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# Biorational management of brinjal shoot and fruit borer *Leucinodes orbonalis*

**AB Soulakhe, SD Bantewad and NE Jayewar**

**Abstract**

An field experiment was carried out on research farm of Department of Agricultural Entomology, College of Agriculture, Badnapur during *Kharif* 2019-20 in randomized block design with three replication and seven treatment comprising of Azadirachtin 1500 ppm, *Metarhizium anisopliae, Beauveria bassiana, Verticillium lecanii, Bt. Kurstaki, NSKE* 5% and untreated control to evaluate the bio-efficacy of these treatments against shoot and fruit borer *Leucinodes orbonalis*.

In all three sprays were applied at an interval of 15 days after each spray and data on fruit infestation on the basis of number and weight basis of the fruit at each picking was recorded. The result indicated that before spray population of the pest suggest nonsignificant distribution, however the treatments of Azadirachtin 1500 ppm, *Bt. Kurstaki* and NSKE 5% were found significantly effective for managment of shoot and fruit borer at 3,7 and 14 days after all three spray followed by *Beauveria bassiana, Metarhizium anisopliae* and *Verticillium lecanii.*

**Keywords:** Lentil, fusarium, fungicides, evaluation, neem

## Introduction

In India, Brinjal is widely cultivated in eight states, practically on all soils from light sand to heavy clay and in almost all eight vegetable growing zones including Maharashtra and Madhya Pradesh (Zone - VII). Although several varieties of brinjal are cultivated, the expected yield of the crop is not achieved so far because of the crop damage caused by the insect pests. Insect pests are most limiting factor for accelerant crop yield. The brinjal crop is attacked by about 140 species of insect pests from seedling stage up to harvesting of crop (Dwivedi *et al.*, 2014) [4]. Brinjal shoot and fruit borer, *Leucinodes orbonalis* (Lepidopetra: Pyralidae) is the major pest throughout Asia (Purohit and Khatri, 1973; Kuppuswamy and Balasubramanian, 1980; Alam *et al.*, 2003) [15, 9, 1]. Shoot and fruit borer is considered to be the most destructive pest of this vegetable crop. The infestation on brinjal can be as high as 75 to 92 per cent (Singh and Sindhu, 1988) [19]. Shrinivasan and Krishnakumar (1983) [18]; Mote (1981) [11] and Datar and Ashtaputre (1984) [3] reported that the 48 - 57 per cent losses in the yield of brinjal fruits due to infestation of *L. orbonalis* in Maharashtra state. Per cent losses in terms of brinjal fruits and fruit weight loss were also estimated by Gangwar and Sachan (1981) [6], Naresh *et al*. (1989) [12], Islam and Quiniones (1990) and Roy and Pande (1994) [16]. This insect can also attack other vegetables of Solanaceae family and results in severe losses.

Larvae bore inside the fruit of brinjal and reduce its yield up to 70 - 75 per cent (Mainali., *et al.*, 2015) [10]. This larva has unique nature of feeding on monophagous diet aided by homing and tunnelling behaviour which ultimately enables the adult insect to face the challenges of chemical pesticides as well making it difficult to manage the insect population in the standing crops. It causes reduction of the yield as well as reduced content of vitamin C up to 80 per cent. Sharma, (2002) [17] reported the losses caused due to this pest may vary from season to season. This is because moderate temperature and high humidity favour the population build-up of brinjal fruit and shoot borer and cause heavy losses during hot and humid climatic conditions (Bhushan *et al*., 2011) [2].

Considering the seriousness of wide spread use of chemicals in brinjal against pest management and subsequently considerable insecticide residues in the consumable products, inducing the resistance through organic means and use of biopesticides or botanical insecticides has become more viable. In this context the present investigation was carried out with prime objective to study effect of some bio-pesticides against *Leucinodes orbonalis* of brinjal crop under field conditions.

## Material and Methods

The present investigations were carried out on "Biorational management of brinjal shoot and fruit borer *Leucinodes orbonalis*" at experimental field of Department of Agricultural Entomology, College of Agriculture, Badnapur, during *Kharif* season of 2019-20. The material and methods to be adopted for the present investigations are presented as below

### To study the effect of bio-pesticides against major insect pests of brinjal

All the recommended agronomical practices were adopted for raising the healthy crop growth. Gap filling was carried out immediately after transplanting, so as to maintain uniform plant population in the plots. Evaluation of the different bio-pesticides for their bio-efficacy against shoot and fruit borer was studied by undertaking the spraying in morning or evening hours with high volume knapsack sprayer (spray fluid 400-500 litre/ ha) depending upon the crop growth stage. There are three sprayings was carried out, first at the appearance of the pests and followed by 15 days interval after first spray and second spray.

### Experimental details

Design of experiment : Randomized Block Design
Replications : Three
Treatments : Seven
Variety : Panchganga - Gaurav
Spacing : 90 cm x 60 cm
Gross plot size : 7.20 m x 4.80 m
Net plot size : 5.40 m x 3.60 m
Date of sowing : 21st July 2019
Season : *Kharif* 2019-20
RDF : 150:75:75 NPK (kg/ha)

### Treatments details

**Table 1:** Details of Treatment

| Tr. No | Treatments | Dose (ml or g/Lit.) | Trade Name | Name of Company |
|---|---|---|---|---|
| $T_1$ | Azadirachtin 1500 ppm | 5ml/ lit. | Econeem | Margo biocontrol Pvt. Ltd. Bangalore |
| $T_2$ | *Metarhizium anisopliae* | 4 g/lit | Bio-magic | M/s. Indore Biotech Ltd., Indore |
| $T_3$ | *Beauveria bassiana* | 4 g/lit | Biosoft | M/s. Agril and Biotech Ltd., Vadodara |
| $T_4$ | *Verticillium lecanii* | 4 g/lit | Verticel | M/s. Excel India Ltd., Mumbai |
| $T_5$ | *Bt. Kurstaki* | 1 g/lit. | Halt | M/s. Wockhard India Ltd., Mumbai |
| $T_6$ | NSKE | 5% | -- | Seed of local neem trees |
| $T_7$ | Untreated control | -- | | |

### Method of observations recording

From each plot five plants were selected randomly and labeled for recording observations of shoot and fruit borer. As soon as the infestation of pest on shoot was initiated, pre-treatment observations were recorded, 24 hours before application of treatments the observations on total number of shoots and number of infested shoots (first spray) and fruit infestation (second and third spray) of five observational plants from each treatment and replication was recorded at before spray and after 3rd, 7th and 14th days after imposing treatments in terms of percentage of infested plants, number of larvae per ten plants and percentage of damaged fruits (number and weight basis). Incidence of brinjal fruit and shoot borer in terms of percentage of damaged fruits on number and weight was recorded by counting and weighing healthy and damaged fruits at each picking separately.

The effect of different treatments on fruit yield was evaluated by determining the level of effects biopesticides and calculating the yield per hectare.

Data on shoot infestation was taken by counting infested and healthy shoots from each plot and expressed by using the following formula.

$$\text{Per cent shoot infestation} = \frac{\text{No of infested shoot}}{\text{Total No. of shoot}} \times 100$$

Data on fruit infestation was taken by counting damaged and healthy fruits from each plot. Percentage fruit infestation was calculated by using following formula.

$$\text{Per cent fruit infestation} = \frac{\text{No of damaged fruit}}{\text{Total No. of fruit}} \times 100$$

$$\text{Per cent damage (Number basis)} = \frac{\text{No of damaged fruit}}{\text{Total No. of fruit}} \times 100$$

$$\text{Per cent damage (Weight basis)} = \frac{\text{Wt. of infested fruit}}{\text{Total Wt. of fruit}} \times 100$$

Other relevant data *e.g.*, number of infested and healthy shoots, infested and healthy fruits, weight of fruit per plot, fruit infestation by number and weight, marketable and infested yield and total yield was taken. Benefit cost ratio (BCR) was also assessed by dividing the net monetary return (B) by the total additional cost due to treatments as worked out (C).

### Statistical analysis

The data obtained on sucking pests was subjected to $\sqrt{\mathbf{x} + 0.5}$ transformation before analysis. The percent fruit damage by borers was subjected to angular transformation. The data statistically analyzed by standard analysis of variance method suggested by Panse and Sukhatame, 1985 [14].

## Results and Discussion

### Effect of bio-pesticides against shoot borer infestation *Leucinodes orbonalis*

### Per cent of shoot borer pre-count one day before first spray

The data present in table 2; fig.1 revealed that pre-treatment population of *L. orbonalis* was found uniform in experimental area with of 14.80 to 15.93 per cent infestation suggesting that data is statistically non-significant. Thereafter, the data on per cent shoot infestation after application revealed significant results among the all treatments.

**Three days after first spraying**

All the biopesticides were found to be significantly superior over untreated control in minimizing the incidence of brinjal shoot borer at all the days of observations after the first application of biopesticides. The data on mean per cent infestation at 3rd day after exposure of biopesticides spray indicated that the treatment $T_1$- Azadirachtin 1500 ppm recorded lowest shoot infestation *i.e*.13.15 per cent which was superior over control and at par with rest of treatments *viz.*, $T_5$-*Bt.Krustaki (*13.63*%)* followed by T6- NSKE 5 per cent (13.63%), $T_3$- *Beauveria bassian* (14.17%), $T_2$- *Metarhizium anisopliae* (14.72%),$T_4$- *Verticillium lecanii* (15.10%). The maximum percent shoot infestation was recorded in control (19.40%) which was significantly inferior to all tested biopesticides treatments.

**Seven days after first spraying**

Subsequently 7th day after spraying a similar trend was observed with a reduction in the shoot infestation in all the treatments. The application of $T_1$-Azadirachtin 1500 ppm recorded lowest shoot infestation *i.e*.12.27 per cent which was superior among the treatments and found statistically at par with $T_5$-*Bt.Krustaki (*12.54%*)* followed by $T_6$- NSKE 5 per cent (13.20%), $T_3$- *Beauveria bassiana (13.67*%), $T_2$- *Metarrhizium anisopliae* (13.89%)and $T_4$-*Verticillium lecanii* (14.85%), respectively. And was significantly superior over untreated control (22.87% shoot infestation).

**Fourteen days after first spraying**

The data on per cent infestation at 14th day after first biopesticidal spray indicated that the treatment $T_1$-Azadirachtin 1500 ppm recorded lowest shoot infestation *i.e*. 11.27 per cent, and which was found similar with $T_5$- *Bt. Kurstaki* (11.43%) followed by $T_6$- NSKE 5 per cent (11.97%),$T_3$-*Beauveria bassiana* (12.72%), $T_2$-*Metarrhizium anisopliae* (12.87%) and $T_4$-*Verticillium lecanii* (13.86%) respectively. It was significantly superior over $T_7$- untreated control plot (20.57% shoot infestation).

**Mean population of shoot bore infestation**

Glance through the pooled results of 3rd, 7th and 14th day after firsts praying of biopesticides indicated that the significant results amongst the treatments. Wherein, $T_1$-Azadirachtin 1500 ppm recorded minimum shoot infestation *i.e*. 12.23 per cent which was superior and significantly at par with all treatments i.e.,$T_5$-*Bt.Krustaki (*12.40%) followed by $T_3$-*Beauveria bassiana* (13.18%), $T_6$- NSKE 5% (13.27%), $T_2$-*Metarrhizium anisopliae* (13.83%) and $T_4$- *Verticillium lecanii* (14.60%). It was significantly superior to reduced shoot infestation over $T_7$-untreated control plot (20.94% shoot infestation).

**Second spray against shoot borer infestation**

The data on an infestation of *L. orbonalis* on shoots after the second spray was presented in Table 3, Fig.2. After the second spray, all bio-pesticidal treatments were significantly superior over untreated control in minimizing the infestation of brinjal shoot borer. The shoot infestation caused by *L. orbonalis* was decreased at 7th day after spraying but gradually increased at 14th.

**Three days after second spraying**

The perusal data of the second spray for per cent infestation at 3rd day indicated that the treatment $T_1$- Azadirachtin @ 1500 ppm recorded lowest shoot infestation i.e. 8.26 per cent which was superior and at par with$T_5$- *Bt. Kurstaki* (8.96%) followed by $T_6$- NSKE 5 percent (9.50%), $T_3$-*Beauveria bassiana* (10.84%) and $T_2$- *Metarhizium anisopliae* (11.67%) and $T_4$-*Verticillium lecanii* (13.53%). Treatment of $T_7$-untreated control plot recorded highest (24.93%) shoot infestation.

**Seven days after second spraying**

Similarly, 7th day after spraying (Table 3, Fig., 2) observed that effectively reduction in the shoot infestation in all the treatments. The plot treated with$T_1$-Azadirachtin 1500 ppm recorded lowest shoot infestation *i.e*. 5.87 per cent which was significantly superior over control and at par with$T_5$-*Bt.Krustaki* (6.23%) and $T_6$- NSKE 5 per cent (7.23%). Though $T_3$-*Beauveria bassiana* (10.53%) followed by $T_4$-*Verticillium lecanii* (13.11%) and $T_2$-*Metarrhizium anisopliae* (11.29%) proved to be second best treatments. These all treatments were significantly superior over $T_7$- untreated control (31.83%) in shoot infestation.

**Table 2:** Effect of biopesticide against shoot borer infestation after 1st spray

| Tr. No. | Treatments | Dose (g/ml/L) | Shoot borer infestation (%) | | | | Pooled Mean |
|---|---|---|---|---|---|---|---|
| | | | 1 DBS | 3 DAS | 7 DAS | 14 DAS | |
| $T_1$ | Azadirachtin 1500 ppm | 5 ml/lit | 15.60 (23.11) | 13.15 (21.22) | 12.27 (20.36) | 11.27 (19.49) | 12.23 (20.36) |
| $T_2$ | *Metarhizium anisopliae* | 4 g/lit | 15.13 (22.69) | 14.72 (22.51) | 13.89 (21.86) | 12.87 (20.97) | 13.83 (21.78) |
| $T_3$ | *Beauveria bassiana* | 4 g/lit | 14.80 (22.48) | 14.17 (21.99) | 13.67 (21.64) | 12.72 (20.86) | 13.18 (21.24) |
| $T_4$ | *Verticillium lecanii* | 4 g/lit | 15.60 (23.05) | 15.10 (22.77) | 14.85 (22.57) | 13.86 (21.82) | 14.60 (22.39) |
| $T_5$ | *Bt. Kurstaki* | 1 g/lit | 15.93 (23.49) | 13.22 (21.24) | 12.54 (20.67) | 11.43 (19.72) | 12.40 (20.54) |
| $T_6$ | NSKE | 5% | 15.33 (23.02) | 13.63 (21.61) | 13.20 (21.25) | 11.97 (20.21) | 13.27 (21.28) |
| $T_7$ | Untreated control | - | 14.87 (22.57) | 19.40 (26.10) | 22.87 (28.47) | 20.57 (26.73) | 20.94 (27.09) |
| | SE (m)+ | | 2.081 | 1.504 | 1.508 | 1.514 | 1.528 |
| | CD at 5% | | NS | 4.634 | 4.645 | 4.663 | 4.708 |
| | CV (%) | | 15.73 | 11.58 | 11.66 | 12.25 | 11.98 |

*Figures in parentheses are arcsine transformed values NS- Non Significant DBS – days before spray DAS days after spray

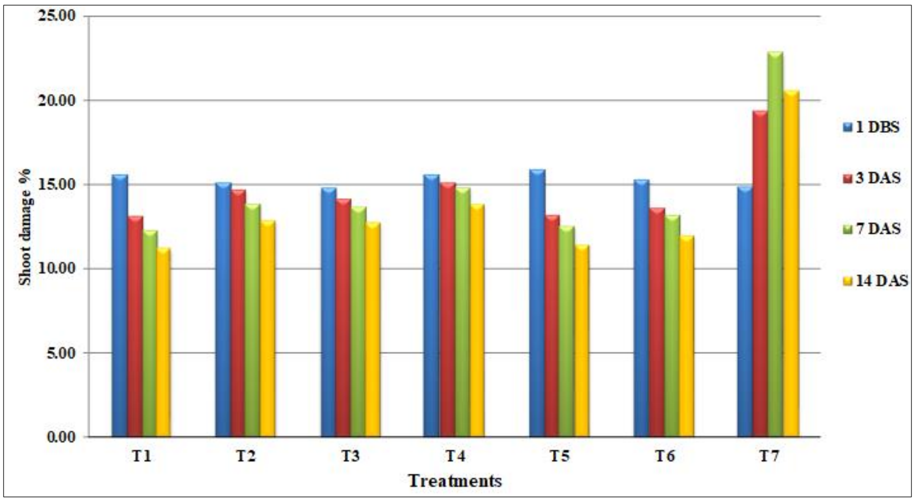


**Fig 1:** Effect of biopesticide against Shoot borer infestation after 1st spray

**Fourteen days after second spraying**

The data on mean per cent infestation at 14th day after exposure of 2ndspray indicated that the treatment $T_1$- Azadirachtin 1500 ppm recorded minimum shoot infestation *i.e*. 6.13 per cent it was significantly superior over untreated control and at par with $T_5$- *Bt. Kurstaki* recorded (6.76% shoot infestation) and $T_6$- NSKE 5 per cent recorded (8.13%). Rest of the treatments $T_3$-*Beauveria bassiana* recorded (11.51%), $T_2$-*Metarrhizium anisopliae* recorded (11.79% shoot infestation) and $T_4$ -*Verticillium lecanii* recorded (13.27%) proved second best treatments. These treatments were proved their effectiveness to reduced shoot infestation over $T_7$- untreated control plot which recorded highest 29.83 per cent.

**Pooled mean of shoot borer infestation after second spray**

The pooled results pertaining to 3rd, 7th and 14th day after second spraying of biopesticides indicated significant results amongst the treatments. Wherein, $T_1$- Azadirachtin 1500 ppm recorded minimum shoot infestation *i.e*. 6.75 per cent which was at par with $T_5$ - *Bt. Kurstaki* recorded (7.32%) followed by T6-NSKE 5 per cent recorded (8.29%) shoot infestation and $T_3$- *Beauveria bassiana* recorded (10.92%), respectively. Rest of the treatments $T_2$- *Metarhizium anisopliae* recorded (11.58%) and $T_4$-*Verticillium lecanii* recorded (13.30%*)* proved second best treatments. But all the biopesticidal treatments were significantly superior over $T_7$- untreated the control plot (28.87 per cent).

**Third spray against shoot borer infestation**

Data pertaining to the effect of different biopesticides on the infestation of shoot borer on brinjal after the third spray are presented in table 4, Fig.3. The data revealed that all the biopesticides were found to be significantly superior over untreated control in reducing the infestation shoot damage on brinjal at 3rd 7th days and 14th days after application of biopesticides.

**Three days after third spraying**

At 3rd day after third spray the mean per cent of shoot infestation indicated that the treatment$T_1$-Azadirachtin 1500 ppm recorded minimum shoot infestation *i.e*. 3.80 per cent which was at par with $T_5$- *Bt. Kurstaki* recorded (3.87%) shoot infestation and $T_6$ - NSKE 5 per cent recorded (4.58%), respectively. Rest of the treatments $T_3$- *Beauveria bassiana* recorded (10.85 percent), $T_2$- *Metarhizium anisopliae* recorded (11.53 percent) and $T_4$-*Verticillium lecanii* recorded (12.92 per cent*)* proved next set of best treatments to reduce the shoot infestation.

**Seven days after third spraying**

Subsequently, at 7thday after third spraying (Table 4, Fig.3) a similar trend was observed with a reduction in the shoot infestation in all the treatments. The plot treated with $T_1$- Azadirachtin 1500 ppm recorded minimum shoot infestation *i.e*. 1.87 per cent which was superior and at par with $T_5$-*Bt. Kurstaki* recorded (2.07 percent) and T6-NSKE 5 per cent recorded (2.31%). Rest of the treatments $T_3$- *B. bassiana* recorded (9.23%), $T_2$-*M.anisoplae* recorded (10.56%) and $T_4$-*V.lecanii* recorded (12.60%*)* proved second best treatments to reduce the shoot infestation. These treatments also effective to reduced shoot infestation over $T_7$- untreated control plot (19.93%).

**Fourteen days after third spraying**

The data on mean per cent infestation at 14th day after exposure of 3rdspray indicated that the treatment $T_1$- Azadirachtin 1500 ppm recorded minimum shoot infestation *i.e*. 2.23 per cent and was found statistically at par with $T_5$- *Bt. Kurstaki* recorded (2.39%) and $T_6$- NSKE 5 per cent recorded (2.58%). Rest of the treatments $T_3$- *B. bassiana* recorded (9.79%), $T_2$- *M. anisopliae* recorded (10.71%) and $T_4$- *V. lecanii* recorded (12.85%*)* proved second best set of treatments to reduce the shoot infestation over $T_7$- untreated control plot (17.67% shoot infestation).

**Mean infestation of shoot boprer after third spray**

The pooled results of third spray pertaining to 3rd, 7th and 14thday after spraying of biopesticides indicated significant results amongst the treatments. Minimum shoot infestation was observed in the plot treated with $T_1$- Azadirachtin 1500 ppm recorded minimum shoot infestation *i.e*. 2.63 per cent which was at par with$T_5$- *Bt. Kurstaki* (2.78 percent) and $T_6$- NSKE 5 per cent recorded (3.16%) shoot infestation. Rest of the treatments $T_3$- *B. bassiana* recorded (9.96%), $T_2$- *M. anisopliae* recorded (10.93%) and $T_4$ - *V. lecanii* recorded (12.81% shoot infestation*)* proved second best treatments to reduce the shoot infestation and were significantly superior over $T_7$- untreated control plot (20.08%).

**Table 3:** Effect of biopesticide against shoot borer infestation after 2nd spray

| Tr. No. | Treatments | Dose (g/ml/L) | Shoot borer infestation (%) | | | Pooled Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| $T_1$ | Azadirachtin 1500 ppm | 5 ml/lit | 8.26 (16.59) | 5.87 (13.90) | 6.13 (14.23) | 6.75 (14.91) |
| $T_2$ | *Metarhizium anisopliae* | 4 g/lit | 11.67 (19.22) | 11.29 (19.54) | 11.79 (20.06) | 11.58 (19.61) |
| $T_3$ | *Beauveria bassiana* | 4 g/lit | 10.84 (19.14) | 10.53 (18.91) | 11.51 (19.80) | 10.96 (19.28) |
| $T_4$ | *Verticillium lecanii* | 4 g/lit | 13.53 (21.54) | 13.11 (21.19) | 13.27 (21.27) | 13.30 (21.33) |
| $T_5$ | *Bt. Kurstaki* | 1 g/lit | 8.96 (17.39) | 6.23 (14.32) | 6.76 (14.94) | 7.32 (15.55) |
| $T_6$ | NSKE | 5% | 9.50 (17.82) | 7.23 (15.53) | 8.13 (16.29) | 8.29 (16.55) |
| $T_7$ | Untreated control | - | 24.93 (29.88) | 31.83 (34.29) | 29.83 (33.03) | 28.87 (32.40) |
| | SE (m)+ | | 1.465 | 1.466 | 1.565 | 1.498 |
| | CD at 5% | | 4.513 | 4.516 | 4.822 | 4.617 |
| | CV (%) | | 12.54 | 12.91 | 13.59 | 13.01 |

*Figures in parentheses are arcsine transformed values DAS days after spray

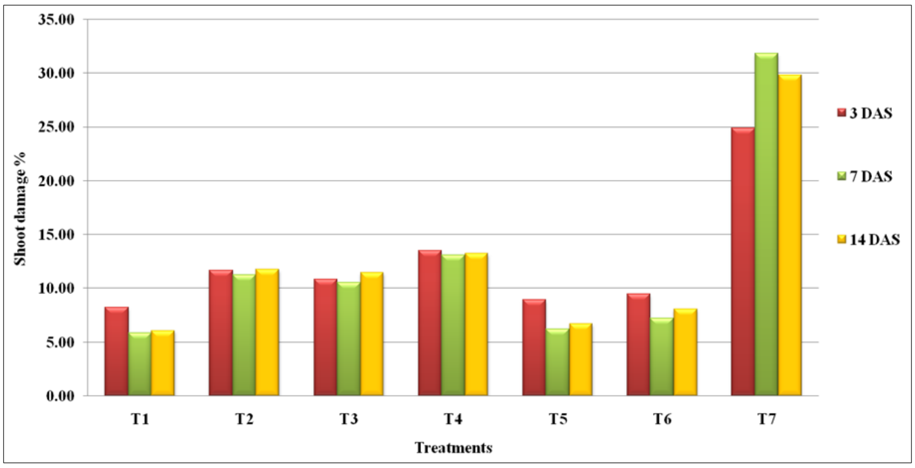


**Fig 2:** Effect of biopesticide against shoot borer infestation after 2nd spray

**Table 4:** Effect of biopesticide against shoot borer infestation after 3rd spray

| Tr. No. | Treatments | Dose (g/ml/L) | Shoot borer infestation (%) | | | Pooled Mean |
|---|---|---|---|---|---|---|
| | | | 3 DAS | 7 DAS | 14 DAS | |
| $T_1$ | Azadirachtin 1500 ppm | 5 ml/lit | 3.80 (11.09) | 1.87 (7.82) | 2.23 (8.57) | 2.63 (9.16) |
| $T_2$ | *Metarhizium anisopliae* | 4 g/lit | 11.53 (19.74) | 10.56 (18.95) | 10.71 (19.08) | 10.93 (19.26) |
| $T_3$ | *Beauveria bassiana* | 4 g/lit | 10.85 (19.16) | 9.23 (17.62) | 9.79 (18.21) | 9.96 (18.33) |
| $T_4$ | *Verticillium lecanii* | 4 g/lit | 12.98 (21.03) | 12.60 (20.74) | 12.85 (20.98) | 12.81 (20.92) |
| $T_5$ | *Bt. Kurstaki* | 1 g/lit | 3.87 (11.24) | 2.07 (8.06) | 2.39 (8.75) | 2.78 (9.35) |
| $T_6$ | NSKE | 5% | 4.58 (12.32) | 2.31 (8.55) | 2.58 (9.05) | 3.16 (9.97) |
| $T_7$ | Untreated control | - | 22.63 (28.39) | 19.93 (26.48) | 17.67 (24.69) | 20.08 (26.52) |
| | SE (m)+ | | 1.303 | 1.122 | 1.224 | 1.216 |
| | CD at 5% | | 4.015 | 3.459 | 3.772 | 3.748 |
| | CV (%) | | 12.85 | 12.57 | 13.58 | 13.00 |

*Figures in parentheses are arcsine transformed values DAS -days after spray

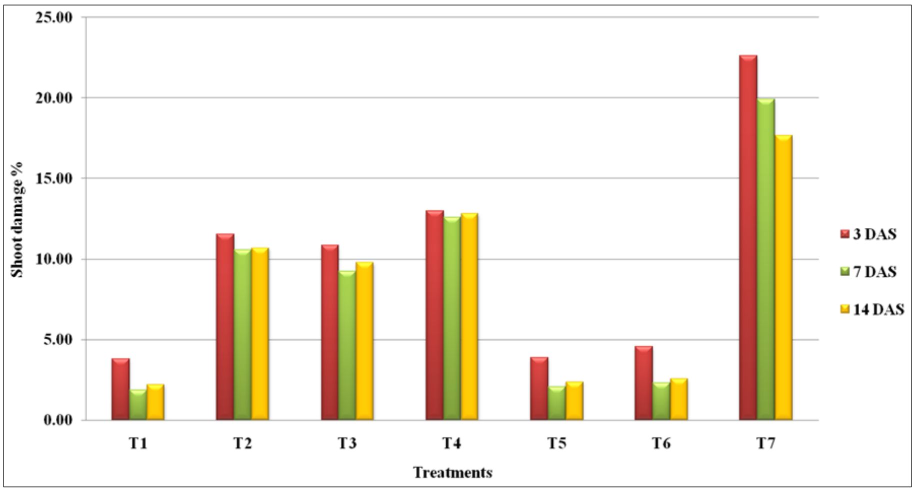


**Fig 3:** Effect of biopesticide against shoot borer infestation after 3rd spray

**Pooled Mean of shoot borer infestation at 1st, 2nd& 3rd Spray**

The pooled data (Table 5 Fig., 3) revealed that treatment T1-Azadirachtin 1500 ppm recorded minimum shoot borer infestation *i.e.* 7.21 per cent which was superior and significantally at par with $T_5$- *Bt. Kurstaki* recorded (7.50%) shoot infestation and $T_6$- NSKE 5 per cent recorded (8.24%) shoot infestation. Rest of the treatments $T_3$- *Beauveria bassiana* recorded (11.37% shoot infestation), $T_2$- *Metarhizium anisopliae* recorded (12.11% shoot infestation) and $T_4$-*Verticillium lecanii* recorded (13.57% shoot infestation*)* proved second best treatments to reduce the shoot infestation. However, they were significantly superior to reduced shoot infestation over $T_7$- untreated control (23.30%). Glance through the pooled mean, it is revealed that biopesticides in decreasing order effectiveness were *viz.*, Azadirachtin 1500 ppm > *Bt. Kurstaki* > NSKE 5 per cent > *Beauveria bassiana* > *Metarhizium anisopliae* > *Verticillium lecanii* but all of them were proved their significance over control in reducing per cent shoot infestation.

The present findings are in closely related to research of Karmakar *et al.*, (2018) [8] among the treatments, Azadirachtin 1% EC @ 2ml/L was found superior than other treatments with 10.92% mean shoot infestation and 10.04% mean fruit infestation, respectively followed by Karanjin 2% EC @ 2ml/L (13.42% shoot and 12.83% fruit infestation).It can be concluded that Azadirachtin could be proved effective in the management of brinjal shoot and fruit borer under organic farming and IPM programmes.

Whereas Nayak *et al.* (2013) [13] reported the 5 percent NSKE was found to be the most effective treatments in reducing the shoot and fruit borer infestation on brinjal on different spray schedule and also recorded maximum yield of brinjal (Mandal *et al.* 2010). Literatures regarding efficacy of microbial pesticides *viz. Metarhizium anisopliae* and *Beauveria bassiana* against brinjal shoot and fruit borer of brinjal are very limited, therefore, present findings may be compared with related works. Karkar *et al.*, (2014) [7] results concluded that among the various botanicals evaluated for their bio-efficacy, the spray of NSKE @ 5% and neem oil @ 0.3% found to be effective in suppressing the insect pests of brinjal.

**Table 5:** Pooled mean of shoot borer infestation at (1st, 2nd & 3rd spray)

| Tr. No. | Treatments | Dose (g/ml/L) | Shoot borer infestation (%) | | | Pooled mean |
|---|---|---|---|---|---|---|
| | | | 1st spray | 2nd spray | 3rd spray | |
| $T_1$ | Azadirachtin 1500 ppm | 5 ml/lit | 12.23 (20.36) | 6.75 (14.91) | 2.63 (9.16) | 7.21 (14.81) |
| $T_2$ | *Metarhizium anisopliae* | 4 g/lit | 13.83 (21.78) | 11.58 (19.61) | 10.93 (19.26) | 12.11 (20.22) |
| $T_3$ | *Beauveria bassiana* | 4 g/lit | 13.18 (21.24) | 10.96 (19.28) | 9.96 (18.33) | 11.37 (19.62) |
| $T_4$ | *Verticillium lecanii* | 4 g/lit | 14.60 (22.39) | 13.30 (21.33) | 12.81 (20.92) | 13.57 (21.55) |
| $T_5$ | *Bt. Kurstaki* | 1 g/lit | 12.40 (20.54) | 7.32 (15.55) | 2.78 (9.35) | 7.50 (15.15) |
| $T_6$ | NSKE | 5% | 13.27 (21.28) | 8.29 (16.55) | 3.16 (9.97) | 8.24 (15.93) |
| $T_7$ | Untreated control | - | 20.94 (27.09) | 28.87 (32.40) | 20.08 (26.52) | 23.30 (26.67) |
| | SE (m)+ | | 1.528 | 1.498 | 1.216 | 1.414 |
| | CD at 5% | | 4.708 | 4.617 | 3.748 | 4.357 |
| | CV (%) | | 11.98 | 13.01 | 13.00 | 12.66 |

*Figures in parentheses are arcsine transformed values

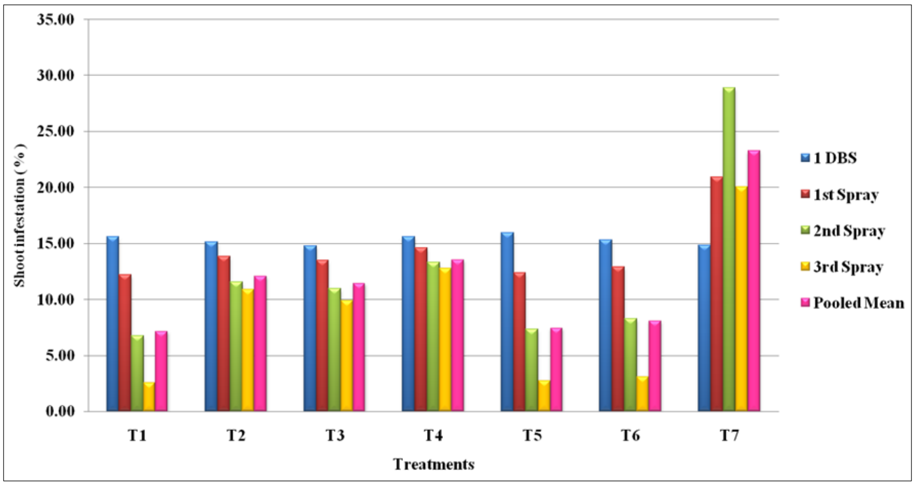


**Fig 4:** Pooled mean over three spray against shoot borer (1st, 2nd & 3rd Spray)

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