www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(8): 681-690

www.thepharmajournal.com
Received: 05-06-2021
Accepted: 22-07-2021

HB Mulani
P.G. Research Fellow, Department of Agricultural Entomology College of Agriculture, Badanpur, Maharashtra, India

SD Bantewad
Head of Department, Department of Agricultural Entomology, VNMKV, Parbhani, Maharashtra, India

NE Jayewar
Assistant Professor, Department of Agricultural Entomology, College of Agriculture, Ambajogai, Maharashtra, India

Corresponding Author:
NE Jayewar
Assistant Professor, Department of Agricultural Entomology, College of Agriculture, Ambajogai, Maharashtra, India

Biointensive management of Okra shoot and fruit borer *Earias* vittella

HB Mulani, SD Bantewad and NE Jayewar

Abstract
A field experiments was conducted to study effect of bio-pesticides against okra shoot and fruit borer *Earias vittella* was carried out during *Kharif* season of 2019-20. Botanical insecticides *viz*., Azadirachtin, biopesticides consisting of *Verticillium lecanii, Metarrhizium anisopliae, Beauveria bassiana* were included in the trial in context with untreated control to evaluate the bio-efficacy of these biorationals.
The result of all three sprays revealed that all the bio pesticidal treatments recorded significantly lower infestation of fruit borer on weight and number basis as compared to untreated control. The treatment sprays with *B. bassiana* was found most significantly superior over other treatments. The next to that was sprays of *Bt*. Kurstaki followed by NSKE 5% and *M. anisoplae* with significantly less fruit infestation, treatment of Azadirachtin 1500 ppm and *V. lecanii* were moderate effective in reducing fruit infestation and were next effective treatments but were superior over untreated control plots.

Keywords: Okra shoot, fruit borer, *Earias* vittella

Introduction
Okra is known by many local names in different parts of the world. It is popularly known as lady's finger in England, gumbo in United States of America, guino – gumbo in Spanish, guibero in Portuguese and bhindi in India. The tender fruits of okra are used as vegetables or in culinary preparations as sliced and dried pieces. It is also used for thickening gravies and soups, because of its high mucilage content. The roots and stems of okra are used for cleaning cane juice (Chauhan, 1972) [5]. Matured fruits and stems containing crude fibre are used in paper industry. It has good nutritional value, particularly the high content of vitamin C (30 mg/100 g), calcium (90 mg/100g), iron (1.5 mg/100 g) and other minerals like magnesium and potassium, vitamin A and B, fats and carbohydrates. It is commercially cultivated in India, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Burma, Japan, Malaysia, Brazil, Ghana, Ethiopia and Southern United States (Anonymous, 2004) [2]. Though okra finds its origin in South-Africa, India stands top in area and production. The major okra growing states includes Andhra Pradesh, Assam, Uttar Pradesh, Bihar, Orissa, West Bengal, Maharashtra and Karnataka (Anonymous, 2018) [3].
One of the important limiting factors in the cultivation of okra is insect pests. Many of the pests occurring on cotton are found to ravage okra crop. As high as 72 species of insects have been recorded on okra (Srinivas Rao and Rajendran, 2003) [16], of which, the sucking pests comprising of Aphids (*Aphis gossypii* Glover), leafhopper *(Amrasca biguttula biguttula* Ishida), whitefly (*Bemisia tabaci* Gennadius) and mite, *Tetranychus cinnabarinus* causes significant damage to the crop. While at later stage fruit borers like *Earias* spp and *Helicoverpa armigera* (Hubner) are cause considerable losses to the crop to the tune of 91.6 per cent (Pareek and Bhargava, 2003) [11]. Where as in general the overall damage due to insect pest is amounts to 48.97 per cent loss in pods yield (Kanwar and Ameta, 2007) [6]. Singh and Brak (1994) [14] reported 32.06 - 40.48 per cent losses in okra due to Shoot and fruit borers (*E. vittella*).
To mitigate the losses due to okra shoot and fruit borer, a huge quantity of pesticides is used in okra and it is unusual for the vegetable growers to give 10-12 sprays in okra in a season and thus the fruits harvested at short intervals are likely to retain unavoidably high level of pesticide residues which may be highly hazardous to consumers. Therefore, use of alternate management practices such use of botanicals is must. There were marked (P<0.05) differences in the efficacy of botanical pesticides and *Azadirachta indica*, *Nicotiana tabacum* and Asafoetida were found safe for toxic residues and cost effective compared to synthetic pesticides. Keeping the point in view, field trials on management of okra shoot and fruit borer

through different bio-pesticides in okra was conducted under field condition with objectives, to study the effect of bio-pesticides against okra shoot and fruit borer.

Materials and Methods

The research work was carried out at field of department of Agricultural Entomology, college of Agriculture, Badnapur during *Kharif* 2019. Badnapur comes under central Maharashtra platue, geographically the college of Agriculture, Badnapur situated at 19° 86'66'' North Latitude with an altitude 75° 70'72'' East Longitude with an altitude 520 meters. It is Aurangabad- Jalna road at a distance of 40 km from Aurangabad and 20 km from Jalna. 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 okra

All the recommended agronomical practices were adopted for raising the healthy crop. Gap filling was carried out immediately after sowing, so as to maintain uniform plant population in the plants. The spraying was done during evening hours with high volume knapsack sprayer (spray fluid 400-500 lit/ha) depending upon the crop growth stage. In all three spraying was carried out, first at the appearance of the pests and second and third at 15 days interval after first spray.

Experimental details

Design of experiment	: RBD
Replications	: Three
Treatments	: Seven
Variety	: Parbhani kranti
Spacing	: 60 x 45 cm
Gross plot size	: 4.80 m x 3.60 m
Net plot size	: 3.60 m x 2.70 m
Date of sowing	: 12/7/ 2019
Season	: *Kharif* 2019-20
RDF	: 100:50:50 NPK kg/ha

Table 1: Treatment details

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

Methods of recording observations

Shoot and fruit borer

From each plot five plants will be selected randomly and labelled for recording observations of sucking pests. As soon as the infestation of pest on shoot was initiated, 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 replication wise was recorded at 3, 7 and 14 days after imposing treatments.

The performance of different application of bio-pesticides as per treatments, number of shoot and fruit borer were recorded from randomly five tagged selected plants. Population pre-treatment observations were recorded from the 24 hours before application of treatments and observation recorded on 3rd, 7th and 14th days after spraying from each observation plants.

The incidence of okra fruit and shoot borer was recorded in terms of percentage of infested plants, and percentage of damaged fruits (number and weight basis). Incidence of okra 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 infestation was evaluated by determining the level of infestation of shoots and fruits by biopesticides and calculating the yield per hectare. The effect of different treatments on okra shoot and fruit borer was determined by counting the percentage shoot and fruit infestation.

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

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

Data on fruit infestation was taken by counting damaged and undamaged 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 fruit, weight of fruit per plot and fruit infestation by number and weight.

Statistical analysis

The data obtained on okra fruit and shoot borer was subjected to angular transformation. The data statistically analysed by standard analysis of variance method suggested by Panse and Sukhatame, 1985 [12] and further results were interpreted.

Result and Discussion

The findings of the present study are described here along with discussion of the relevant aspects in justified manner to draw a concrete conclusion. The results and discussion are presented here under different sub headings.

Effect of different biopesticides against shoot and fruit borer infestation on okra

The average data on the percent infestation of shoot and fruit borer (*E. vittella*) recorded one day before sprays and at time interval 3, 7 and 14 days after first, second and third spray.

Shoot infestation after first spray (Number basis)

Pre-count before first spray

It is evident from the data the results in Table 2 that there was no significant difference of shoot infestation among the treatments before spraying. The results were statically non - significant indicating that the uniform distribution of shoot borer infestation.

Three days after first spray

The data presented in table 2 revealed that all the treatments were found to be significantly superior over untreated control in reducing infestation of *E. vittella* on shoots. The infestation of *E. vittella* on shoots varied from 3.93 to 12.17 per cent.

The lowest infested okra shoots was observed in plot treated with treatment T_3-*B.bassiana* @ 4g/lit (3.93 per cent) and which was found at par with T5- *Bt. Kurstaki* (5.57 per cent). The other group of the treatments as T_6- NSKE 5% (7.49 per cent), T_3- *M. anisoplae* @4 g/lit (8.02 per cent), T_1- Azadirachtin 1500 ppm (8.51 per cent) and T_4- *V. lecanii* @4g /lit (9.42 per cent) were found moderate against shoot and fruit borer on okra. The maximum percent shoot infestation was recorded in control (12.17 per cent), which was significantly inferior to all tested bio pesticidal treatments.

Seven days after first spray

Data recorded on 7th day after first spraying showed that, the minimum shoot damage (4.46 per cent) was recorded in the plots treated with T_5- *Bt. Kurstaki* and found at par with T_3- *B. bassiana* @4g/lit (4.81 per cent) followed by T_6- NSKE 5% showing (7.03 per cent), T_2- *M. anisoplae* @4 g/lit showing (7.76 per cent) and T_1- azadirachtin 1500 ppm @ 5ml/lit (9.82 per cent). The maximum shoot damage (15.41 per cent) was recorded in control plot.

Fourteen days after first spray

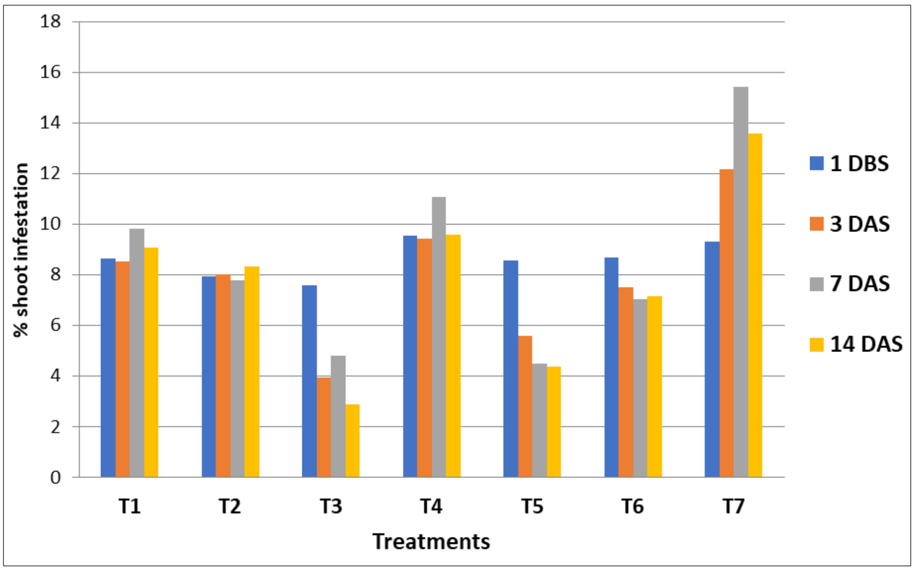
Data recorded on 14th days after the first application data revealed that T_3-*B.bassiana* @ 4g/lit maintained its effectiveness in reducing the shoot damage infestation (2.89 per cent shoot damage) and which was found at par with T_5- *Bt. krutaki* @1g/lit (4.36 per cent). The next order found effective against shoot borer with T_6- NSKE 5% (7.13 per cent shoot damage), T_2- *M. anisoplae* @ 4 g/lit (8.34 per cent), T_1- Azadirachtin 1500 ppm (9.07 per cent) and T_4- *V. lecanii* @ 4g/lit (9.58 per cent). The highest infestation (13.58 per cent) was recorded in control plot.

Mean of shoot infestation after first spray

The overall percent shoot damage by okra shoot and fruit borer was found to be minimum (3.87 percent) in treated with T_3- *B. bassiana* @4g/lit which was significantly at par with T_5- *Bt. krustaki* @1g/lit (5.22 percent) followed by T_6- NSKE 5% (7.54 percent). The other group of the treatments T_2- *M. anosoplae* @4g/lit (8.04 per cent), T1-Azadirachtin 1500 ppm (9.13 percent) and T_4- *V. lecanii* @4g/lit (10.12 percent) are moderate effective and in control (13.72 percent), which was significantly inferior to all tested bio pesticidal treatments.

Table 2: Effects of various treatments on shoot borer infestation after first spraying

Tr. No.	Treatments	Dose (g/ml/L)	% shoot infestation				Mean
			1 DBS	3 DAS	7 DAS	14 DAS	
T_1	Azadirachtin 1500ppm	5 ml/lit	8.65 (16.95)	8.51 (16.84)	9.82 (17.94)	9.07 (17.49)	9.13 (17.42)
T_2	*Metarhizium anisopliae*	4 g/lit	7.95 (16.33)	8.02 (16.33)	7.76 (15.87)	8.34 (16.69)	8.04 (16.29)
T_3	*Beauveria bassiana*	4 g/lit	7.57 (15.80)	3.93 (11.30)	4.81 (12.58)	2.89 (9.67)	3.87 (11.18)
T_4	*Verticillium lecanii*	4 g/lit	9.53 (17.88)	9.42 (17.76)	11.05 (19.27)	9.58 (17.97)	10.01 (18.33)
T_5	*Bt. Kurstaki*	1 g/lit	8.56 (16.88)	5.57 (13.52)	4.46 (11.89)	4.36 (12.02)	4.79 (12.47)
T_6	NSKE	5%	8.67 (17.04)	7.49 (15.79)	7.03 (15.34)	7.13 (15.24)	7.21 (15.45)
T_7	Untreated control	-	9.32 (17.75)	12.17 (20.31)	15.41 (23.03)	13.58 (21.60)	13.72 (21.64)
	SE (m)+		1.467	1.449	1.804	1.179	1.477
	CD at (5%)		4.519	4.463	5.560	3.633	4.552
	CV (%)		14.99	15.70	18.88	12.92	15.83



*Figures in parentheses are angular transformed values

Fig 1: Per Cent shoot infestation in okra after First spraying

Fruit infestation at second spray (Number basis)
Pre-count before second spray

It is evident from data (Table 3) that there was no significant difference of fruit infestation among the treatments before spraying.

Three days after second spray

Three day after second spray the treatment T_3- *B. bassiana* was observed best with minimum fruit damage (13.19 per cent) and which was found at par with T_5- *Bt. Kurstaki* @ 1g/lit, NSKE 5% (15.81 per cent) followed by T_6- NSKE 5% (18.14 per cent) and T_2- *M. anisoplae* @ 4g/lit (19.05 per cent). The rest treatments like T_1- Azadirachtin 1500 ppm (21.00 per cent) and T_4- *V. lecanii* @4g/lit (21.50 percent) proved less effective but these were significantly superior over control. The maximum fruit damage (22.24 percent) was recorded in control plot.

Seven days after second spray

After 7th day of second application, all the treatments were found significantly superior than the control. The minimum fruit damage (12.52 per cent fruit damage) was recorded with T_3- *B. bassiana* @4g/lit and which was at par with T_5- *Bt. krustaki* @1g/lit, T_6- NSKE 5% and T_2- *M. anisoplae* @4g/lit which recorded fruit damage 15.03, 17.66 and 18.79 per cent and were significantly superior over rest of the treatments. The rest treatments like T_1- Azadirachtin 1500 ppm (20.89 percent) and T_4- *V. lecanii* @ 4g/lit (22.36 percent) proved moderate effective but these were significantly superior over control. The maximum fruit damage (28.04 percent) was recorded in control plot.

Fourteen days after second spray

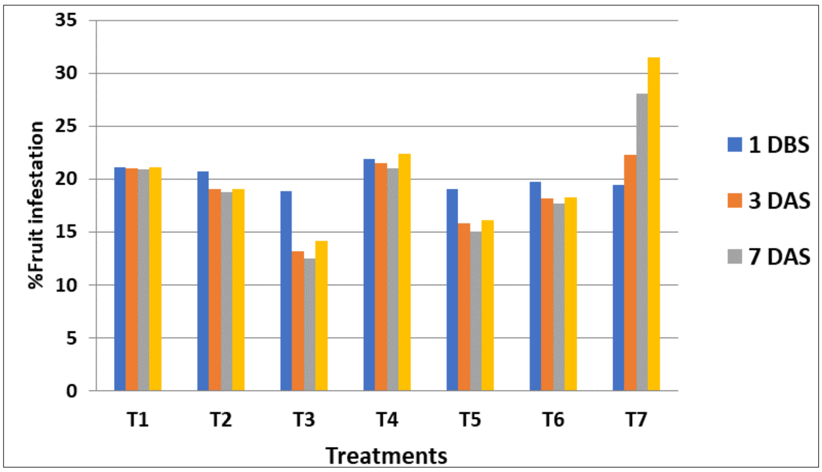
After 14th day of second application, T_3- *B. bassiana* @4g/lit gave the best performance and recorded lowest (14.18 per cent) fruit damage and found at par with T_5- *Bt. Kurstaki* @ 1g/lit (16.15 per cent) followed by T_6- NSKE 5%, T_2- *M. anisoplae* @ 4g/lit and T_1- azadirachtin 1500 ppm which recorded fruit damage 18.26, 19.09 and 21.08 per cent and were significantly superior over rest of the treatments. The maximum fruit damage (31.52 percent) was recorded in control plot.

Mean of fruit infestation after second spray

The overall per cent fruit damage by okra shoot and fruit borer was found to be minimum (13.29 percent) in plot treated with T_3- *B. bassiana* which was significantly better and at par with T_5- *Bt. Kurstaki* (15.66 per cent) followed by T_6 - NSKE 5% (18.02 per cent), T_2 - *M. anisoplae* (18.97 per cent). The other treatments T_1- Azadirachtin 1500 ppm (20.99 per cent) and T_4- *V. lecanii* (21.63 per cent) are moderate effective and in control (27.37 per cent), which was significantly inferior to all tested boipesticidal treatments.

Table 3: Effects of various treatments on fruit borer infestation after second spraying

Tr. No.	Treatments	Dose (g/ml/L)	% fruit infestation (Number basis)				Mean
			1 DBS	3 DAS	7 DAS	14 DAS	
T_1	Azadirachtin 1500ppm	5 ml/lit	21.14 (26.90)	21.00 (27.22)	20.89 (27.15)	21.08 (27.19)	20.99 (27.18)
T_2	*Metarhizium anisopliae*	4 g/lit	20.72 (26.40)	19.05 (25.84)	18.79 (25.65)	19.09 (25.88)	18.97 (25.79)
T_3	*Beauveria bassiana*	4 g/lit	18.85 (25.16)	13.19 (20.83)	12.52 (20.28)	14.18 (21.98)	13.29 (21.03)
T_4	*Verticillium lecanii*	4 g/lit	21.86 (27.35)	21.50 (27.47)	21.04 (27.15)	22.36 (28.12)	21.63 (27.58)
T_5	*Bt. Kurstaki*	1 g/lit	19.03 (24.89)	15.81 (23.22)	15.03 (22.65)	16.15 (23.47)	15.66 (23.11)
T_6	NSKE	5%	19.77 (26.13)	18.14 (25.18)	17.66 (24.81)	18.26 (25.22)	18.02 (25.07)
T_7	Untreated control	-	19.45 (25.61)	22.24 (28.09)	28.04 (31.93)	31.52 (34.11)	27.26 (31.37)
	SE (m)+		2.060	1.775	1.823	1.788	1.795
	CD at (5%)		6.347	5.468	5.617	5.508	5.531
	CV (%)		13.69	12.10	12.31	11.66	12.02



*Figures in parentheses are angular transformed values

Fig 2: % Fruit infestation in okra after second spraying

Fruit infestation at third spray (Number basis)
Three days after third spray

The data presented in table 4 revealed that all the treatments were found to be significantly superior over untreated control in reducing infestation of *E. vittella* on fruit. The lowest infested of okra fruit was observed in plot treated with treatment T_3- *B. bassiana* @ 4g/lit (9.67 per cent) and which was at par with T_5- *Bt. Kurstaki* @1g/lit (12.86 per cent). The other set of the treatments T_6- NSKE 5% (16.05 per cent) followed by T_2- *M. anisoplae* (18.16%), T_1- Azadirachtin 1500 ppm (20.49 per cent) and T_4- *V. lecanii* @4g/lit (21.84 percent) proved moderate effective but these were significantly superior over control. The maximum fruit damage (33.78 percent) was recorded in control plot.

Seven days after third spray

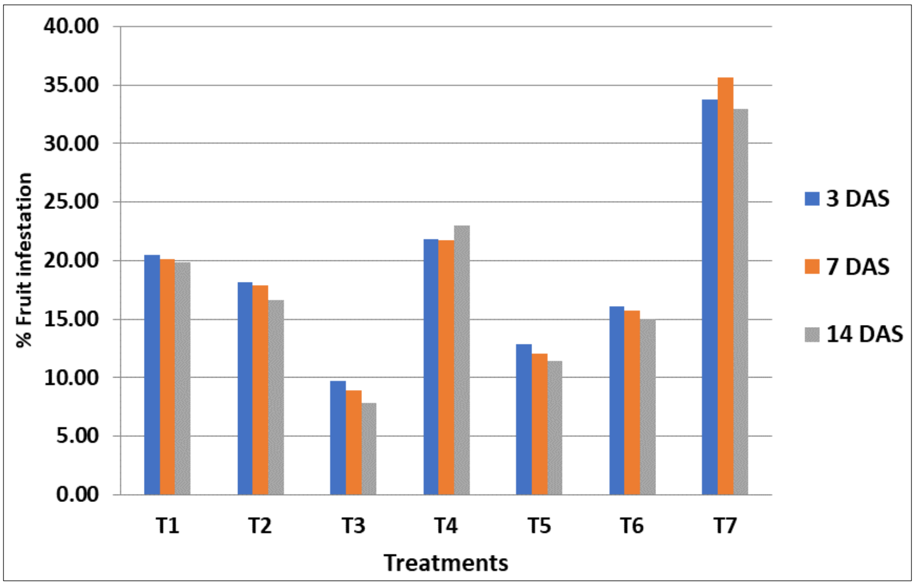
After 7th day of bio-pesticidal application, all the treatments were found significantly superior than the control. The minimum fruit damage (8.90 per cent fruit damage) was recorded with T_3- *B. bassiana* @ 4g/lit and at par with T_5- *Bt. Kurstaki* @1g/lit 12.05 per cent fruit damage, followed by T_6- NSKE 5% (15.68 per cent). The next effective treatments, T_2 - *M. anisoplae* @4g/lit (fruit damage 17.88 per cent), T_1 - Azadirachtin 1500 ppm (20.15 per cent) and T_4 -*V. lecani* @4g/lit (21.72 per cent) proved less effective but these were significantly superior over control. The maximum fruit damage (35.63 per cent) was recorded in control plot.

Fourteen days after third spray

Fourteen day after third application, T_3 - *B. bassiana* @ 4g/lit was observed best with minimum fruit damage (7.79 per cent) and at par with T_5 - *Bt. Kurstaki* @ 1g/lit and T_6 - NSKE 5 %, which recorded fruit damage 11.39 and 14.98 per cent, respectively and were significantly superior over rest of the treatments in respect of reducing infestation. The rest treatments like T_1- Azadirachtin 1500 ppm (19.83 percent), T_4 - *V. lecanii* @ 4g/lit (22.97 per cent) and proved less effective but these were significantly superior over control. The maximum fruit damage (32.95 per cent) was recorded in control plot.

Table 4: Effects of various treatments on fruit borer infestation after third spraying

Tr. No.	Treatments	Dose (g/ml/L)	% fruit infestation (Number basis)			Mean
			3 DAS	7 DAS	14 DAS	
T_1	Azadirachtin 1500ppm	5 ml/lit	20.49 (26.69)	20.15 (26.47)	19.83 (26.22)	20.15 (26.46)
T_2	*Metarhizium anisopliae*	4 g/lit	18.16 (25.10)	17.88 (24.90)	16.66 (23.89)	17.56 (24.63)
T_3	*Beauveria bassiana*	4 g/lit	9.67 (11.99)	8.90 (17.14)	7.79 (16.05)	8.78 (15.06)
T_4	*Verticillium lecanii*	4 g/lit	21.84 (27.69)	21.72 (27.61)	22.97 (28.58)	22.17 (27.96)
T_5	*Bt. Kurstaki*	1 g/lit	12.86 (20.53)	12.05 (19.77)	11.39 (19.60)	12.1 (19.96)
T_6	NSKE	5%	16.05 (23.47)	15.68 (23.13)	14.98 (22.67)	15.57 (23.09)
T_7	Untreated control	-	33.78 (35.33)	35.63 (36.49)	32.95 (34.75)	34.12 (35.52)
	SE (m)+		2.384	2.267	2.242	2.297
	CD at (5%)		7.346	6.984	6.908	7.079
	CV (%)		16.35	15.66	15.83	15.94



*Figures in parentheses are angular transformed values

Fig 3: % Fruit infestation in okra after third spraying

Mean of fruit infestation after third spray

The overall per cent fruit damage by okra shoot and fruit borer was found to be minimum (8.78 percent) in plot treated with T_3- *B. bassiana* @4g/lit which was significantly better than all the biopesticidal treatments and found at par with T_5- *Bt. Kurstaki* @1g/lit (12.10 percent). The other group of the treatments T_6- NSKE 5% (115.57 per cent) followed by T_2- *M. anisoplae* @4g/lit (17.56 percent), T_1- Azadirachtin 1500 ppm (20.15 per cent) and T_4- *V. lecanii* @4g/lit (22.17 per cent) are moderate effective. The maximum fruit damage (34.12 percent) was recorded in control plot.

Pooled mean of two consecutive sprays

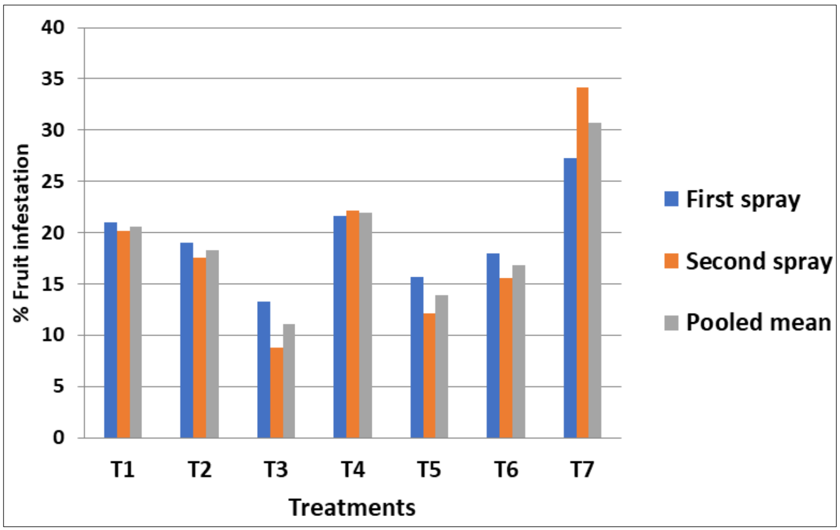
The data on average percentage of fruit borer infestation on okra fruit number basis is presented in table (5). Data revealed that all the bio pesticidal treatments were significantly superior over untreated control. The average fruit borer infestation ranged from 11.03 to 21.90 in bio pesticidal treatments as against 30.69% in untreated control plot.

The treatment with sprays of T_3- *B. bassiana* and thereafter sprays was most effective and recorded significantly low fruit infestation of 11.03 percent and which was found at par with T_5 *Bt. Kurstaki* 13.88 per cent followed by T_6- NSKE 5%

(fruit damage 16.79 per cent). The next to that sprays of T_2- *M. anisoplae* with 18.26 per cent fruit infestation. Followed by T_1- Azadirachtin 1500 ppm (20.57 %) and T_4- *V. lecanii* (21.90 per cent) were moderate effective in reducing fruit infestation but were superior over untreated control plots 30.69 per cent.

Table 5: Overall performance of biopesticides against shoot and fruit borer (number basis) (pooled of 2 sprays)

Tr. No.	Treatments	Dose (g/ml/L)	Mean of % fruit infestation (Number basis)		Pooled mean
			1st spray	2nd spray	
T_1	Azadirachtin 1500ppm	5 ml/lit	20.99 (27.18)	20.15 (26.46)	20.57 (26.82)
T_2	*Metarhizium anisopliae*	4 g/lit	18.97 (25.79)	17.56 (24.63)	18.26 (25.21)
T_3	*Beauveria bassiana*	4 g/lit	13.29 (21.03)	8.78 (15.06)	11.03 (18.04)
T_4	*Verticillium lecanii*	4 g/lit	21.63 (27.58)	22.17 (27.96)	21.9 (27.77)
T_5	*Bt. Kurstaki*	1 g/lit	15.66 (23.11)	12.1 (19.96)	13.88 (21.53)
T_6	NSKE	5%	18.02 (25.07)	15.57 (23.09)	16.79 (24.08)
T_7	Untreated control	-	27.26 (31.37)	34.12 (35.52)	30.69 (33.44)
	SE (m)+		1.795	2.297	2.046
	CD at (5%)		5.531	7.079	6.305
	CV (%)		12.02	15.94	13.98



*Figures in parentheses are angular transformed values

Fig 4: Per cent Fruit infestation in okra after mean of two consecutive spraying

Fruit infestation at second spray (Weight basis)
Pre-count before second spray

It is evident from the results (Table 6) that there was no significant difference among the fruit infestation on weight basis of the treatments before second spraying. The results were statically non-significant indicating uniform distribution of fruit borer infestation in all the treatments ranging from 20.88 to 23.51 per cent.

Three days after second spray

Three day after second application of biopesticides, T_3- *B. bassiana* @4g/lit was observed best with minimum fruit damage on weight basis with (15.65 per cent) and which was at par with T_5- *Bt. Kurstaki* @1g/lit, T_6- NSKE 5% and T_2- *M. anisoplae* @4g/lit which recorded fruit damage 18.62, 21.01 and 21.85 per cent and were significantly superior over rest of the treatments in respect of reducing infestation. The rest treatments like T1- Azadirachtin 1500 ppm (23.00 per cent), T_4- *V. lecanii* @4g/lit (23.36 percent) proved less effective but these were significantly superior over control. The maximum fruit damage (24.34 percent) was recorded in control plot.

Seven days after second spray

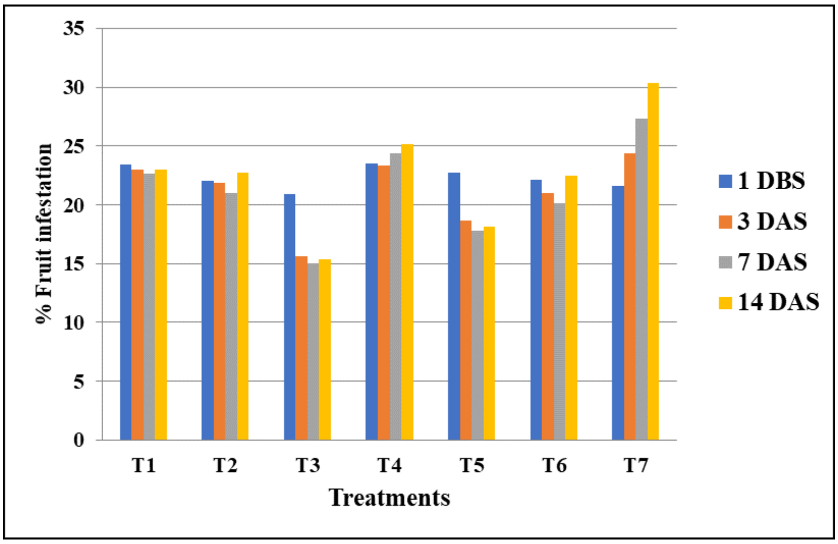
After 7th day of biopesticidal application, all the treatments were found significantly superior than the control. The minimum fruit damage (14.98 per cent fruit damage) was recorded with T_3- *B. bassiana* @4g/lit and similar with T5- *Bt. Kurstaki* @1g/lit followed bt T6- NSKE 5%, and T_2- *M. anisoplae* @4g/lit which recorded fruit damage 17.76,20.15 and 21.03 per cent and were significantly superior over rest of the treatments in respect of reducing infestation and at par with *B. bassiana* @4g/lit. The rest treatments like T_1- Azadirachtin 1500 ppm (22.67 percent), and T_4- *V. lecanii* @4g/lit (224.35 percent) proved less effective but these were significantly superior over control. The maximum fruit damage (27.32 percent) was recorded in control plot.

Fourteen days after second spray

After 14th day of second application, T_3- *B. bassiana* @4g/lit gave the best performance and recorded lowest (15.38 per cent) fruit damage and at par with T5- *Bt. Kurstaki* @1g/lit (18.11 percent fruit damage) followed by T_6- NSKE 5% and T_2- *M. anisoplae* @4g/lit which recorded fruit damage 22.48 and 22.74 per cent and were significantly superior over rest of the treatments in respect of reducing infestation. The maximum fruit damage (30.37 percent) was recorded in control plot.

Table 6: Effects of various treatments on fruit borer infestation after second spraying

Tr. No.	Treatments	Dose (g/ml/L)	Per cent fruit infestation (Weight basis)				Mean
			1 DBS	3 DAS	7 DAS	14 DAS	
T_1	Azadirachtin 1500ppm	5 ml/lit	23.42 (28.87)	23.00 (28.54)	22.67 (28.35)	23.02 (28.58)	22.89 (28.49)
T_2	*Metarhizium anisopliae*	4 g/lit	22.02 (27.81)	21.85 (27.69)	21.03 (27.04)	22.74 (28.24)	21.87 (27.65)
T_3	*Beauveria bassiana*	4 g/lit	20.88 (26.65)	15.65 (22.78)	14.98 (22.34)	15.38 (22.60)	15.33 (22.57)
T_4	*Verticillium lecanii*	4 g/lit	23.51 (28.73)	23.36 (28.62)	24.35 (29.26)	25.20 (29.93)	24.30 (29.27)
T_5	*Bt. Kurstaki*	1 g/lit	22.74 (28.38)	18.62 (25.47)	17.76 (24.80)	18.11 (25.04)	18.16 (25.10)
T_6	NSKE	5%	22.12 (27.86)	21.01 (27.05)	20.15 (26.38)	22.48 (28.04)	21.21 (27.15)
T_7	Untreated control	-	21.63 (27.35)	24.34 (29.29)	27.32 (31.19)	30.37 (33.14)	27.34 (31.20)
	SE (m)+		2.279	1.999	1.874	1.833	1.902
	CD at (5%)		7.021	6.158	5.775	5.649	5.860
	CV (%)		14.12	12.79	12.00	11.37	12.05



*Figures in parentheses are angular transformed values

Fig 5: Per cent fruit infestation in okra after second spraying

Mean of fruit infestation after second spray

The overall percent fruit damage by okra shoot and fruit borer was found to be minimum (15.33 percent) in plot treated with T_3- *B. bassiana* @4g/lit which was significantly better than all the bio pesticidal treatments and found at par with T_5- *Bt. Kurstaki* @1g/lit (18.16 per cent) followed bt T_6- NSKE 5% (21.21 per cent) and T_2- *M. anisoplae* @4g/lit (21.87 per cent). The other treatments T_1- Azadirachtin 1500 ppm (22.89 per cent) and T_4- *V. lecanii* @4g/lit (24.30 per cent) are least effective in control (27.34 percent), which was significantly inferior to all tested bio pesticidal treatments.

Fruit infestation at third spray (Weight basis)

Three days after third spray

The data presented in table 22 revealed that all the treatments were found to be significantly superior over untreated control in reducing infestation of *E. vittella* on fruits. The infestation of *E. vittella* on fruits varied from 10.71 to 32.02 per cent.

The lowest infested okra fruit was observed in plot treated with treatment T_3- *B. bassiana* (10.71 er cent) and which was found at par with T_5- *Bt. Kurstaki* (13.71 per cent). The other group of the treatments T_6- NSKE 5% (19.71 per cent) followed bt T2- *M. anisoplae* (20.48 per cent), T_1- Azadirachtin 1500 ppm (22.30 per cent) and T_4- *V. lecanii* (24.86 per cent) proved moderate effective but these were significantly superior over control. The maximum fruit damage (32.02 per cent) was recorded in control plot.

Seven days after third spray

After 7th day of bio pesticidal application, all the treatments were found significantly superior than the control. The minimum fruit damage (9.85 per cent) fruit damage was recorded with T_3- *B. bassiana* and at par with T_5- *Bt. Kurstaki* 12.41 per cent fruit damage. The next effective treatments, T6- NSKE5% (19.13 per cent), T_2- *M. anisoplae* (19.99 per cent) T_1- Azadirachtin 1500 ppm (22.30 per cent) and T_4- *V. lecanii* (23.54 per cent) proved moderate effective but these were significantly superior over control. The maximum fruit damage (35.80 per cent) was recorded in control plot.

Fourteen days after third spray

After 14th day of bio-pesticidal application, all the treatments were found significantly superior than the control. The minimum fruit damage (9.47 per cent) fruit damage was recorded with T_3- *B. bassiana* and at par with T_5- *Bt. Kurstaki* 12.06 per cent fruit damage. The next effective treatments, T_2- *M. anisoplae* (19.88 per cent), T6- NSKE5% (20.11 per cent), T_1- Azadirachtin 1500 ppm (22.76 per cent) and T_4- *V. lecanii* (24.45 per cent) proved moderate effective but these were significantly superior over control. The maximum fruit damage (35.80 per cent) was recorded in control plot.

Mean of fruit infestation after second spray

The overall per cent fruit damage by okra shoot and fruit borer was found to be minimum (10.01 percent) in plot treated with T_3- *B. bassiana* which was significantly better than all the bio-pesticidal treatments and at par with T_5- *Bt. Kurstaki* (12.72 percent). The other set of the treatments T6- NSKE 5% (19.65 per cent), T_2- *M. anisoplae* (20.11 per cent), T_1- Azadirachtin 1500 ppm (22.45 per cent) and T_4- *V. lecanii*

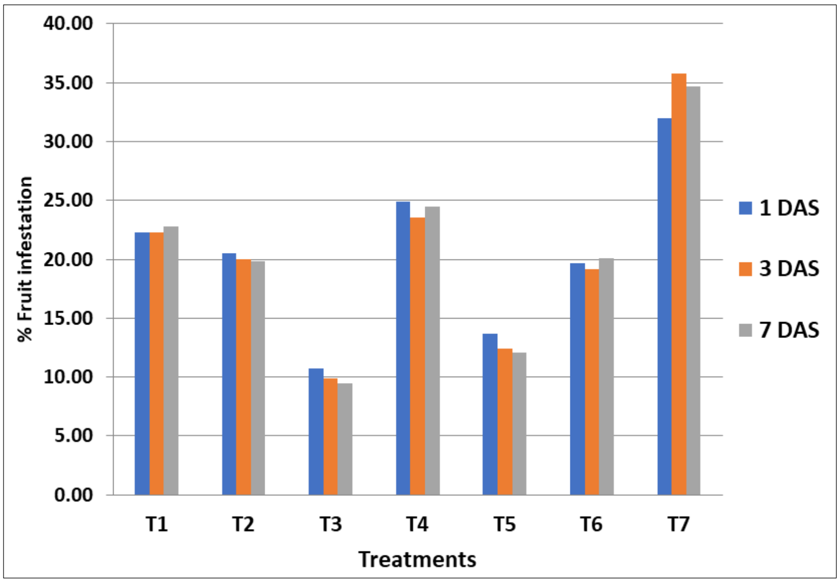
(24.28 per cent) are least effective in control (34.16 per cent) and proved less effective but these were significantly superior over control. The maximum fruit damage (34.16 percent) was recorded in control plot.

Pooled mean for fruit infestation of second and third spray

It was observed that all the bio pesticidal treatments recorded significantly lower infestation of fruit borer on weight basis as compared to untreated control. The average fruit infestation in the bio pesticidal treatments ranged from 12.67 per cent to 24.29 per cent as against 30.75 % in untreated control. The treatment with sprays of T_3- *B. bassiana* was most found significantly superior over other treatments. The next to that was sprays of T5 Bt. Kurstaki (15.44 per cent) followed by T6- NSKE 5 % (20.43 per cent), T_2- *M. anisoplae* with 20.99 per cent fruit infestation, T_1- Azadirachtin 1500 ppm (22.67 per cent) and T_4-*V. lecanii* (24.29 per cent) were moderate effective in reducing fruit infestation but were superior over untreated control plots.

Table 7: Effects of various treatments on fruit borer infestation after third spraying

Tr. No.	Treatments	Dose (g/ml/L)	% fruit infestation (Weight basis)			Mean
			3 DAS	7 DAS	14 DAS	
T_1	Azadirachtin 1500ppm	5 ml/lit	22.30 (28.12)	22.30 (28.12)	22.76 (28.46)	22.45 (28.23)
T_2	*Metarhizium anisopliae*	4 g/lit	20.48 (26.72)	19.99 (26.31)	19.88 (25.75)	20.11 (26.26)
T_3	*Beauveria bassiana*	4 g/lit	10.71 (18.51)	9.85 (17.66)	9.47 (17.32)	10.01 (17.83)
T_4	*Verticillium lecanii*	4 g/lit	24.86 (29.67)	23.54 (28.68)	24.45 (29.27)	24.28 (29.20)
T_5	*Bt. Kurstaki*	1 g/lit	13.71 (21.12)	12.41 (19.75)	12.06 (19.26)	12.72 (20.04)
T_6	NSKE	5%	19.71 (26.14)	19.13 (25.70)	20.11 (26.10)	19.65 (25.98)
T_7	Untreated control	-	32.02 (34.02)	35.80 (36.53)	34.67 (35.86)	34.16 (35.47)
		SE (m)+	2.321	2.109	2.274	2.234
		CD at (5%)	7.151	6.497	7.007	6.885
		CV (%)	15.27	13.99	15.15	14.80

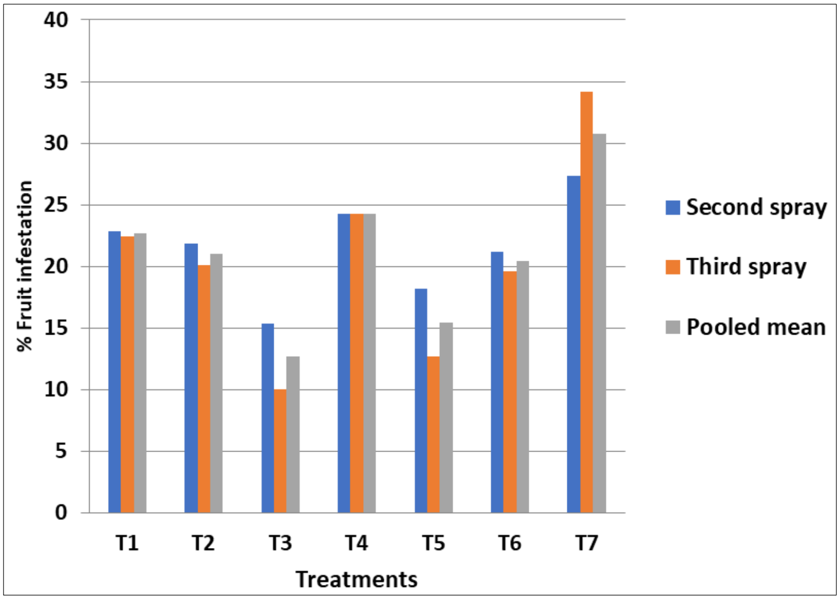


*Figures in parentheses are angular transformed values

Fig 6: Per cent Fruit infestation in okra after third spraying

Table 8: Overall performance of biopesticides against shoot and fruit borer (weight basis) (Pooled of 2 sprays)

Tr. No.	Treatments	Dose (g/ml/L)	Mean of % fruit infestation (Weight basis)		Pooled mean
			1st spray	2nd spray	
T_1	Azadirachtin 1500ppm	5 ml/lit	22.89 (28.49)	22.45 (28.23)	22.67 (28.36)
T_2	*Metarhizium anisopliae*	4 g/lit	21.87 (27.65)	20.11 (26.26)	20.99 (26.95)
T_3	*Beauveria bassiana*	4 g/lit	15.33 (22.57)	10.01 (17.83)	12.67 (15.2)
T_4	*Verticillium lecanii*	4 g/lit	24.30 (29.27)	24.28 (29.20)	24.29 (29.23)
T_5	*Bt. Kurstaki*	1 g/lit	18.16 (25.10)	12.72 (20.04)	15.44 (22.57)
T_6	NSKE	5%	21.21 (27.15)	19.65 (25.98)	20.43 (26.56)
T_7	Untreated control	-	27.34 (31.20)	34.16 (35.47)	30.75 (33.33)
	SE (m)+		1.902	2.234	2.068
	CD at (5%)		5.860	6.885	6.372
	CV (%)		12.05	14.80	13.42



*Figures in parentheses are angular transformed values

Fig 7: Per cent Fruit infestation in okra after mean of two consecutive spraying

Singh and Singh (2011) [15] worked on efficacy of some bio-pesticides *viz*., *B. bassiana* @ 2.5 kg/ha, *B. thuringiensis* @ 1LE/ha, NSKE @ 5 per cent, NPV @ 250 LE/ha, trichocard 2.5 lakh eggs/ha, hand picking, thiomethoxam against okra shoot borer, *Earias sp.* and *Helicoverpa armigera* and indicated that nendosulfan 35 EC @ 1.0 LE/ha and *B. thuringiensis* @ 1.0 lit/ha, were found most effective in managing both borer pests and gave higher yield of marketable immature fresh fruits of okra.

Nayak *et al.* (2012) [10] conducted studies on the efficacy of five bio-pesticides on okra fruit borer, *E. vittella* during summer and kharif season in 2007 and revealed that application of Biodart *(B. thuringiensis*) and Daman (*B. bassiana*) both @ 1 kg/ha at 50, 60, 70, 80 and 90 days after sowing resulted in less fruit damage both on number infested fruits and weight loss bases than other compounds. Both the bio-pesticides also resulted in higher fruit yield with high cost-benefit ratio.

It is evident from the above findings that all the treatments were effective in reducing shoot and fruit damage at different intervals after each spray in comparison to untreated control. The efficacy of entmo-pathogenic fungi *Beauveria* bassiana and entmopathogen *Bacillus thuringiensis* was also found in reducing the infestation of shoot and fruit borer, which is in conformity with the finding of Nayak *et al.* (2013) [9]. Five 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) [7]. 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. It was reported that high mortality of *Ceratitis capitata* found in *M. anisopliae* treatment (Castillo *et al.* 2000) [4]. Entomo-pathogenic fungi *B. bassiana* and *Metarhizium anisopliae* could be effectively used as pest management option in production of organic tomato (Phukon *et al.* 2014) [13]. *M. anisopliae* was found most effective entomopathogenic fungi with minimum surviving larval population of pod borer (Phukon *et al.* 2014) [13] Entomopathogenic fungi *Beauveria bassiana* is a promising and extensively researched biological control agent that can suppress a variety of economically important insect pests (Adsure *et al.* 2015) [1].

References

1. Adsure SP, Mohite PB. Efficacy of entomopathogenic fungi against gram pod borer, Helicoverpa armigera (Hub.) on chickpea. Journal of Global Biosciences 2015;4(8):3154-3157.
2. Anonymous. Horticultural Statistics. National Horticulture Board, Ministry of Agriculture, Govt. of India 2004, 10-24.
3. Anonymous. Horticulture Statistics at a glance 2018 – Ministry of Agriculture and Farmers welfare 2018.
4. Castillo MA, Moya P, Hernández E, Yúfera EP. Susceptibility of Ceratitis capitata Wiedemann (Diptera: Tephritidae) to entomopathogenic fungi and their extracts. Biological Control 2000;19:274-282.
5. Chauhan DVS. Vegetable production in India. 3rd Edition Publication Ram Prasad and Sons, Agra 1972.
6. Kanwar N, Ameta OP. Assessment of loss caused by insect pests of okra (*Abelmoschus esculentus* (L.) Moench]. Pestology 2007;31(5):45-47.
7. Mandal S, Singh NJ, Konar A. Efficacy of synthetic and botanical insecticide against whitefly (Bemiciatabaci) and shoot and fruitborer (Leucinodes orbonalis G.) on brinjal (*Solanum melongena* L.). Journal of Crop and Weed 2010;6(1):49-51.
8. Nagar J, Khinchi SK, Naga BL, Sharma SL, Hussain A, Sharma A. Effect of abiotic factors on incidence of sucking insect pests and their major natural enemies of okra. Journal of Entomology and Zoology Studies 2017;5(3):88.
9. Nayak US, Baral K, Rath LK, Mondal P. Comparative efficacy of some bio-pesticides and botanicals against brinjal shoot and fruit borer, Leucinodes orbonalis Guenee. Journal of Interacademicia 2013;17(1):39-43.7-890.
10. Nayak US, Rath LK, Das SK. Efficacy of certain biopesticide against okra fruit borer, *Earias vittella* (Fabricius). J Insect Sci 2012;25(3):286-288.

11. Pareek BL, Bhargava MC. Estimation of avoidable losses in vegetable crops caused by borers under semi-arid conditions of Rajasthan. Insect Environment 2003;9:59-60.
12. Panse VG, Sukhatame PV. Statistical methods for agricultural workers. I.C.A.R, New Delhi 1985.
13. Phukon M, Sarma I, Borgohain R, Sarma B, Goswami J. Efficacy of Metarhizium anisopliae, Beauveria bassiana and neem oil against tomato fruit borer, Helicoverpa armigera under field condition. Asian Journal of Bioscience 2014;9(2):151-155.
14. Singh G, Brak KS. Effects of dates of sowing on the incidence of *Amrasca bigutulla* (Ishida) and Earias spp. on okra. Indian Journal of Ecology 1994;21:140-144.
15. Singh H, Singh K. Evaluation of some bio-pesticides for management of fruit borer in okra (*Abelmoschus esculentus* Linn.). Ann. Entomol 2011;29(1):63-65.
16. Srinivasa Rao, Rajendran R. Joint action potential of neem with other plant extracts against the Pest Management and Econ. Zool 2003;10:131-136.