15.13) and highest weight of single fruit (98.45 g).

From the results it is concluded that fruit length was significantly related to the treatments. Though length of fruit is a genetic character, *E. vitella* infested fruits have become short and deformed. So the treatment with lowest fruit damage shows maximum fruit length. This result is in line with the findings of Raghunath (2011) who reported that morphological characters like plant height, fruit length were negatively correlated with the population of *E. vitella* and also negatively correlated with percentage of shoot and fruit damage.

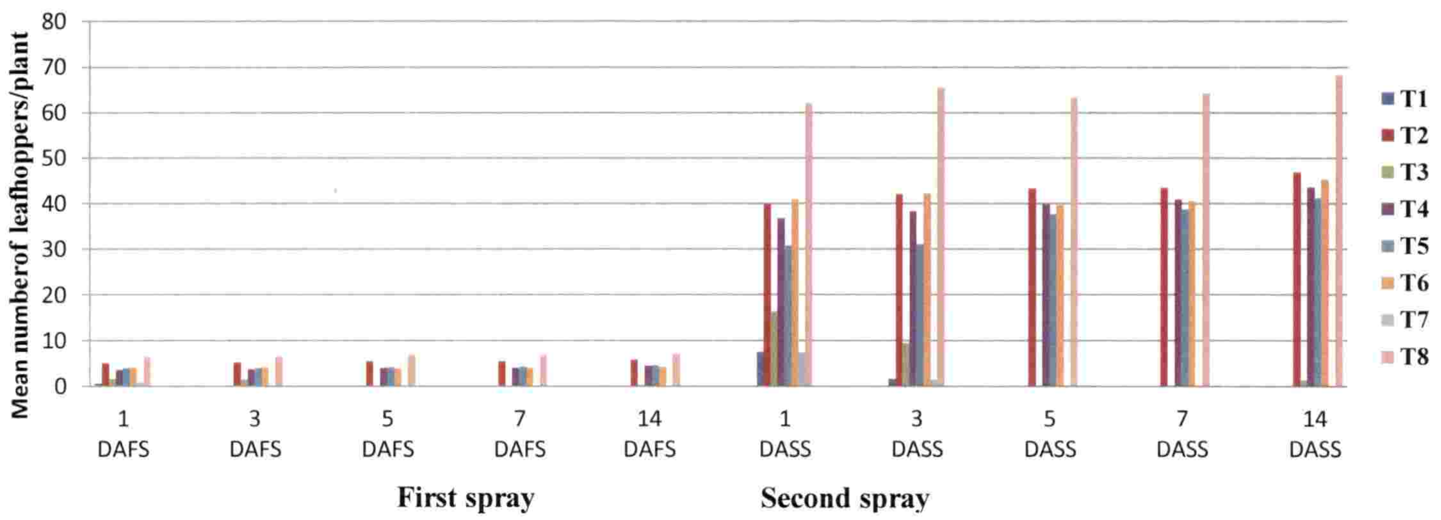
In the present study Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC recorded lowest fruit infestation and maximum fruit length. Fruit infestation was maximum in absolute control and has minimum fruit length. Length of the fruit is directly related to the yield. Treatments with high fruit length also recorded high yield.

## 5.3 YIELD ATTRIBUTES

### 5.3.1 Yield of okra during rabi (September to December 2018) and summer season (January to April 2019)

From the fresh weight of the fruits, total and marketable yield was calculated and concluded that Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC recorded maximum yield of 469.86 and 594.31 g per plant during rabi and summer season respectively, which shows the higher efficacy of Chlorantraniliprole 8.8 per

**Fig 4. Mean number of leafhoppers per plant during rabi season from September 2018 to December 2018**




DAFS – Days after first spray, DASS – Days after second spray

$T_1$: Chlorantraniliprole 8.8%+thiamethoxam 17.5% SC (Voliam flexi®) @ 0.7ml/l; $T_2$: Lambda cyhalothrin 4.6%+chlorantraniliprole 9.3% ZC (Ampligo®) @ 0.4 ml/l; $T_3$: Thiamethoxam 12.6%+ lambda cyhalothrin 9.5% ZC (Alika®) @ 0.5 ml/l; $T_4$: Flubendiamide 19.92% w/w+ thiacloprid 19.92% w/w (Belt-expert®) @ 0.4ml/l; $T_5$: Novaluron 10 EC @ 2ml/l; $T_6$: Chlorantraniliprole 18.5 SC @ 0.3 ml/l (check); $T_7$: Thiamethoxam 25 WG @ 0.3g/l (check); $T_8$: Absolute control cent + Thiamethoxam 17.5 per cent SC against okra shoot and fruit borer (Fig 7). Similar findings were reported by Akter *et al.* (2018) that in tomato IPM module with Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC recorded the highest yield and high benefit-cost ratio, this may be due to the high efficacy of Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC against fruit borers.

The present study is in line with the findings of Shahiduzzaman *et al.* (2017) that Volium flexi 300 SC significantly reduced pod infestation in mungbean and recorded higher yield. Anjabapu (2018) reported that Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC recorded highest marketable yield (149 q/ha) in brinjal. Similar findings were reported by Rambhau (2018) that minimum seed damage and maximum seed cotton yield (13.12 q/ha) was recorded from Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC treated plots. According to Hossain (2015), Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC 0.5 ml/l of water significantly reduced the pod borer infestation in mungbean and recorded high yield of 2347 kg/ha which supports the present study.

In the present study, the second highest yield was recorded from plots treated with Chlorantraniliprole 18.5 SC (439.99 and 584.13 g per plant during rabi and summer season respectively). It was followed by Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC with yield of 415.59 and 520.00 g per plant during rabi and summer season respectively. During summer season Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC was on par with Novaluron 10 EC with yield of 512.97 g per plant. The above result is in line with the findings of Shrivastava (2016) that Chorantraniliprole @ 30 g a.i./ha recorded highest yield in okra. Sen *et al.* (2017) reported that Ampligo 150 ZC @ 28-35 g a.i./ha treated plots recorded maximum marketable yield in brinjal which is in line with the present study. Bajya *et al.* (2015) reported that during both seasons Ampligo

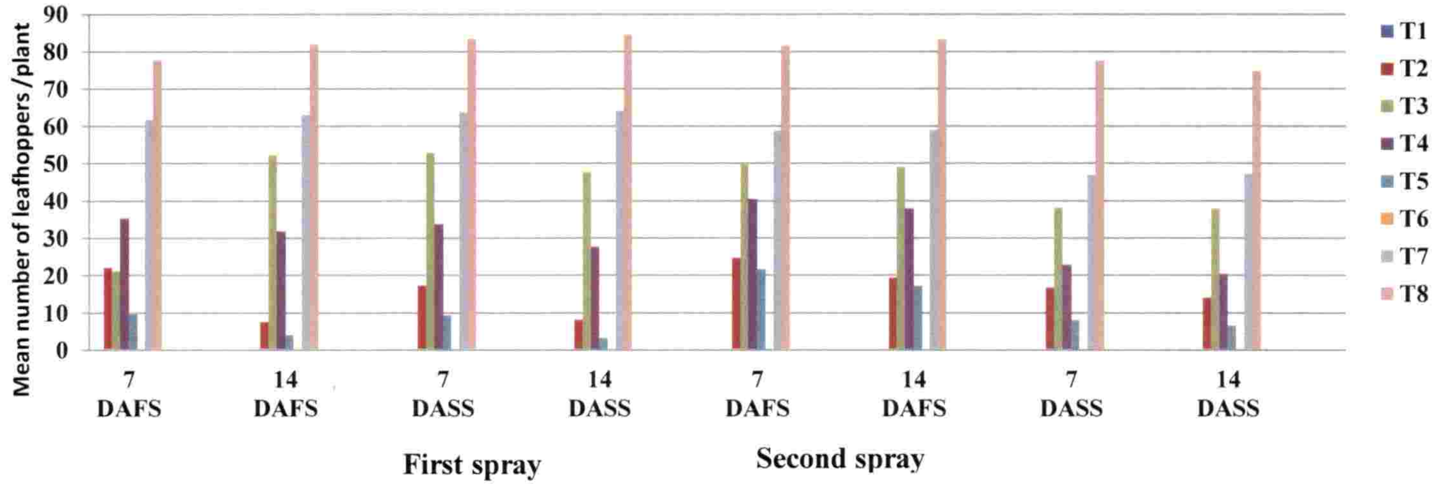
150 ZC recorded highest yield of 15.17 and 17.59 q/ha respectively also substantiate the present study.

## 5.4 ECONOMICS OF PRODUCTION OF OKRA DURING RABI (SEPTEMBER TO DECEMBER 2018) AND SUMMER SEASON (JANUARY TO APRIL 2019)

Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC treated plots recorded high net returns during both rabi (Rs. 192330.54/ha) and summer season (Rs. 28788592/ha). It was followed by Chlorantraniliprole 18.5 SC (16408705 and 56758322 Rs./ha during rabi and summer season respectively). Similar findings were reported by Anjabapu (2018) that in brinjal Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC recorded the highest net returns of Rs. 1,16,360/ha. Shahiduzzaman *et al.* (2017) reported that the highest net income of 27225 Tk/ha was recorded from plots treated with Voliam Flexi 300 SC and also high benefit-cost ratio of 6.28 and 4.27 were obtained from Volium flexi 300 SC treated plots. These findings are supportive of present study.

In the present study the highest benefit-cost ratio was obtained from Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC treated plots and it was 2.42 and 3.12 during rabi and summer season respectively. The report of Rambhau (2018) showed that Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC recorded highest benefit-cost ratio of 3.72, which supports the present study. The findings of Shahiduzzaman (2017) that the highest benefit-cost ratio of 3.39 was obtained from Volium flexi 300 SC treated plots in chickpea is in line with the above result. Hossain (2015) reported that Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC treated plots recorded high net returns of 33060 Tk/ha and benefit-cost ratio of 5.80.

**Fig 5. Mean number of leafhoppers per plant during summer season from January 2019 to April 2019**




DAFS – Days after first spray, DASS – Days after second spray

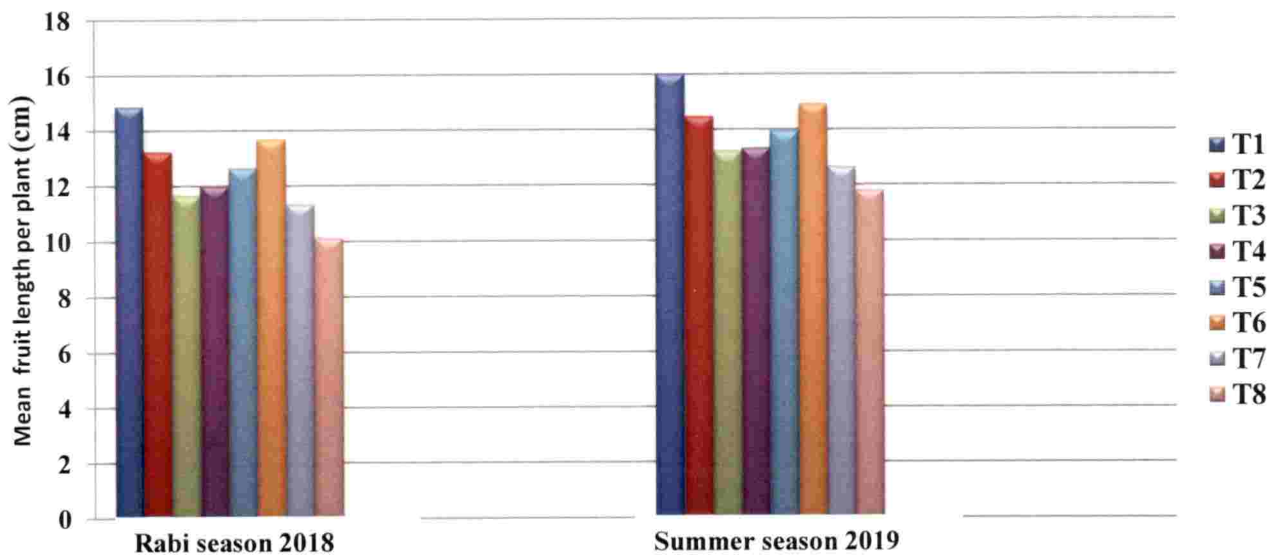
$T_1$: Chlorantraniliprole 8.8%+thiamethoxam 17.5% SC (Voliam flexi®) @ 0.7ml/l; $T_2$: Lambda cyhalothrin 4.6%+chlorantraniliprole 9.3% ZC (Ampligo®) @ 0.4 ml/l; $T_3$: Thiamethoxam 12.6%+ lambda cyhalothrin 9.5% ZC (Alika®) @ 0.5 ml/l; $T_4$: Flubendiamide 19.92% w/w+ thiacloprid 19.92% w/w (Belt-expert®) @ 0.4ml/l; $T_5$: Novaluron 10 EC @ 2ml/l; $T_6$: Chlorantraniliprole 18.5 SC @ 0.3 ml/l (check); $T_7$: Thiamethoxam 25 WG @ 0.3g/l (check); $T_8$: Absolute control

It was followed by Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC (2.01 and 2.51 during rabi and summer season respectively) and Novaluron 10 EC (2.01 and 2.41 during rabi and summer season respectively). Similar results were reported by Uchware (2017) that Chlorantraniliprole 18.5 SC recorded benefit-cost ratio of 2.72 in okra. These findings are supportive of present study.

Reddy *et al.* (2018) evaluated the persistence and dissipation of combination insecticides in cowpea, concluded that in the combination of Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC, single insecticides were dissipated to Below Quantification Level (BQL) on $10^{th}$ day. As a single insecticide Chlorantraniliprole dissipated at $7^{th}$ and Thiamethoxam at $5^{th}$ day. They also conducted the risk assessment revealed that Theortical Maximum Residual Concentration (TMRC) of the mixtures on cowpea pods were below Maximum Permissible Intake (MPI) at 2hrs after spraying. Hence the recommended dose of the insecticide mixture was safe to the environment and also safe to the consumers.

Compared to other insecticides, cost of new insecticides is high but it provides higher yield by reducing the infestation. Voliam flexi is a combination insecticide (Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC) which is effective against borers and sucking pest. So it eliminates the cost of other insecticides and also reduces the cost of spraying. This compensates the high cost of Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC. This is also supported by findings of Sangamithra *et al.* (2018) that the combination insecticides with different modes of action and target group is effective against pest infestation and also reduces the number of insecticide spraying and they fit very well in the IPM strategies. Similar opinion was raised by Blackshaw (1995) that combination of two insecticides reduces the labour charge by reducing the number of applications.

Fig 6. Mean fruit length per plant taken during rabi season (September to December 2018) and summer season (January to April 2019)




$T_1$: Chlorantraniliprole 8.8%+thiamethoxam 17.5% SC (Voliam flexi®) @ 0.7ml/l; $T_2$: Lambda cyhalothrin 4.6%+chlorantraniliprole 9.3% ZC (Ampligo®) @ 0.4 ml/l; $T_3$: Thiamethoxam 12.6%+ lambda cyhalothrin 9.5% ZC (Alika®) @ 0.5 ml/l; $T_4$: Flubendiamide 19.92% w/w+ thiacloprid 19.92% w/w (Belt-expert®) @ 0.4ml/l; $T_5$: Novaluron 10 EC @ 2ml/l; $T_6$: Chlorantraniliprole 18.5 SC @ 0.3 ml/l (check); $T_7$: Thiamethoxam 25 WG @ 0.3g/l (check); $T_8$: Absolute control.

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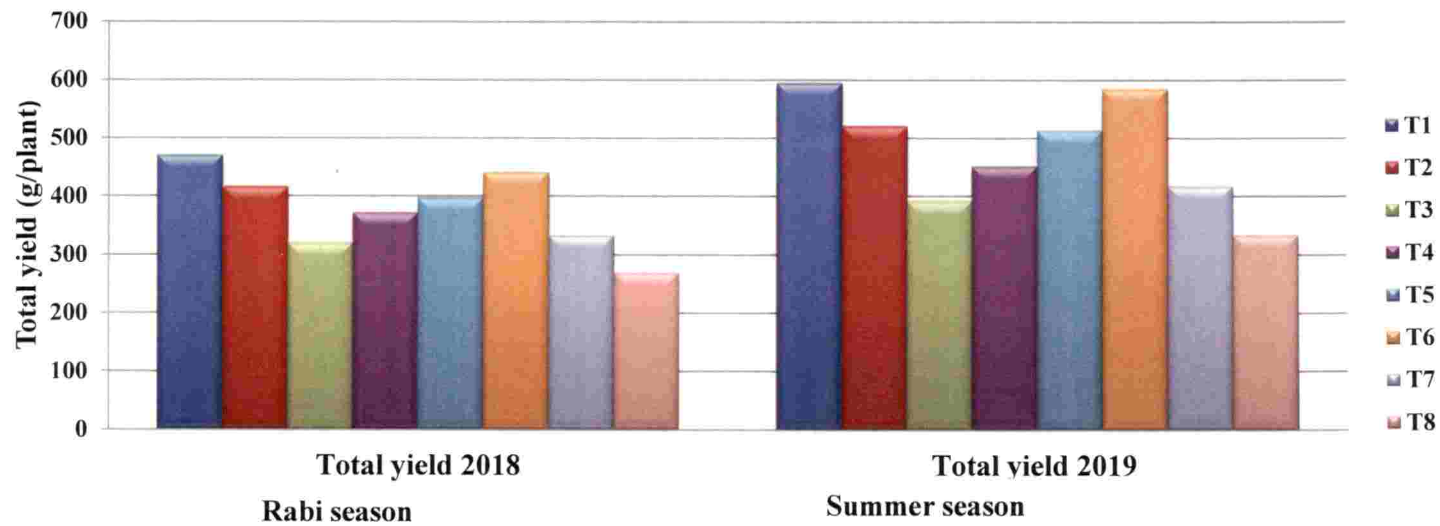
**Fig 7. Effect of treatments on okra yield during rabi (September to December 2018) and summer season (January to April 2019)**




$T_1$: Chlorantraniliprole 8.8%+thiamethoxam 17.5% SC (Voliam flexi®) @ 0.7ml/l; $T_2$: Lambda cyhalothrin 4.6%+chlorantraniliprole 9.3% ZC (Ampligo®) @ 0.4 ml/l; $T_3$: Thiamethoxam 12.6%+ lambda cyhalothrin 9.5% ZC (Alika®) @ 0.5 ml/l; $T_4$: Flubendiamide 19.92% w/w+ thiacloprid 19.92% w/w (Belt-expert®) @ 0.4ml/l; $T_5$: Novaluron 10 EC @ 2ml/l; $T_6$: Chlorantraniliprole 18.5 SC @ 0.3 ml/l (check); $T_7$: Thiamethoxam 25 WG @ 0.3g/l (check); $T_8$: Absolute control

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# *Summary*

## 6. SUMMARY

Field study was conducted on 'Evaluation of new insecticides against major pests of okra, *Abelmoschus esculent tus* L.' at College of Agriculture, Padannakkad and RARS Pilicode sub centre, Karuvachery in two seasons during rabi season from September 2018 to December 2018 and summer season from January 2019 to April 2019. The objective of study was 'to study the efficacy of different new insecticides against major pests of okra, viz., shoot and fruit borer, gram pod borer, leaf roller and leafhopper'.

The field experiment consists of eight treatments and three replications and the crop selected was okra, variety 'Varsha Uphar'. Fertilizer application and other cultural practices were followed as per recommendations of KAU, Package of Practices Recommendations: Crops 2016 (KAU, POP) except for plant protection measures. The different treatments were; $T_1$: Chlorantraniliprole 8.8 per cent + thiamethoxam 17.5 per cent SC (Voliam flexi®) @ 0.7ml/l; $T_2$: Lambda cyhalothrin 4.6 per cent + chlorantraniliprole 9.3 per cent ZC (Ampligo®) @ 0.4 ml/l; $T_3$: Thiamethoxam 12.6 per cent + lambda cyhalothrin 9.5 per cent ZC (Alika®) @ 0.5 ml/l; $T_4$: Flubendiamide 19.92 per cent w/w + thiacloprid 19.92 per cent w/w (Belt-expert®) @ 0.4ml/l; $T_5$: Novaluron 10 EC @ 2ml/l; $T_6$: Chlorantraniliprole 18.5 SC @ 0.3 ml/l (check); $T_7$: Thiamethoxam 25 WG @ 0.3g/l (check); $T_8$: Absolute control. Treatments were applied one at vegetative and one at reproductive stage after the incidence of pest. The observations like damage symptoms were recorded at seven and fourteen days after treatment and population of jassids were recorded at one, three, five, seven and fourteen days after treatment. Biometric observations and yield parameters were recorded during each harvest.

The results obtained from the present study are:

- Efficacy of new insecticides along with two standard check was tested against okra shoot and fruit borer at vegetative and reproductive stage of the crop revealed that Voliam flexi (Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC) @ 0.7 ml/l of water was superior over all the treatments in reducing the shoot and fruit infestation during rabi and summer season.
- Novaluron 10 EC @ 2 ml/l showed significant reduction in shoot and fruit infestation during rabi season after Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC.
- The population of gram pod borer, *Helicoverpa armigera* was negligible during both seasons.
- The damage caused by leaf roller was significantly reduced by Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC @ 0.7 ml/l of water. There was no incidence of leaf roller after first spray during both rabi and summer season.
- After Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC, Novaluron 10 EC and Lamda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC (Ampligo) were found to be effective against leaf roller during rabi and summer season.
- Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC @ 0.7 ml/l of water was very effective against the population of leafhopper. The population of adults and nymphs of leafhopper was drastically reduced by Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC and three days after spray no hoppers were found.
- Alika (Thiamethoxam 12.6 per cent + Lamda cyhalothrin 9.5 per cent ZC) @ 0.5ml/l of water significantly reduced the population of leaf hopper after Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC.

No hoppers were found after five days after treatment and it increased after fourteen days.

- Length of the fruit was inversely proportional to the percentage of damage caused by *Earias vitella.* Maximum fruit length was recorded from Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC treated plots during both rabi and summer season. This indicates higher efficacy of Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC against *E. vitella*.
- The highest total yield was recorded from Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC treated plots during rabi and summer season with yield of 469.86 and 594.31 g/plant respectively.
- The highest marketable yield was also recorded from Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC treated plots during rabi and summer season with 442.87 and 571.87 g/plant respectively.
- Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC also showed high benefit-cost ratio of 2.42 and 3.12 during rabi and summer season respectively.

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# *Abstract*

# EVALUATION OF NEW INSECTICIDES AGAINST MAJOR PESTS OF OKRA, *Abelmoschus esculentus* L.

**by**

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**ABSTRACT**

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## ABSTRACT

An experiment was conducted on 'Evaluation of new insecticides against major pests of okra, *Abelmoschus esculentus* L.' at College of Agriculture, Padannakkad and RARS Pilicode sub centre, Karuvachery in two seasons *viz.*, rabi season (September to December 2018) and summer season (January to April 2019).The objective of the study was 'to study the efficacy of different new insecticides against major pests of okra, *viz.*, shoot and fruit borer, gram pod borer, leaf roller and leafhopper'. The variety selected for the study was Varsha Uphar released by Haryana Agricultural University, Hisar.

The experiment was laid out in Randomized Block Design with 8 treatments and 3 replications. The different treatments were; $T_1$: Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC (Voliam flexi®) @ 0.7ml/l; $T_2$: Lambda cyhalothrin 4.6 per cent + Chlorantraniliprole 9.3 per cent ZC (Ampligo®) @ 0.4 ml/l; $T_3$: Thiamethoxam 12.6 per cent + Lambda cyhalothrin 9.5 per cent ZC (Alika®) @ 0.5 ml/l; $T_4$: Flubendiamide 19.92 per cent w/w + Thiacloprid 19.92 per cent w/w (Belt-expert®) @ 0.4ml/l; $T_5$: Novaluron 10 EC @ 2ml/l; $T_6$: Chlorantraniliprole 18.5 SC @ 0.3 ml/l (check); $T_7$: Thiamethoxam 25 WG @ 0.3g/l (check); $T_8$: Absolute control. Treatments were applied one at vegetative and one at reproductive stage after the incidence of pest. The observations like damage symptoms were recorded at seven and fourteen days after treatment and population of jassids were recorded at one, three, five, seven and fourteen days after treatment. Biometric observations and yield parameters were recorded during each harvest. The data recorded from field experiment was tabulated and statistical analysis was performed using analysis of variance (ANOVA).

Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC ($T_1$ -Voliam flexi) @ 0.7 ml/l of water significantly reduced the percentage of shoot and fruit damage during both rabi and summer season. No infestation was recorded at seven

and fourteen days after treatment. It was on par with the standard check Chlorantraniliprole 18.5 SC. The damage caused by leaf roller was significantly reduced by Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC @ 0.7 ml/l of water. There was no incidence of leaf roller after seven and fourteen days after first spray until the end of the crop period during both rabi and summer season. Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC @ 0.7 ml/l of water was very effective against the population of leafhopper. The population of adults and nymphs of leafhopper was drastically reduced by Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC and three days after spray no hoppers were found on plots treated with Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC. It showed non-significant difference with standard check Thiamethoxam 25 WG @ 0.3 g/l of water. Alika (Thiamethoxam 12.6 per cent + Lamda cyhalothrin 9.5 per cent ZC) @ 0.5ml/l of water significantly reduced the population of leaf hopper after Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC. Hopper population was negligible at fifth and seventh day after treatment while it was increased by fourteenth day.

Length of the fruit was inversely proportional to the percentage of damage caused by *Earias vitella.* Maximum fruit length of 14.85 cm and 15.99 cm was recorded from Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC treated plots during both rabi and summer season respectively. This indicates higher efficacy of Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC against *E. vitella*. The highest total yield was recorded from Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC treated plots during rabi and summer season with yield of 469.86 and 594.31 g/plant respectively. Chlorantraniliprole 8.8 per cent + Thiamethoxam 17.5 per cent SC also showed high benefit-cost ratio of 2.42 and 3.12during rabi and summer season respectively.