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Assessment of Shoot and Fruit Damage on Number Basis in Okra

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A B S T R A C T

To assess the shoot/fruit infestation and damage (number basis) on okra was undertaken during *kharif* season of 2016-17 in field of Insectory premises of Entomology Section, College of Agriculture, Nagpur. The trial incorporating nine treatments including control which were replicated thrice in Randomized Block Design. During this investigation, on the basis of above parameters revealed that, lowest infestation (shoot and fruit infestation) and highest yield over control was observed in treatment of Spinosad 45 SC 0.01% (T_8; 6.52%) shoot infestation, 12.83% fruit infestation and 16.13% fruit damage with 86.79 q/ha yield followed by Emamectin benzoate 5 SG 0.02% (T_7), Indoxacarb 15.5 EC 0.01% (T_5), Acetamiprid 20 SP 0.2 g/lit (T_6) *Bacillus thuringensis* 2ml/l (T_4), Neem oil 2% (T_1), NSE 5% (T_3) and Karanj oil 2% (T_2).

Introduction

Okra (*Abelmoschus esculentus* L.) is one of the most popular vegetable crop grown extensively all over India. However, summer and *kharif* are the favourable seasons for its cultivation. The area under okra cultivation in India is 4,09,000 ha with production of 41,93,000 metric tonnes. Whereas, in Maharashtra State it is cultivated on 26,2,030.3 ha area with production of 1, 65,900.4 metric tonnes (Anonymous, 2015).

Among the various insect pests, sucking pests like leafhopper, *Amrasca biguttula biguttula* Ishida and whitefly, *Bemisia tabaci* Gennadius pose a major threat affecting the okra production.The damage due to fruit borer accounts for nearly 45% in Karnataka, 22.5% in Uttar Pradesh, 25.93-40.91% in Madhya Pradesh and in Rajasthan it was estimated that if insecticidal protection was not given there would be a net yield loss of 54.04% and repeated use of insecticides has resulted in the development of resistance in the insect pest and disturbance to the agro- ecosystem by affecting the non-target pests and somewhere its indirect effect found on fruit/ shoot infestation and damage Hence, in the present study we recorded the number of infested shoots in each plot a day before first spray and 3, 7 and 14 days after each spraying on five randomly selected plants from each plot and recorded number of infested fruits and number of marketable fruits on five randomly selected plants from each net plot picking wise. In

order to know the per cent fruit infestation. The fruits were plucked from 5 selected plants, they were counted Similarly, from those total fruits the infested fruits due to fruit borer were separated and counted.

Materials and Methods

The present field experiment was carried out on Okra crop, variety Akola bahar during *kharif* season 2016-2017 in the Insectory field of Entomology Section, College of Agriculture, Nagpur.

The experiment was laid out in a randomized block design with Nine treatments consisting Neem oil 2% (T_1), Karanj oil 2% (T_2), NSE 5% (T_3), *Bacillus thuringensis* 2ml/l (T_4), Indoxacarb 15.5 EC 0.01% (T_5), Acetamiprid 20 SP 0.2 g/lit (T_6), Emamectin benzoate 5 SG 0.02% (T_7), Spinosad 45 SC0.01%(T8) including (T9) control (water spray) were evaluated after each spray against Natural enemies and observed the effect on them.

The plot size was kept 12.6 m^2 with a spacing of 60 x 45 cm between rows and plants respectively and recommended agronomical practices were followed.

And the efficacy of each treatment was determined on the basis of per cent shoot infestation, fruit infestation (on number basis) by shoot and fruit borer. The cumulative (average) per cent of shoot and fruit infestation and fruit damage was calculated to see the overall effect of various treatments. With the help of following formula

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

$$\text{Per cent fruit Infestation (Number basis)} = \frac{\text{Number of infestation fruits}}{\text{Total number of fruits}} \times 100$$

Results and Discussion

Cumulative per cent shoot infestation by shoot and fruit borer

Shoot infestation was noticed at 30 DAS and continue upto 65 DAS. The data on the cumulative per cent shoot infestation presented in Table 1 and illustrated in figure 1. From the results, it was revealed that, all the treatments were significantly superior over control in reducing the shoot infestation.

Among these different treatments, Spinosad 45 SC 0.01% (T_8) recorded minimum (6.52%) shoot infestation and was found to be the best followed by Emamectin benzoate 5 SG 0.02% (T_7; 7.09%) and Indoxacarb 15.8 EC 0.01% (T_5; 7.50%). Devi *et al.,* (2014) reported 5.00% shoot infestation with the treatment spinosad 45% SC and emamectin benzoate 5% SG 5.50%.

The next effective treatment in reducing per cent shoot infestation was of Acetamiprid 20 SP 0.2 g/lit (T_6; 7.92%) and it was followed by *Bacillus (B.t.)* (1×10^8 CFU) 2ml/lit (T_4; 8.51%). Puranik *et al.,* (2002) reported 11.07% shoot infestation of *L. orbonalis* with the treatment halt WP (*Bt*).

The next promising treatment in reducing per cent shoot infestation was of Neem oil 2% (T_1; 8.83%) followed by NSE 5% (T_3; 8.94%).

Both these treatments were statistically at par with each other. Our present findings regarding efficacy of neem oil 2% (T_5) confirmed the findings of Panzade (2006), who recorded 7.95%, shoot infestation with the treatment of neem oil 1%.

The Karanj oil 2% (T_2; 9.06%) showed least effectiveness in reducing per cent shoot

infestation but found to be superior over control (T_9; 10.29%).

Per cent fruit infestation by shoot and fruit borer, 3, 7 and 14 days after first spray (On number basis)

The data pertaining to per cent fruit infestation indicated (Table 2) that, all the treatments were significantly superior over control in suppressing fruit borer infestation. 3 DAT, the treatment of Spinosad 45 SC 0.01% (T_8) recorded the lowest (18.40%) infestation followed by Emamectin benzoate 5 SG 0.02% (T_7; 19.65%), Indoxacarb 15.8 EC 0.01% (T_5; 20.20%), Acetamiprid 20 SP 0.2 g/lit (T_6; 20.35%) and these treatments were statistically at par with the treatment of Spinosad 45 SC 0.01% (T_1). Priya and Mishra (2007) reported 7.74% fruit borer infestation with the treatment of spinosad 45% SC. Anil and Sharma (2010) recorded lowest fruit infestation with emamectin benzoate 5 SG 0.002%.

The next effective treatment was of *Bacillus thuringensis* 2 ml/l (T_4), which recorded 21.80% fruit infestation followed by Neem oil 2%(T_1; 22.10%) and NSE 5%(T_3; 23.01), Karanj oil 2% (T_2; 23.90%) and all these treatments were statistically at par with each other.

7 days after first spray, the treatment Spinosad 45 SC 0.01% (T_8) recorded the lowest (19.65%) infestation followed by Emamectin benzoate 5 SG 0.02% (T_7; 20.55%), Indoxacarb 15.8 EC 0.01% (T_5; 21.05%), Acetamiprid 20 SP 0.2 g/lit (T_6; 21.08%) and these treatment were statistically at par with the treatment of Spinosad 45 SC 0.01% (T_8).

The next promising treatments were of *Bacillus thuringensis* 2 ml/l (T_4; 22.04%), Neem oil 2% (T_1; 22.80%), NSE 5% (T_3; 23.60%) and Karanj oil 2% (T_2; 25.60%). The treatment regarding Karanj oil 2% (T_2) showed higher infestation 27.06 % but found to be superior over control (T_9), where 31.60% infestation was recorded. Puranik *et al.*, (2002) reported 11.78% fruit infestation with Dipel 8L.

Similar type of results were obtained 14 days after first spray in which the treatment Spinosad of 45 SC 0.01% (T_8) recorded the lowest (21.15%) infestation followed by Emamectin benzoate 5 SG 0.02% (T_7; 21.45%), Indoxacarb 15.8 EC 0.01% (T_5; 21.85%), Acetamiprid 20 SP 0.2 g/lit (T_6; 21.90%) and these treatments were statistically at par with the treatment of Spinosad 45 SC 0.01% (T_8).

In botanicals and biopesticide promising treatments were of *Bacillus thuringensis* 2 ml/l (T_4; 22.84%), Neem oil 2% (T_1; 22.90%), NSE 5% (T_3; 23.80%) and these treatments were statistically at par with the treatment of *Bacillus thuringensis* 2ml/l (T_4). The treatment regarding Karanj oil 2% (T_2) showed higher infestation 28.01% but found to be superior over control (T_9), where 31.60% infestation was recorded.

As the results on this parameter are also studied after second and third spray the results are not discussed here. They are discussed further in results obtained after second and third spray.

Per cent fruit infestation by shoot and fruit borer, 3, 7 and 14 days after second spraying (on number basis)

The results reported in Table 2 revealed that, all the treatments were found to be superior over control in reducing per cent fruit infestation, 3 DAT. The treatment of Spinosad 45 SC 0.01% (T_8) recorded the lowest fruit infestation (8.40%).

The next effective treatment in reducing per cent fruit infestation was of Emamectin

benzoate 5 SG 0.02% (T_7; 21.10%), Indoxacarb 15.8 EC 0.01% (T_5; 21.19%) followed by Acetamiprid 20 SP 0.2 g/lit, *Bacillus thuringensis* 2ml/l (T_4; 23.80%), Neem oil 2% (T_1; 24.80%) NSE 5% (T_3; 25.80%) and Karanj oil 2% (T_2; 27.10%). Priya and Mishra (2007) reported 7.74% fruit borer infestation with the treatment of spinosad 45% SC. Anil and Sharma (2010) recorded lowest fruit infestation with emamectin benzoate 5 SG 0.02% and Bajad *et al.*, (2011) registered lowest fruit damage 27.13% with Indoxacarb 0.007%. In treatment of Karanj oil (T_2) somewhat higher per cent fruit infestation of 27.10% was recorded but the treatment was found to be superior over control (T_8; 32.30%). Similar results on per cent fruit infestation were obtained 7 days after second spray and are discussed below.

The results showed that, the treatment of Spinosad 45 SC 0.01% (T_8) recorded lowest fruit infestation (9.50%).

The next promising treatments were of Emamectin benzoate 5 SG 0.02% (T_7; 21.15%), Indoxacarb 15.8 EC 0.01% (T_5; 23.54 %), Acetamiprid 20 SP 2 g/lit (T_6; 23.54) *Bacillus thuringensis* 2 ml/l (T_7; 23.90%), and Neem oil 2% (T_1; 25.12%) and all these treatments were statistically at par with the treatment of Emamectin benzoate 5 SG 0.02% (T_7). Malik and Lal (1989) reported the effect of neem oil 1 % and their findings are comparable with the results obtained during this study. Singh *et al.*, (1998) recorded 27.97% fruit infestation of *E.vittella* 8 DAT with the treatment of *Bt* which corroborate with the present findings.

Plate.1 Shoot infested by *Earias vittella*

Plate.2 Fruit infested by *Earias vittella*

Table.1 Cumulative per cent shoot infestation by shoot and fruit borer

Tr. No.	Treatments	R-I	R-II	R-III	Mean
T_1	Neem oil	9.24 (3.03)	8.13 (2.85)	8.94 (2.98)	8.83 (2.97)
T_2	Karanj oil	9.82 (3.13)	8.40 (2.89)	8.97 (2.99)	9.06 (3.00)
T_3	Neem Seed Extract	9.55 (3.09)	8.33 (2.88)	8.95 (2.99)	8.94 (2.98)
T_4	*Bacillus (B.t.)* (1×10^8 CFU)	9.01 (3.00)	8.35 (2.88)	8.19 (2.86)	8.51 (2.91)
T_5	Indoxacarb 15.8 E.C	7.18 (2.67)	7.77 (2.78)	7.55 (2.74)	7.50 (2.73)
T_6	Acetamiprid 20 S.P	8.13 (2.85)	7.47 (2.73)	8.18 (2.86)	7.92 (2.81)
T_7	Emamectine Benzoate 5 SG	6.64 (2.57)	7.56 (2.74)	7.08 (2.66)	7.09 (2.66)
T_8	Spinosad 45 SC	6.19 (2.48)	6.77 (2.60)	6.60 (2.56)	6.52 (2.55)
T_9	Control (Water spray)	10.30 (3.20)	10.07 (3.17)	10.50 (3.24)	10.29 (3.20)
"F" test		**Sig.**			
S.E.(m)±		**0.26**			
C.D at 5%		**0.78**			

(Figures in parenthesis are square root transformed values.)

Table.2 Mean per cent fruit infestation by shoot and fruit borer (on number basis)

Treatments	1st spray			2nd spray			3rd spray		
	3DAT	7DAT	14DAT	3DAT	7DAT	14DAT	3DAT	7DAT	14DAT
Neem oil	22.10 (28.04)	22.80 (28.52)	22.90 (28.59)	24.80 (29.86)	25.12 (30.07)	25.82 (30.53)	24.50 (29.66)	25.09 (30.05)	25.75 (30.49)
Karanj oil	23.90 (29.26)	25.60 (30.39)	28.01 (31.95)	27.10 (31.37)	28.85 (32.48)	30.10 (33.27)	26.10 (30.72)	27.80 (31.82)	30.01 (33.21)
Neem Seed Extract	23.01 (28.66)	23.60 (29.06)	23.80 (29.19)	25.80 (30.52)	26.30 (30.85)	27.70 (31.75)	24.70 (29.80)	26.10 (30.72)	27.50 (31.62)
Bacillus (B.t.) (1×10^8 CFU)	21.80 (27.83)	22.04 (27.99)	22.84 (28.54)	23.80 (29.19)	24.10 (29.40)	24.50 (29.66)	22.80 (28.52)	23.90 (29.26)	24.10 (29.40)
Indoxacarb 15.8 E.C	20.20 (26.70)	21.05 (27.30)	21.85 (27.86)	22.20 (28.11)	23.54 (29.02)	22.80 (28.52)	21.85 (27.86)	22.10 (28.04)	22.77 (28.50)
Acetamiprid 20 S.P	20.35 (26.81)	21.08 (27.33)	21.90 (27.90)	23.20 (28.79)	23.54 (29.02)	22.80 (28.52)	23.10 (28.72)	23.35 (28.89)	22.90 (28.59)
Emamectine Benzoate 5 SG	19.60 (26.27)	20.55 (26.95)	21.45 (27.59)	21.10 (27.34)	21.15 (27.38)	21.20 (27.41)	19.95 (26.52)	21.10 (27.34)	21.20 (27.41)
Spinosad 45 SC	18.40 (25.40)	19.65 (26.31)	21.15 (27.38)	8.40 (16.84)	9.50 (17.95)	11.70 (20.00)	7.80 (16.21)	8.50 (16.95)	10.70 (19.09)
Control (Water spray)	30.10 (33.27)	31.60 (34.20)	32.80 (34.93)	32.81 (34.94)	33.50 (35.36)	34.15 (35.75)	36.10 (36.92)	38.70 (38.46)	40.10 (39.28)
F Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SEm(±)	1.41	1.46	1.51	1.62	1.57	1.54	1.51	1.58	1.63
CD @ 5%	4.23	4.38	4.52	4.86	4.70	4.62	4.53	4.74	4.88

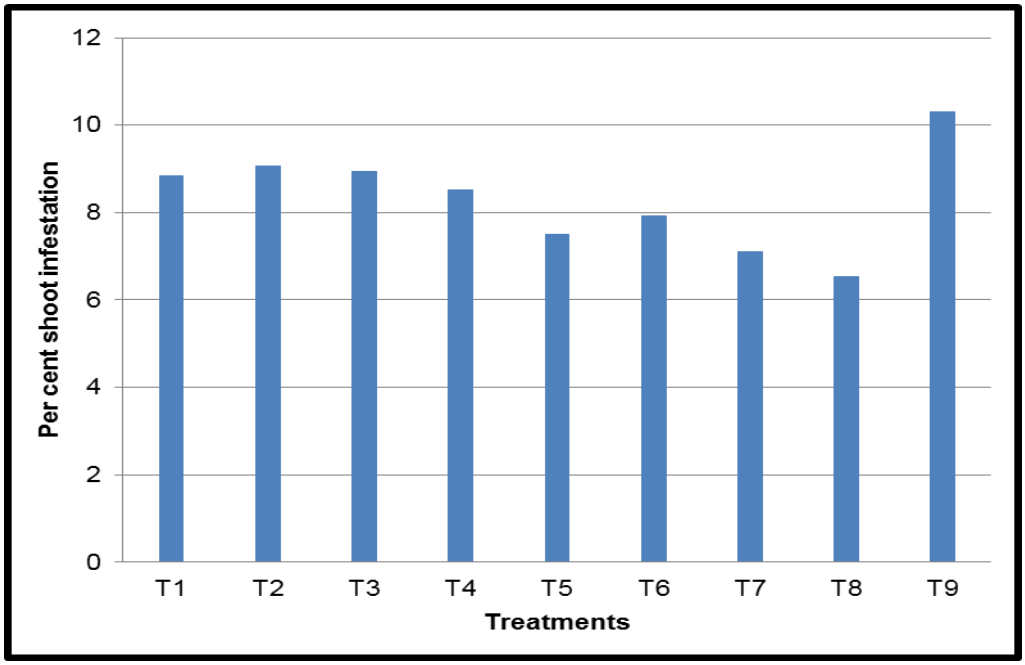
(Figures in parenthesis are arcs in transformed values.)

Table.3 Cumulative per cent fruit infestation by shoot and fruit borer (On number basis)

Tr. No.	Treatments	R-I	R-II	R-III	Mean
T_1	Neem oil	24.34 (29.56)	22.85 (28.55)	26.64 (31.07)	24.61 (29.74)
T_2	Karanj oil	25.48 (30.31)	30.67 (33.62)	29.75 (33.05)	28.63 (32.34)
T_3	Neem Seed Extract	24.64 (29.76)	25.27 (30.17)	27.15 (31.40)	25.68 (30.44)
T_4	*Bacillus (B.t.)* (1×10^8 CFU)	22.34 (28.20)	22.08 (28.02)	26.56 (31.02)	21.86 (27.87)
T_5	Indoxacarb 15.8 E.C	21.38 (27.54)	20.98 (27.26)	21.18 (27.40)	22.97 (28.63)
T_6	Acetamiprid 20 S.P	21.93 (27.92)	22.02 (27.98)	23.21 (28.80)	22.38 (28.23)
T_7	Emamectine Benzoate 5 SG	18.39 (25.39)	20.85 (27.16)	19.77 (26.39)	19.67 (26.32)
T_8	Spinosad 45 SC	13.54 (21.59)	13.02 (21.15)	11.93 (20.20)	12.83 (20.98)
T_9	Control (Water spray)	33.67 (35.46)	36.99 (37.45)	32.57 (34.79)	34.41 (35.91)
"F" test		**Sig.**			
S.E.(m)±		**0.96**			
C.D at 5%		**2.90**			

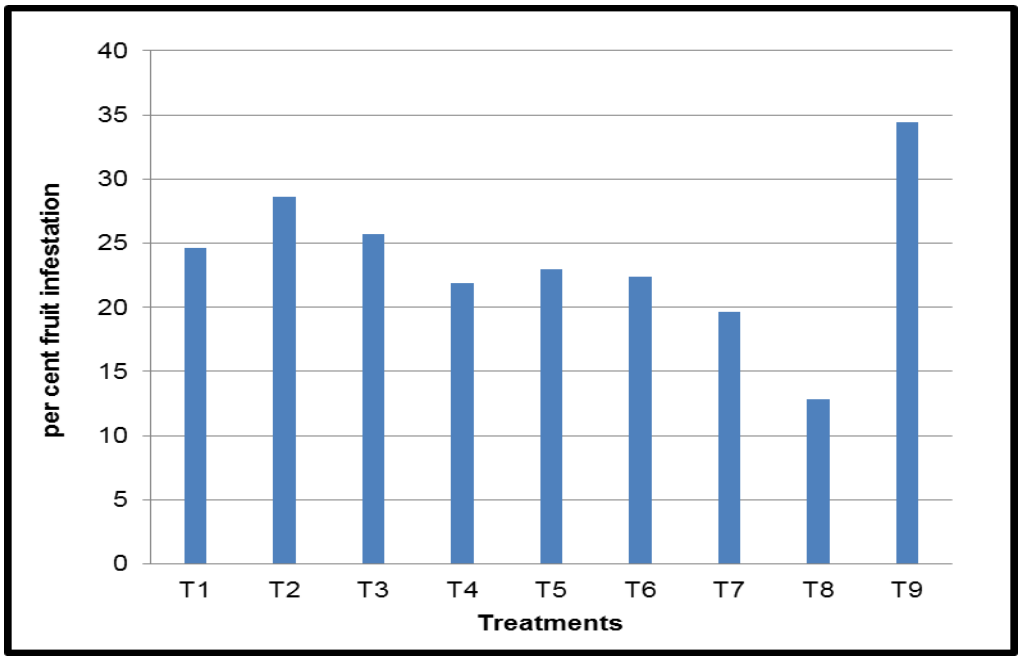
(Figures in parenthesis are arcs in transformed values.)

Fig.1 Cumulative per cent shoot infestation by shoot and fruit borer



T_1 = Neem oil – 2%; T_2 = Karanj oil – 2%; T_3 = NSE – 5%; T_4 = *Bacillus thuringiensis* – 2 ml/lit; T_5 = Indoxacarb 15.8 EC – 0.01%; T_6 = Acetamiprid 20 SP – 0.2 g/lit; T_7 = Emamectin Benzoate 5 SG – 0.02%; T_8 = Spinosad 45 SC – 0.01%; T_9 = Control (water spray)

Fig.2 Cumulative per cent fruit infestation by shoot and fruit borer (on number basis)



T_1 = Neem oil – 2%; T_2 = Karanj oil – 2%; T_3 = NSE – 5%; T_4 = *Bacillus thuringiensis* – 2 ml/lit; T_5 = Indoxacarb 15.8 EC – 0.01%; T_6 = Acetamiprid 20 SP – 0.2 g/lit; T_7 = Emamectin Benzoate 5 SG – 0.02%; T_8 = Spinosad 45 SC – 0.01%; T_9 = Control (water spray)

The treatment of Karanj oil 2% (T_2) recorded 28.85% fruit infestation but found to be superior over control (T_9; 33.50%).Reddy and Srinivasa (2001) recorded 11.40% fruit damage with pungam oil 2%.

Similar types of results were obtained 14 days after second spray in which the treatment of Spinosad 45 SC 0.01% (T_8) recorded the lowest (11.70%) infestation. Next promising treatment was of Emamectin benzoate 5 SG 0.02% (T_7; 21.20%) followed by Indoxacarb 15.8 EC 0.01% (T_5; 22.80%), Acetamiprid 20 SP 0.2 g/lit (T_6; 22.80%) and these treatments were statistically at par with the treatment of Emamectin benzoate 5 SG 0.02% (T_7).

In botanicals and biopesticide promising treatments were of *Bacillus thuringensis* 2 ml/l (T_4; 24.50%), Neem oil 2% (T_1; 25.82%), NSE 5% (T_3; 27.70%) and these treatments were statistically at par with the treatment of *Bacillus thuringensis* 2 ml/l (T_4). The treatment regarding Karanj oil 2% (T_2) showed higher infestation 30.10% but found to be superior over control (T_9), where 34.15% infestation was recorded.

Per cent fruit infestation by shoot and fruit borer, 3, 7 and 14 days after third spray (on number basis)

It was evident from that, all treatments were superior over control in minimizing the shoot and fruit borer infestation, 3 DAT. The lowest infestation of fruit borer was recorded with the treatment of Spinosad 45 SC 0.01% (T_8; 7.80%). The second best treatment was of Emamectin benzoate 5 SG 0.02% (T_7; 19.95%) and third one was of Indoxacarb 15.8 EC 0.01% (T_5; 21.85%).

The next effective treatments were of Acetamiprid 20 SP 0.2 g/lit (T_6; 23.10%) *Bacillus thuringensis* 2ml/l (T_4; 22.80%), Neem oil 2% (T_1; 24.50), NSE 5% (T_3; 24.70%) and Karanj oil 2% (T_2; 26.10%) and all these treatments were equally effective in reducing fruit infestation. The result of NSE 5% (T_3) confirm the finding of Ambekar *et al.*, (2000). They recorded 27.25% infestation of *E. vittella*. The result of neem oil 2% (T_1) confirm the findings of Malik and Lal (1989). The result on efficacy of *Bacillus thuringensis* 2 ml/l (T_4) confirm the findings of Kharbade *et al.*, (1999).

The treatment of Karanj oil (T_2; 26.10%) was found to be least effective but found to be superior over control (T_8; 36.10%). The results on Karanj oil (T_2) confirm the findings of Srinivasa rao *et al.*, (2002) and Reddy and Srinivasa (2001).

The data pertaining to per cent fruit infestation 7 days after third spray indicated that, all the treatments were superior over control in suppressing the fruit borer infestation. The treatment Spinosad 45 SC 0.01% (T_8) recorded lowest (8.50%) fruit infestation followed by Emamectin benzoate 5 SG 0.02% (T_7; 21.10%). Next best treatments were of Indoxacarb 15.8 EC 0.01% (T_5; 22.10%) and Acetamiprid 20 SP 0.2 g/lit (T_6; 23.35%) and these treatments were found to be statistically at par with each other.

The next effective treatments were of *Bacillus thuringensis* 2ml/l (T_4; 23.90%), Neem oil 2% (T_1; 25.09%), NSE 5% (T_3; 26.10%) and Karanj oil 2% (T_2; 27.80%) and all these treatments were statistically comparable with each other. The findings of NSE 5% (T_3) confirm the findings of Sarode and Gabhane (1994). They reported 27.25% fruit infestation of *E.vittella* with the treatment of NSE 5%. The result on efficacy of neem oil 2% (T_1) agree with the findings of Malik and Lal (1989) and the result on efficacy of *Bacillus thuringensis* var. kurstaki 2ml/l (T_4) agree with the findings of Kharbade *et al.*, (1999) and Singh *et al.*, (1998).

The treatment of Karanj oil 2% (T_2; 27.80%) found to be least effective but superior over control (T_9; 38.70%). The result on Karanj oil 2% (T_2) confirm the results of Srinivasa rao *et al.,* (2002) and Reddy and Srinivasa (2001) for brinjal shoot and fruit borer *L. orbonalis*.

Similar types of results were obtained 14 days after third spray in which the treatment of Spinosad 45 SC 0.01% (T_8) recorded the lowest (10.70%) infestation. Next promising treatments were of Emamectin benzoate 5 SG 0.02% (T_7; 21.20%), Indoxacarb 15.8 EC 0.01% (T_5; 22.77%), Acetamiprid 20 SP 0.2 g/lit (T_6; 22.90%), *Bacillus thuringensis* 2 ml/l (T_4; 24.10%) and these treatment were statistically at par with the treatment of Emamectin benzoate 5 SG 0.02% (T_7)

In botanicals promising treatments were of, Neem oil 2% (T_1; 25.75%), NSE 5% (T_3; 27.50%) and these treatments were statistically at par with each other.

The treatment regarding Karanj oil 2% (T_2) showed higher infestation 30.07% but found to be superior over control (T_9), where 31.60% infestation was recorded.

Cumulative per cent fruit infestation by shoot and fruit borer (on number basis)

The cumulative per cent fruit infestation of all pickings presented in (Table 3) and illustrated in figure 2 revealed that, all the treatments were significantly superior over control (T_9). Among these different treatments, Spinosad 45 SC 0.01% (T_8) was found to be the most promising one, which consistently maintained lowest fruit infestation throughout the period of experimentation with the average of 12.86% infestation. The next promising treatment was of Emamectin benzoate 5 SG 0.02% (T_7; 20.81%), Indoxacarb 15.8 EC 0.01% (T_5; 22.04%), Acetamiprid 20 SP 0.2 g/lit (T_6; 22.46), *Bacillus thuringensis* 2 ml/l (T_4) in which 23.32% infestation was observed.

The remaining treatments in descending order of efficacy were, Neem oil 2% (T_1; 24.32%) and NSE 5% (T_3; 25.39%) which were comparable with each other in reducing per cent fruit infestation. Our findings on NSE 5% (T_3) agree with the results of Singh *et al.,* (1998). They recorded 27.84% fruit infestation 4 days after treatment NSE (100%). The findings on efficacy of neem oil 2% (T_1) corroborate with the results of Singh *et al.,* (1998). They recorded 27.98% fruit infestation of *E.vittella* with the treatment neem seed oil (1kg/ha). The results on efficacy of *Bacillus thuringensis* 2 ml/l (T_4) agree with studies of Singh *et al.,* (1998). They reported 25.14% fruit infestation of *E.vittella* with the treatment of *Bt* Var. Kurstaki 1.5 kg a.i./ha.

The treatment Karanj oil 2% (T_2) recorded 27.49% fruit infestation and this treatment was found to be least effective. The results on Karanj oil 2% (T_6) could not be discussed for want of supporting literature.

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