Research Article

# Bio Efficacy of Newer Insecticide Tolfenpyrad (15% EC) Against Shoot and Fruit Borer of Brinjal

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**Abstract**

The experiment on the bioefficacy of tolfenpyrad 15 EC @ 100, 125 and 150 g a.i. /ha along with Imidacloprid 17.8 % SL @ 22.5 g a.i. /ha, Chlorantraniliprole 18.5 SC @ 40 g a.i. /ha, Cypermethrin 25 EC @ 50 g a.i. /ha and Pyriproxyfen 5 EC + Fenpropathrin 15 EC @ 100 g a.i. /ha against fruit and shoot borer, *Leucinodes orbonalis* was conducted at R.C.A., Udaipur during during 2016 and 2017. Based on the two season results, the lowest shoot infestation was recorded from the application of tolfenpyrad (15% EC) @ 150 g a.i. /ha which resulted in 16.62, 15.00 and17.62, 17.62, per cent at seven days after first and second spray during *Rabi*, 2016 and *Kharif*, 2017, respectively and it was found at par with Chlorantraniliprole 18.5 SC @ 40 g a.i. /ha with 17.98, 15.80 and 18.27, 19.53, per cent at 7 after first and second spray during *Rabi*, 2016 and *Kharif*, 2017, respectively. The lowest fruit infestation was recorded from the application of tolfenpyrad (15% EC) @ 150 g a.i. /ha and it was found at par with Chlorantraniliprole 18.5 SC @ 40 g a.i. /ha. and also recorded higher marketable yield. No phytotoxicity effects on brinjal crop was observed even at higher doses of tolfenpyrad 15 EC @ 300 g a.i. /ha.

**Keywords:** Bioefficacy, Insecticides, *Leucinodes orbonalis*, Brinjal

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## Introduction

Brinjal (*Solanum melongena* Linnaeus) also known as eggplant is referred as "King of vegetables", originated from Indian sub-continent, with as the probable centre of origin [1, 2]. It is called brinjal in India, and Aubergine in Europe. The name eggplant derives from the shape of the fruit of some varieties, which are white and shape very similarly to chicken eggs. It is grown in almost all states of India with an area of 7.29 lakh hectares under cultivation and production of [3]. A substantial proportion of brinjal yield is lost due to biotic and abiotic stresses. Brinjal crop is infested with plethora of insect-pests right from seedling stage to senescence crop. It harbours more than 140 species of insect-pests [4, 5]. [6] and [7] however listed only 36 and 53 insects, respectively on this crop.

Among the insect pests the most destructive and serious pest of brinjal is brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee. It remained a major pest of brinjal since two decades. The main difficulty in evolving a suitable control measure against this pest is that it belongs to one of the most serious categories of insect pest internal feeder. Once the larva bores into petiole and midrib of leaves and tender shoots, it causes dead hearts. In later stages, it also bore into flower bud and fruits. The brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee (Pyralidae: Lepidoptera) is the most important insect pest of brinjal and the apparent yield loss varying from 20-90 per cent in various parts of the country [8], 85–90 per cent have been reported [9-11]. It is estimated that the economic injury level equals to 6 per cent infestation of shoot and fruit in India [12]. The insecticides have been used extensively for the control of these insect-pests for want of natural enemy complex. At present, alternate applications of newer insecticides are made for the control of *L. Orbonalis*. The present investigation was, therefore, planned to evaluate some alternate insecticides against shoot and fruit borer on brinjal under field conditions.

## Materials and Methods

The experimental site was located at the Instructional Farm, Rajasthan College of Agriculture, Udaipur, situated at 75.40 E Latitude and 23.40 N Longitude at an elevation of 582.17 MSL in the sub-humid southern region of Rajasthan, India. The zone has a typical sub-tropical climatic condition characterized by moderate winter and hot summer associated with high humidity especially during months of August and September. The average rainfall of this tract ranges between 450-650mm, contributed by South-West monsoon from July to September with occasional rains during the winter season. During summers, the atmospheric temperature may go as high as 45.5 0C, while in winters, it may fall as low as 3.5 0C occasionally.

The experiment on the bioefficacy of tolfenpyrad (15%EC) against fruit & shoot borer was conducted in Randomized Block Design with three replications at R.C.A., Udaipur during *Rabi*, 2016 and *Kharif*, 2017. Brinjal variety Kavch was transplanted in the plots each measuring 4.0 x 5.0 Sq. m. at row to row and plant to plant spacing of 75 cm x 45 cm, respectively. The Brinjal variety Kavch was transplanted on 6$^{th}$ September, 2016 and 26$^{th}$ April, 2017. There were nine treatments replicated three times. The test chemical, tolfenpyrad (15% EC) was tested at four doses *viz.* 100, 125, 150 and 300 g a.i. /ha. The highest dose of 300 g a.i. /ha was aimed for phytotoxicity and residue studies, wherein the soil and fruit samples were collected from this. Different doses of test chemical was tested in comparison with standard check treatment *viz.* Imidacloprid 17.8 % SL @ 22.5 g a.i. /ha, Chlorantraniliprole 18.5 SC @ 40 g a.i. /ha, Cypermethrin 25 EC @ 50 g a.i. /ha and Pyriproxyfen 5 EC + Fenpropathrin 15 EC @ 100 g a.i. /ha along with untreated check. Each treatment was applied two times initiating first spray as soon as the pest population crossed the ETL level and subsequent second spray was given at 17 days interval.

For the observation on the shoot and fruit borer incidence, three plants were selected in each plot wherein, per cent shoot damage was recorded with the following formulae:

$$\text{Per cent shoot infestation} = \frac{\text{Numbers of infested shoots}}{\text{Total numbers of shoots}} \times 100$$

Similarly, the observations were also recorded on per cent fruit damage at each picking with the following formulae:

$$\text{Per cent fruit infestation} = \frac{\text{Numbers of infested fruits}}{\text{Total numbers of fruits}} \times 100$$

***Phytotoxicity***

The phytotoxicity of tolfenpyrad (15% EC) at 150, 300 g a.i. /ha and untreated check was assessed at by visual observation, the observation were scored on 1, 3, 7, 10 and 15 days after last spray by recording the leaf chlorosis, leaf tip burning, leaf necrosis, leaf epinasty, leaf hyponasty, vein clearing and wilting and were graded on 0-10 point as per the phytotoxicity scale given below:

| Score | Percent crop affected |
|---|---|
| 0 | No adverse effect |
| 1 | 1-10 |
| 2 | 11-20 |
| 3 | 21-30 |
| 4 | 31-40 |
| 5 | 41-50 |
| 6 | 51-60 |
| 7 | 61-70 |
| 8 | 71-80 |
| 9 | 81-90 |
| 10 | 91-100 |

***Marketable Yield***

The periodic picking of fruits was done at regular intervals. The weight of healthy fruits of all pickings was pooled together and yield per hectare was calculated for each treatment separately.

## Results and Discussion

***Shoot damage***

The data recorded present investigation during pre and post spray period revealed that per cent shoot infestation before first and second spray ranged from 28.11 to 32.01 and 27.19 to 40.91; 29.78 to 31.99 and 28.54 to 38.98 per cent and there was no significant difference in the per cent shoot infestation the treatments during *Rabi*, 2016 and *Kharif*, 2017, respectively. The data presented in **Tables 1-2** reveals that during *Rabi*, 2016 and *Kharif*, 2017 all the treatments were found significantly superior to untreated control. The lowest shoot infestation was recorded from the

application of tolfenpyrad (15% EC) @ 150 g a.i. /ha which resulted in 17.32 & 19.66; 16.50 & 19.38; 21.00 & 26.21; 18.27 & 20.66 per cent at 10 and 15 days after first and second spray during *Rabi*, 2016 and *Kharif*, 2017, respectively and it was found at par with Chlorantraniliprole 18.5 SC @ 40 g a.i. /ha with 19.00 & 20.65; 17.84 & 20.20; 21.50 & 27.79; 20.00 & 21.62 per cent at 10 and 15 days after first and second spray during *Rabi*, 2016 and *Kharif*, 2017, respectively, these two treatments were superior to tolfenpyrad (15% EC) @ 125 g a.i. /ha which resulted in 20.66 & 22.32; 20.00 & 22.31;, 23.54 & 28.00; 21.62 & 23.18 followed by Pyriproxyfen 5 EC + Fenpropathrin 15 EC @ 100 g a.i. /ha with 20.99 & 23.32; 20.30 & 22.63;, 29.68 & 33.50; 21.24 & 23.94 per cent shoot infestation at 10 and 15 days after first and second spray during *Rabi*, 2016 and *Kharif*, 2017, respectively. But differed significantly with Imidacloprid 17.8% SL @ 22.5 g a.i. /ha which recorded as the least effective treatment with highest per cent shoot infestation.

**Table 1** Bioefficacy of tolfenpyrad (15% EC) against shoot infestation by shoot and fruit borer in brinjal crop during *Rabi*, 2016

| S. No | Treatment | Dos--age (g.a.i/ ha) | Per cent shoot infestation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | I Spray | | | | | | II Spray | | | | | |
| | | | Pre Count | 3 DAS | 5 DAS | 7 DAS | 10 DAS | 15 DAS | Pre Count | 3 DAS | 5 DAS | 7 DAS | 10 DAS | 15 DAS |
| $T_1$ | Tolfenpyrad (15% EC) | 100 | 34.46 (32.01)* | 31.95 (28.00) | 31.09 (26.66) | 26.37 (19.73) | 27.50 (21.32) | 29.33 (24.00) | 36.51 (35.50) | 29.73 (24.60) | 27.27 (21.00) | 25.84 (19.00) | 27.27 (21.00) | 29.44 (24.15) |
| $T_2$ | Tolfenpyrad (15% EC) | 125 | 34.11 (31.45) | 31.71 (27.63) | 30.21 (25.31) | 26.08 (19.32) | 27.03 (20.66) | 28.19 (22.32) | 33.32 (30.18) | 29.33 (24.00) | 26.71 (20.20) | 25.47 (18.50) | 26.55 (20.00) | 28.19 (22.31) |
| $T_3$ | Tolfenpyrad (15% EC) | 150 | 32.14 (28.30) | 30.65 (26.00) | 29.10 (23.66) | 24.06 (16.62) | 24.60 (17.32) | 26.32 (19.66) | 31.43 (27.19) | 27.97 (22.00) | 25.10 (18.00) | 22.79 (15.00) | 23.97 (16.50) | 26.12 (19.38) |
| $T_4$ | Imidacloprid 17.8% SL | 22.5 | 33.62 (30.66) | 33.00 (29.67) | 32.16 (28.33) | 28.18 (22.30) | 29.08 (23.63) | 29.77 (24.65) | 33.33 (30.20) | 30.98 (26.50) | 28.32 (22.50) | 26.56 (20.00) | 29.29 (23.94) | 29.84 (24.76) |
| $T_5$ | Chlorantranilip role 18.5 SC | 40 | 32.02 (28.11) | 30.86 (26.31) | 29.32 (23.99) | 25.09 (17.98) | 25.84 (19.00) | 27.03 (20.65) | 32.57 (28.99) | 28.63 (23.00) | 26.56 (20.00) | 23.40 (15.80) | 25.45 (17.84) | 26.71 (20.20) |
| $T_6$ | Cypermethrin 25 EC | 50 | 33.21 (30.00) | 32.79 (29.33) | 31.94 (27.99) | 26.57 (20.00) | 27.97 (22.00) | 30.22 (25.33) | 33.51 (30.48) | 29.47 (24.20) | 26.91 (20.50) | 25.54 (18.60) | 26.91 (20.50) | 32.07 (28.20) |
| $T_7$ | Pyriproxyfen 5EC+ Fenpropathrin 15 EC | 100 | 33.10 (29.83) | 31.82 (27.80) | 30.87 (26.33) | 26.32 (19.66) | 27.27 (20.99) | 28.88 (23.32) | 33.58 (30.59) | 29.33 (24.00) | 27.06 (20.70) | 25.55 (18.60) | 26.77 (20.30) | 28.41 (22.63) |
| $T_8$ | Untreated control | - | 32.14 (28.30) | 32.37 (28.67) | 32.58 (29.00) | 32.79 (29.33) | 33.00 (29.66) | 32.37 (28.67) | 39.76 (40.91) | 40.11 (41.50) | 40.39 (42.00) | 40.69 (42.50) | 41.26 (43.50) | 38.05 (37.99) |
| | S. Em ± | | 1.38 | 0.69 | 1.14 | 0.67 | 0.61 | 0.54 | 1.58 | 0.56 | 1.08 | 0.33 | 0.53 | 1.82 |
| | C.D. at 5% | | N.S | 2.08 | 2.83 | 2.04 | 1.84 | 1.64 | N.S | 1.78 | 223 | 0.99 | 1.62 | 5.51 |

*Figures in parenthesis are retransformed percent value. DAS: Days after spray; N.S: Non Significant

***Fruit damage***

The data recorded present investigation during pre and post spray period revealed that per cent fruit infestation before first and second spray ranged from 29.00 to 37.00 and 25.33 to 39.33; 30.60 to 33.65 and 24.91 to 34.32 per cent and there was no significant difference in the per cent shoot damage the treatments during *Rabi*, 2016 and *Kharif*, 2017, respectively. The data presented in **Tables 3-4** reveals that during *Rabi*, 2016 and *Kharif*, 2017; all the treatments were found significantly superior to untreated control. The lowest fruit infestation was recorded from the application of tolfenpyrad (15% EC) @ 150 g a.i. /ha which resulted in 20.00 and 25.00; 11.20 and 12.85; 18.32 and 21.24; 17.64 and 20.26 per cent at 10 and 15 days after first and second spray during *Rabi*, 2016 and *Kharif*, 2017, respectively and it was found at par with Chlorantraniliprole 18.5 SC @ 40 g a.i. /ha with 22.10 and 26.00 ; 16.00 and 17.50; 22.29 and 23.94; 19.66 and 22.21 per cent at 10 and 15 days after first and second spray during *Rabi*, 2016 and *Kharif*, 2017, respectively, these two treatments were superior to tolfenpyrad (15% EC) @ 125 g a.i. /ha which resulted in 23.00 and 28.00; 17.00 and 19.00; 23.30 and 24.25; 21.30 and 24.24 per cent fruit infestation. Imidacloprid 17.8% SL @ 22.5 g a.i. /ha recor ded as the least effective treatment with highest per cent fruit infestation. The two years data indicated that spray of tolfenpyrad (15% EC) @ 150 g a.i/ha was found most effective in the management of brinjal fruit and shoot borer (*Leucinodes orbonalis*) in brinjal in terms of per cent shoot and fruit infestation. Various insecticides are evaluated against brinjal shoot and fruit borer by different researchers during the last 10 years and reported variable result.

**Table 2** Bioefficacy of tolfenpyrad (15% EC) against shoot infestation by shoot and fruit borer in brinjal crop during *Kharif*, 2017

| S. No | Treatment | Dosage (g.a.i/ha) | Per cent shoot infestation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | I Spray | | | | | | II Spray | | | | | |
| | | | Pre Count | 3 DAS | 5 DAS | 7 DAS | 10 DAS | 15 DAS | Pre Count | 3 DAS | 5 DAS | 7 DAS | 10 DAS | 15 DAS |
| $T_1$ | Tolfenpyrad (15% EC) | 100 | 33.71 (30.80)* | 30.58 (25.88) | 28.67 (23.02) | 27.03 (20.66) | 32.42 (28.75) | 32.85 (29.45) | 34.46 (32.01) | 31.69 (27.60) | 29.15 (23.72) | 27.50 (21.33) | 29.10 (23.66) | 30.85 (26.29) |
| $T_2$ | Tolfenpyrad (15% EC) | 125 | 33.20 (29.99) | 30.48 (25.74) | 29.12 (23.69) | 26.08 (19.32) | 29.02 (23.54) | 31.95 (28.00) | 34.11 (31.45) | 30.63 (25.95) | 28.41 (22.64) | 27.03 (20.66) | 27.71 (21.62) | 28.78 (23.18) |
| $T_3$ | Tolfenpyrad (15% EC) | 150 | 34.45 (31.99) | 29.50 (24.25) | 27.27 (21.00) | 24.82 (17.62) | 27.27 (21.00) | 30.79 (26.21) | 32.29 (28.54) | 29.93 (24.89) | 27.00 (20.61) | 24.82 (17.62) | 25.31 (18.27) | 27.03 (20.66) |
| $T_4$ | Imidacloprid 17.8% SL | 22.5 | 33.21 (30.00) | 32.11 (28.26) | 31.23 (26.88) | 28.36 (22.56) | 32.30 (28.55) | 37.14 (36.45) | 37.55 (37.15) | 33.00 (29.67) | 31.00 (26.52) | 28.78 (23.18) | 29.50 (24.25) | 31.63 (27.50) |
| $T_5$ | Chlorantraniliprole 18.5 SC | 40 | 33.83 (30.99) | 30.37 (25.56) | 28.01 (22.05) | 25.31 (18.27) | 27.62 (21.50) | 31.81 (27.79) | 33.00 (29.67) | 29.70 (24.55) | 27.49 (21.30) | 26.23 (19.53) | 26.57 (20.00) | 27.71 (21.62) |
| $T_6$ | Cypermethrin 25 EC | 50 | 33.07 (29.78) | 31.18 (26.82) | 30.09 (25.15) | 27.03 (20.66) | 33.82 (31.00) | 36.19 (34.86) | 36.39 (35.20) | 31.61 (27.48) | 29.40 (24.09) | 27.49 (21.30) | 28.40 (22.62) | 31.83 (27.82) |
| $T_7$ | Pyriproxyfen 5EC+ Fen propathrin 15 EC | 100 | 34.44 (31.99) | 30.60 (25.92) | 29.12 (23.68) | 26.08 (19.32) | 33.01 (29.68) | 35.36 (33.50) | 35.90 (34.39) | 31.01 (26.54) | 28.18 (22.30) | 26.57 (20.00) | 27.44 (21.24) | 29.29 (23.94) |
| $T_8$ | Untreated control | - | 34.32 (31.78) | 34.03 (31.32) | 39.57 (40.59) | 37.46 (37.00) | 40.24 (41.73) | 40.70 (42.54) | 38.63 (38.98) | 39.03 (39.66) | 37.86 (37.66) | 37.46 (37.00) | 38.05 (37.99) | 38.25 (38.33) |
| | S. Em ± | | 0.75 | 0.48 | 0.39 | 1.00 | 0.48 | 0.68 | 2.59 | 2.33 | 1.75 | 1.26 | 1.22 | 1.67 |
| | C.D. at 5% | | N.S | 1.45 | 1.17 | 3.04 | 1.45 | 2.06 | N.S | 7.05 | 5.30 | 3.82 | 3.70 | 5.05 |

*Figures in parenthesis are retransformed percent value. DAS: Days after spray; N.S: Non Significant

**Table 3** Bioefficacy of tolfenpyrad (15% EC) against fruit infestation by shoot and fruit borer in brinjal crop during *Rabi*, 2016

| S. No. | Treatment | Dosage (g.a.i/ha) | Per cent fruit infestation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | I Spray | | | | | | II Spray | | | | | |
| | | | Pre Count | 3 DAS | 5 DAS | 7 DAS | 10 DAS | 15 DAS | Pre Count | 3 DAS | 5 DAS | 7 DAS | 10 DAS | 15 DAS |
| $T_1$ | Tolfenpyrad (15% EC) | 100 | 34.03 (31.33)* | 31.61 (27.50) | 29.33 (24.00) | 28.32 (22.50) | 30.00 (25.00) | 33.51 (30.50) | 34.04 (31.33) | 29.33 (24.00) | 27.62 (21.50) | 25.25 (18.20) | 25.84 (19.00) | 26.92 (20.50) |
| $T_2$ | Tolfenpyrad (15% EC) | 125 | 33.83 (31.00) | 31.31 (27.00) | 28.99 (23.50) | 26.92 (20.50) | 28.66 (23.00) | 31.94 (28.00) | 32.15 (28.33) | 27.97 (22.00) | 25.33 (18.30) | 24.27 (16.90) | 24.35 (17.00) | 25.84 (19.00) |
| $T_3$ | Tolfenpyrad (15% EC) | 150 | 32.58 (29.00) | 29.33 (24.00) | 27.61 (21.50) | 25.10 (18.00) | 26.55 (20.00) | 30.00 (25.00) | 30.21 (25.33) | 22.79 (15.00) | 20.27 (12.00) | 18.43 (10.00) | 19.55 (11.20) | 21.68 (12.85) |
| $T_4$ | Imidacloprid 17.8 % SL | 22.5 | 36.47 (35.33) | 34.75 (32.50) | 33.21 (30.00) | 32.27 (28.50) | 32.89 (29.50) | 35.06 (33.00) | 35.55 (34.00) | 29.33 (24.00) | 27.41 (21.20) | 25.40 (18.40) | 25.99 (19.20) | 27.13 (20.80) |
| $T_5$ | Chlorantraniliprole 18.5 SC | 40 | 37.44 (30.00) | 30.00 (25.00) | 28.32 (22.50) | 25.84 (19.00) | 27.97 (22.10) | 30.66 (26.00) | 34.23 (31.67) | 24.43 (17.11) | 22.38 (14.50) | 21.12 (13.00) | 23.57 (16.00) | 24.72 (17.50) |
| $T_6$ | Cypermethrin 25 EC | 50 | 37.46 (37.00) | 34.76 (32.50) | 31.30 (27.00) | 30.32 (25.50) | 30.65 (26.00) | 33.52 (30.50) | 33.83 (31.00) | 29.00 (23.50) | 27.26 (21.00) | 25.10 (18.00) | 25.84 (19.00) | 26.13 (20.05) |
| $T_7$ | Pyriproxyfen 5EC+ Fenpropathrin 15 EC | 100 | 36.85 (36.00) | 33.52 (30.50) | 30.65 (26.00) | 28.65 (23.00) | 30.00 (25.00) | 32.88 (29.50) | 33.37 (30.33) | 28.66 (23.00) | 27.10 (20.76) | 24.96 (17.81) | 25.98 (19.20) | 27.60 (21.55) |
| $T_8$ | Untreated control | - | 36.79 (36.00) | 37.16 (36.50) | 37.46 (37.00) | 37.75 (37.50) | 38.05 (38.00) | 38.34 (38.50) | 38.83 (39.33) | 39.39 (40.27) | 39.86 (41.08) | 40.27 (41.78) | 40.39 (42.00) | 40.68 (42.50) |
| | S. Em ± | | 1.33 | 0.58 | 0.55 | 0.57 | 0.61 | 0.61 | 1.57 | 0.28 | 0.73 | 0.31 | 0.46 | 1.53 |
| | C.D. at 5% | | N.S | 1.76 | 1.67 | 1.73 | 1.84 | 1.85 | N.S | 0.85 | 2.30 | 0.93 | 1.39 | 2.60 |

*Figures in parenthesis are retransformed percent value. DAS: Days after spray; N.S: Non Significant

The present observations on the effectiveness of cypermethrin and imidacloprid are in conformity with those of [13] in brinjal against *L. Orbonalis.* [14] reported that Chlorantraniliprole was found effective in reducing shoot infestation by *L. Orbonalis*. The effectiveness of Fenpropathrin is also similar to those of [13, 15-18].

**Table 4** Bioefficacy of tolfenpyrad (15% EC) against fruit infestation by shoot and fruit borer in brinjal crop during *Kharif*, 2017

| S. No. | Treatment | Dosage (g.a.i/ha) | Per cent fruit infestation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | I Spray | | | | | | II Spray | | | | | |
| | | | Pre Count | 3 DAS | 5 DAS | 7 DAS | 10 DAS | 15 DAS | Pre Count | 3 DAS | 5 DAS | 7 DAS | 10 DAS | 15 DAS |
| $T_1$ | Tolfenpyrad (15% EC) | 100 | 34.23 (31.64)* | 33.10 (29.45) | 31.23 (26.88) | 29.02 (23.53) | 29.71 (24.57) | 30.81 (26.24) | 31.72 (27.64) | 30.65 (25.98) | 29.32 (23.98) | 27.93 (21.94) | 29.07 (23.61) | 31.29 (26.97) |
| $T_2$ | Tolfenpyrad (15% EC) | 125 | 33.58 (30.60) | 32.33 (28.60) | 29.72 (24.57) | 27.71 (21.62) | 28.85 (23.30) | 29.50 (24.25) | 31.19 (26.82) | 29.95 (24.92) | 28.43 (22.66) | 26.08 (19.32) | 27.49 (21.30) | 29.49 (24.24) |
| $T_3$ | Tolfenpyrad (15% EC) | 150 | 34.26 (31.70) | 30.30 (25.45) | 28.68 (23.02) | 24.82 (17.62) | 25.34 (18.32) | 27.44 (21.24) | 29.94 (24.91) | 29.10 (23.65) | 27.03 (20.66) | 24.31 (16.95) | 24.83 (17.64) | 26.75 (20.26) |
| $T_4$ | Imidacloprid 17.8% SL | 22.5 | 34.92 (32.77) | 33.15 (29.90) | 32.37 (28.09) | 31.30 (27.00) | 32.29 (28.54) | 31.49 (27.29) | 32.78 (29.32) | 32.35 (28.63) | 31.07 (26.63) | 29.25 (23.87) | 30.39 (25.60) | 32.55 (28.95) |
| $T_5$ | Chlorantraniliprole 18.5 SC | 40 | 34.58 (32.22) | 30.79 (26.21) | 29.07 (23.61) | 27.03 (20.94) | 28.15 (22.29) | 29.29 (23.94) | 30.66 (26.00) | 29.11 (23.67) | 27.72 (21.64) | 25.31 (18.27) | 26.32 (19.66) | 28.12 (22.21) |
| $T_6$ | Cypermethrin 25 EC | 50 | 35.46 (33.65) | 33.21 (30.00) | 31.36 (27.65) | 26.32 (19.66) | 26.57 (20.00) | 30.17 (25.26) | 31.39 (27.14) | 30.57 (25.87) | 29.25 (23.87) | 27.73 (21.65) | 28.88 (23.32) | 31.07 (26.63) |
| $T_7$ | Pyriproxyfen 5EC+ Fenpropathrin 15 EC | 100 | 34.79 (32.56) | 33.42 (30.33) | 32.14 (28.30) | 26.57 (20.00) | 28.36 (22.56) | 29.72 (24.58) | 31.83 (27.82) | 30.81 (26.24) | 29.02 (23.53) | 26.80 (20.33) | 27.95 (21.96) | 30.16 (25.25) |
| $T_8$ | Untreated control | - | 34.90 (32.73) | 35.63 (33.94) | 36.24 (34.94) | 36.65 (35.63) | 36.04 (34.62) | 35.63 (33.94) | 35.86 (34.32) | 36.27 (35.00) | 36.67 (35.67) | 36.87 (36.00) | 36.47 (35.33) | 36.87 (36.00) |
| | S. Em ± | | 1.37 | 1.96 | 1.83 | 1.63 | 1.51 | 1.71 | 1.89 | 1.36 | 1.27 | 1.17 | 1.01 | 1.50 |
| | C.D. at 5% | | N.S | 5.94 | 5.54 | 4.95 | 4.59 | 5.19 | N.S | 4.12 | 3.85 | 3.56 | 3.06 | 4.55 |

*Figures in parenthesis are retransformed percent value. DAS: Days after spray; N.S: Non Significant

***Phytotoxicity***

The phytotoxicity of tolfenpyrad (15% EC) at 150, 300 g a.i. /ha was assessed at 1, 3, 7, 10 and 15 days after spray was recorded on ten randomly selected plants by visual observations. Result revealed that either of the treatments of tolfenpyrad (15% EC) *viz*. 150 and 300 g a.i. /ha did not show any type visible phytotoxicity symptoms in terms of leaf chlorosis, leaf tip burning, leaf necrosis, leaf epinasty, leaf hyponasty, vein clearing, wilting and rosetting on leaves at which indicates that tolfenpyrad (15%EC) even at its higher doses is not phototoxic.

***Marketable Yield***

The highest yield was recorded in highest dosage of tolfenpyrad (15% EC) @ 150 g a.i. /ha (188.00 &195.48 q/ha) which was on at par with its lower dosage tolfenpyrad 405 (15% EC) @ 125 g a.i. /ha (182.50 & 192.96 q/ha) and Chlorantraniliprole 18.5 SC @ 40 g a.i. /ha (181.50 & 186.34 q//ha.

## Conclusion

It is evident from the above results that tolfenpyrad @ 150g a.i./ha was found most effective against fruit & shoot borer. The highest yield was recorded in highest dosage of test chemical tolfenpyrad (15% EC) @ 150 g a.i. /ha and it was significantly at par with its lower dosage *i.e.* tolfenpyrad (15% EC) @ 125 g a.i. /ha. Further insecticidal treatments did not produce any significant impact on the population of natural enemies during the investigation. It is also clear that higher dose of tolfenpyrad @ 300g a.i. / ha did not produce any phytotoxicity to the treated crop.

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