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Efficacy of bio-insecticides and botanicals against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee)

Ankur Prakash Verma, Umesh Chandra, Anuj Shakya, Reetesh Pratap Singh, Bhupendra Singh and Khursheed Alam

Abstract
The present investigation was carried out during the Kharif season, 2017-18 at Student's Instructional Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P) to study the efficacy of bio-insecticides and botanicals against brinjal shoot and fruit borer (Leucinodes orbonalis Guenee). The bio-insecticides and botanicals tested were: Emamectin benzoate 5 SG @ 75 g a.i/ha, Spinosad 45 SL @ 18 g a.i/ha, NSKE 5%, Karanj seed extract 5%, Onion extract 5%, Garlic extract 5%, Tobacco extract 5%, Cannabis (bhang) leaf extract 5%, Wood ash 10 g/ plant and compared with control. Results showed that Emamectin benzoate 5 SG (75 g a.i/ha) treated plots showed lowest infestation and gave higher fruit yield (313.85 q/ha) followed by Spinosad 45 SL (18 g a.i/ha) and NSKE (5%) which gave 300.58 and 284.33 q/ha fruit yield respectively. The least effective treatment was Wood ash (10 g/plant) and yielded only 225.14 q/ha healthy fruits. The maximum cost-benefit ratio was obtained from Emamectin benzoate 5 SG 75 g a.i/ha (1:21.23) treated plots. Tobacco leaf extract 5% treated plots though ecofriendly but gave least cost-benefit ratio (1:1.27). This study recommends the use of bio-insecticides and botanicals as they are significantly efficient in managing the brinjal shoot and fruit borer infestation.

Keywords: bio-insecticides, botanicals, Brinjal shoot and fruit borer, *Leucinodes orbonalis*

Introduction
Brinjal (*Solanum melongena* L.) is one of the widely used vegetable crop and popular in many parts of the world *viz.*, Central, South and South East Asia, some parts of Africa and Central America (Harish *et al.*, 2011) [9]. It is one of the major vegetable crops in India extensively grown under diverse agro-climatic conditions throughout the year. The area of cultivation under brinjal in India is 728 thousand hectares with production of 12.66 lakh metric tons (Anonymous, 2019) [3].

Shoot and fruit borer, *Leucinodes orbonalis* Guenee is the key pest of brinjal causing enormous damage in all brinjal growing areas. It is an internal borer which damages the tender shoots and fruits. Adult moth having dirty whitish wings and speckled markings lays eggs on young leaves/ flowers/ calyx of the fruits. After hatching the larvae starts boring into the petiole/ midrib of the leaves/ growing shoots/ flower buds/ fruits and closes the bore hole with frays. After entering, it will feed inside the midribs/ flower/ ovary of flower and the pulp of fruit. The damaged shoots and the flowers droop down and the damaged fruits get rotten from inside. This reduces plant growth, which in turn, reduces fruit number and size. The entry hole on the fruits is not visible as they get smaller due to increase in size of fruits while a small depression can be often observed. Only the large and more round exit holes are visible on the fruits. Such fruits lose their market value.

Several insecticides belonging to various groups such as organophosphates, organochlorines, carbamates as well as many newer molecules like diamides, neonicotinoids, spinosyns, pyrethroids, phenyl pyrazoles, avermectins, oxadiazones and their combinations have been recommended for management of this pest in various parts of country (Patra *et al.*, 2018; Singh, 2018; Sarnabati and Ray, 2017; Islam *et al.*, 2016; Patra *et al.*, 2009) [15, 22, 19, 10, 14]. Farmers largely follow the chemical management method in order to get quick results which invited the problems of pesticide resistance, secondary pest outbreak, residual toxicity, toxicity to beneficial organisms and resurgence. The current pesticide use is not only non-sustainable but, if continued, it will adversely affect eggplant and other vegetable production (Mathur *et*

al., 2012b) [13]. There have been several reports that strongly recommends the use of various botanicals and bio-insecticides for managing the brinjal shoot and fruit borer population (Dehariya *et al.*, 2016; Ashadul *et al.*, 2014; Malsawmzuali *et al.*, 2013; Kalawate and Dethe, 2012; Rahman *et al.*, 2009b) [7, 5, 12, 11, 17]. The present investigation was undertaken in order to highlight the potential of various botanicals and pesticides of biological origin for managing the population of brinjal shoot and fruit borer under field conditions.

Methods and Materials

The present investigation was conducted during *Kharif* season 2017-18 at Student's Instructional Farm, N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.), India (26.47 ^{0}N; 82.12 ^{0}E). Twenty-four days old seedlings (3 to 4 leaves stage) were transplanted by adopting recommended agronomic practices in the fields according to the plan of experiment with 60 cm x 45 cm spacing. The brinjal variety used is NDB-2 (Narendra deva brinjal- 2). The design used in the experiment is Randomized Block Design (RBD). Foliar application of different treatments was applied with the help of manually operated knapsack sprayer. The insecticides to be applied in the given area was worked out through following formula:

$$\text{Amount of Insecticide required (Kg/ha)} = \frac{\text{Total spray required (L)X Strength\% of required solution}}{\text{Given\% strength of insecticides}}$$

Brinjal crop was monitored regularly for recording occurrence of brinjal shoot and fruit borer and thereby managing the pest at Economic threshold level (> 5% shoot or fruit damage). The bio-insecticides and botanicals tested were: Emamectin benzoate 5 SG @ 75 g a.i/ha, Spinosad 45 SC @ 18 g a.i/ha, NSKE 5%, Karanj seed extract 5%, Onion extract 5%, Garlic extract 5%, Tobacco extract 5%, Cannabis leaf extract 5%, Wood ash 10 g/ plant and compared with control. Pre-treatment observation was taken 1 day before spraying and post treatment observations were taken on 7th, 10th and 14th days after spraying. Percent shoot and fruit infestation was worked out by using following formula:

$$\text{Percent shoot Infestation (\%)} = \frac{\text{Number of infested shoots}}{\text{Number of total shoots}} \text{ X } 100$$

$$\text{Percent fruit Infestation (\%)} = \frac{\text{Number of infested fruits}}{\text{Number of total fruits}} \text{ X } 100$$

The fruit yield was taken on individual plot basis in kg/plot, which were converted into q (quintal)/ha for making comparison between treatments to evaluate the effectiveness of treatments against shoot and fruit borer. The cost benefit ratio was determined for each treatment by using the following formula (Rahman *et al.*, 2009a) [16]:

$$\text{Cost: benefit ratio} = \frac{\text{Value of saved yield over control (Rs/ha)}}{\text{Total cost of treatment application (Rs/ha)}}$$

Data analysis: Data on shoot and fruit damage was analyzed by using one way analysis of variance (ANOVA). Appropriate transformation is applied with a randomized block design through the online OP-STAT software (Sheoran *et al.*, 1998) [20]. The means that differed significantly were separated by least significant difference (LSD) at p= 0.05. Standard error of the Mean can be calculated through following formula:

$$\text{SEM} = \frac{\sigma}{\sqrt{n}}$$

Where,
σ = Standard deviation
n = number of observations

Results and Discussion

Effect of bio-insecticides and botanicals-

Shoot infestation

As per the findings, the minimum shoot infestation was recorded in case of Emamectin benzoate 5 SG after both 1st (2.68, 3.66 and 4.69 per cent) and 2nd spray (4.78, 4.25 and 4.88 per cent) at 7, 10 and 14 days after spraying respectively (table 1). It was followed by Spinosad 45 SC > NSKE 5% > Karanj seed extract 5% > Onion extract 5% > Garlic extract 5% > Tobacco extract 5% > Cannabis leaf extract 5% > Wood ash and compared to control. All the treatments were found effective and significantly superior over the control (fig 1).

Table 1: Effect of bio-insecticides & botanicals against shoot damage by brinjal shoot and fruit borer based on per cent during *Kharif* season, 2017-18

S. No.	Treatments	Pre treatment (1 DBS)	Per cent shoot damage 1st spray			Pre treatment (1DBS)	Per cent shoot damage 2nd spray		
			7 DAS	10 DAS	14 DAS		7 DAS	10 DAS	14 DAS
T_1	Spinosad 45 SL	8.61 (3.09)*	3.87(2.20)	5.07 (2.46)	6.51(2.74)	8.09(3.01)	5.85 (2.61)	5.51 (2.55)	6.15 (2.67)
T_2	Emamectin benzoate 5 SG	7.85 (2.97)	2.68(1.91)	3.66 (2.15)	4.69(2.38)	7.14(2.85)	4.78 (2.40)	4.25 (2.29)	4.88 (2.42)
T_3	NSKE	7.34 (2.88)	4.90(2.42)	6.37 (2.71)	7.64(2.93)	8.04(3.00)	6.30 (2.70)	5.97 (2.64)	6.38 (2.71)
T_4	Garlic extract	9.41 (3.22)	6.98(2.82)	7.68 (2.94)	8.92(3.14)	8.93(3.15)	7.17 (2.85)	6.80 (2.79)	7.22 (2.86)
T_5	Onion extract	9.22 (3.19)	6.75(2.78)	7.31 (2.88)	8.57(3.09)	9.00(3.16)	7.35 (2.88)	6.96 (2.82)	7.19 (2.86)
T_6	Karanj seed extract	10.33 (3.36)	5.61(2.57)	5.73 (2.59)	7.00(2.82)	7.86(2.97)	6.44 (2.72)	6.25 (2.69)	6.46 (2.73)
T_7	Tobacco leaf extract	10.11 (3.32)	7.24(2.87)	7.78 (2.96)	8.60(3.09)	8.43(3.07)	7.48 (2.91)	7.11 (2.84)	7.32 (2.88)
T_8	Cannabis leaf extract	10.34 (3.36)	8.25(3.04)	9.36(3.21)	9.94(3.30)	9.80(3.28)	8.38 (3.06)	8.07 (3.01)	8.29 (3.04)
T_9	Wood ash	11.27 (3.50)	9.22(3.19)	9.75(3.27)	10.44(3.38)	10.45(3.38)	9.14 (3.18)	8.74 (3.12)	8.84 (3.13)
T_{10}	Control (water spray)	11.37 (3.51)	12.8(3.71)	13.47(3.80)	13.09(3.75)	12.84(3.71)	13.17(3.76)	12.90(3.72)	12.72(3.70)
SEM		0.43	0.31	0.33	0.28	0.25	0.25	0.25	0.25
CD at 5% level		1.29	0.93	1.01	0.85	0.75	0.77	0.77	0.77

*Figures under parentheses () are square root transformed values
DBS- Day before spraying
DAS- Days after spraying
SEM- Standard error of the mean
CD 5% level - Critical difference at 5% level of significance

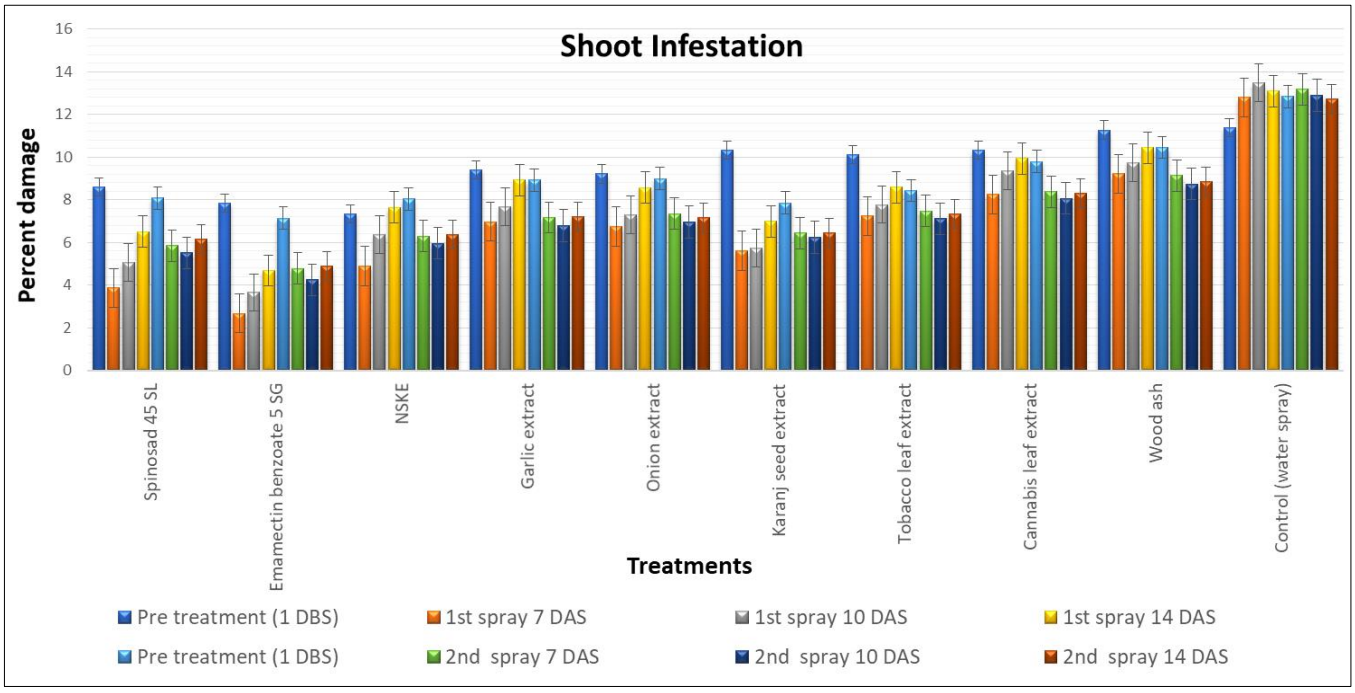

Fig 1: Effect of bio-insecticides & botanicals against shoot damage by brinjal shoot and fruit borer based on per cent during *Kharif* season, 2017-18

Fruit infestation

Different treatment evaluated showed significant results in managing the fruit damage by brinjal shoot and fruit borer. Out of different treatments, Emamectin benzoate 5 SG recorded lowest infestation of 3.78, 4.36 and 5.15 per cent after 1st spray and 4.67, 4.17 and 5.10 per cent after 2nd spray at 7, 10 and 14 days after spraying respectively (table 2). It was followed by Spinosad 45 SC which recorded 4.90, 5.53 and 6.05 per cent infestation after 1st application and 5.81, 5.22 and 6.13 per cent after 2nd application. Botanicals were also found to be significant in managing the pest population. Among botanicals NSKE 5% showed lowest infestation followed by Karanj seed extract 5%, Onion extract 5%, Garlic extract 5%, Tobacco extract 5%, Cannabis leaf extract 5% and Wood ash (fig 2).

Table 2: Effect of bio-insecticides & botanicals against fruit damage by brinjal shoot and fruit borer based on per cent during *Kharif* season, 2017-18

S. No.	Treatments	Pre treatment (1 DBS)	Per cent fruit damage 1st spray			Pre treatment (1DBS)	Per cent fruit damage 2nd spray		
			7 DAS	10 DAS	14 DAS		7 DAS	10 DAS	14 DAS
T_1	Spinosad 45 SL	8.83 (3.13)*	4.90(2.42)	5.53(2.55)	6.05(2.65)	8.51(3.08)	5.81(2.60)	5.22(2.49)	6.13(2.66)
T_2	Emamectin benzoate 5 SG	8.15 (3.02)	3.78(2.18)	4.36(2.31)	5.15(2.48)	7.63(2.93)	4.67(2.38)	4.17(2.27)	5.10(2.47)
T_3	NSKE	7.59 (2.93)	5.51(2.55)	6.08(2.66)	6.52(2.74)	8.59(3.09)	6.54(2.74)	5.99(2.64)	6.65(2.76)
T_4	Garlic extract	9.51 (3.24)	7.82(2.97)	8.28(3.04)	8.59(3.09)	9.36(3.21)	7.56(2.92)	7.11(2.84)	7.69(2.94)
T_5	Onion extract	9.48 (3.23)	7.65(2.94)	7.88(2.97)	8.43(3.07)	9.22(3.19)	7.46(2.90)	6.81(2.79)	7.58(2.93)
T_6	Karanj seed extract	10.13 (3.33)	6.37(2.71)	6.92(2.81)	7.30(2.88)	8.78(3.12)	6.95(2.82)	6.14(2.67)	6.96(2.82)
T_7	Tobacco leaf extract	10.07 (3.32)	8.24(3.04)	8.65(3.10)	9.08(3.17)	9.96(3.31)	8.06(3.01)	7.51(2.91)	8.29(3.04)
T_8	Cannabis leaf extract	10.21 (3.34)	9.08(3.17)	9.36(3.21)	9.88(3.29)	10.64(3.41)	8.90(3.14)	8.17(3.02)	8.90(3.14)
T_9	Wood ash	11.14 (3.48)	9.79(3.28)	10.00(3.31)	10.54(3.39)	11.17(3.48)	9.54(3.24)	8.89(3.14)	9.59(3.25)
T_{10}	Control (water spray)	11.49 (3.53)	11.61(3.55)	12.21(3.63)	12.57(3.68)	13.18(3.76)	13.12(3.75)	13.26(3.77)	13.67(3.82)
SEM		0.34	0.17	0.17	0.16	0.17	0.16	0.15	0.21
CD at 5% level		1.02	0.51	0.51	0.50	0.52	0.48	0.45	0.65

*Figures under parentheses () are square root transformed values
DBS- Day before spraying
DAS- Days after spraying
SEM- Standard error of the mean
CD 5% level - Critical difference at 5% level of significance

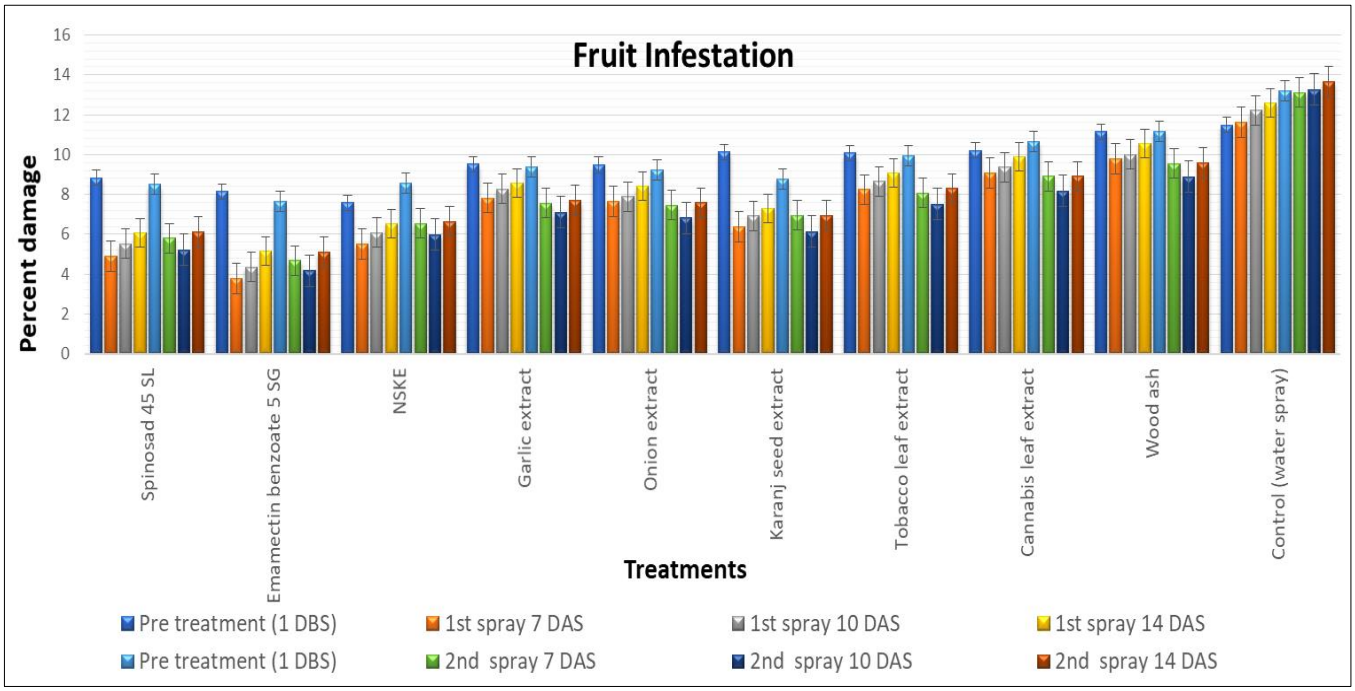

Fig 2: Effect of bio-insecticides & botanicals against fruit damage by brinjal shoot and fruit borer based on per cent during *Kharif* season, 2017-18

Yield

As it is evident from the table 3 and fig 3 that the highest fruit yield was observed from the plot treated with Emamectin benzoate 5 SG i.e., 313.85 q/ha. It was followed by Spinosad 45 SC which recorded 300.58 q/ha. of fruit yield. Next best treatment was NSKE 5% (284.33 q/ha.) followed by Karanj seed extract 5% (270.63 q/ha.), Onion extract 5% (260.12 q/ha.), Garlic extract 5% (251.81 q/ha.), Tobacco extract 5% (246.52 q/ha.), Cannabis leaf extract 5% (232.01 q/ha.) and Wood ash (225.14 q/ha.) as compared to control which recorded 207.70 q/ha. of fruit yield.

Table 3: Yield, economics and cost-benefit ratio of the treatments against brinjal shoot and fruit borer during *Kharif* season, 2017-18

S. No.	Treatments	Total quantity of insecticide required (lit/kg/ha)	Cost of insecticide (Rs./lit/kg)	Total cost of insecticides (Rs.)	Cost of treatment application (Rs./ha)*	Yield (q/ha)	Saved yield over control (q/ha)	Value of saved yield (Rs./ha)	Gross Income (Rs./ha)	Cost-benefit ratio
T_1	Spinosad 45 SL	0.36	15000	5400	5900	300.58	92.88	92880	300580	1:15.74
T_2	Emamectin benzoate 5 SG	0.50	9000	4500	5000	313.85	106.15	106150	313850	1:21.23
T_3	NSKE	25	400	10000	10500	284.33	76.63	76630	284330	1:7.29
T_4	Garlic extract	25	600	15000	15500	251.81	44.11	44110	251810	1:2.84
T_5	Onion extract	25	600	15000	15500	260.12	52.42	52420	260120	1:3.38
T_6	Karanj seed extract	25	300	7500	8000	270.63	62.93	62930	270630	1:7.86
T_7	Tobacco leaf extract	15	2000	30000	30500	246.52	38.82	38820	246520	1:1.27
T_8	Cannabis leaf extract	25	500	12500	13000	232.01	24.31	24310	232010	1:1.87
T_9	Wood ash	740	10	7400	7900	225.14	17.44	17440	225140	1:2.20
T_{10}	Control (water spray)	-	-	-	-	207.70	-	-	207700	-

*Includes cost of labours and cost of insecticides
Labour charge @ Rs. 250/day
Selling price of the produce @ Rs. 1000/q

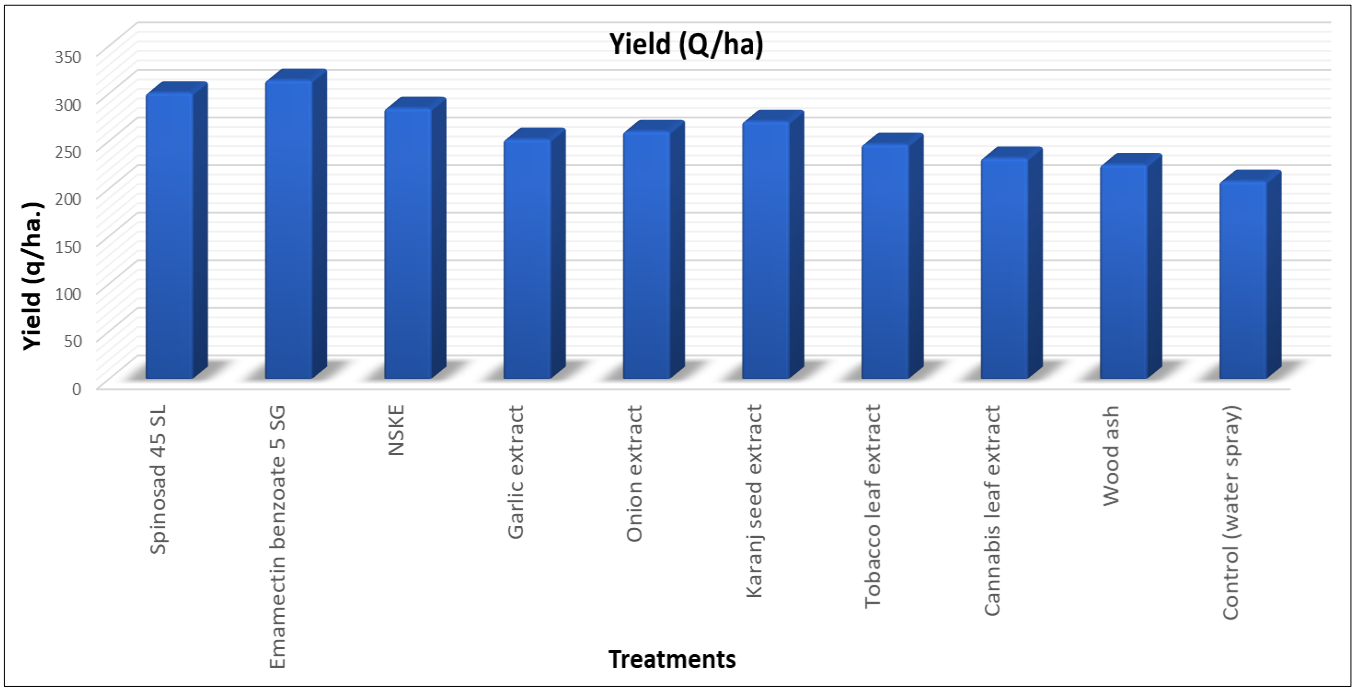

Fig 3: Yield of brinjal fruits under different treatments during *Kharif* season, 2017-18

Economics of treatments

The most economical treatment observed during the course of study was Emamectin benzoate 5 SG as it showed the highest cost-benefit ratio as compared to other treatments i.e., 1:21.23 (table 3 and fig 4). It was followed by Spinosad 45 SC which recorded cost to benefit ratio of 1:15.74. Different trend was observed in case of botanicals, Karanj seed extract 5% was the most economical treatment among the botanicals which showed 1:7.86 cost to benefit ratio followed by NSKE 5% (1:7.29) > Onion extract 5% (1:3.38) > Garlic extract 5% (1:2.84) > Wood ash (1:2.20), Cannabis leaf extract 5% (1:1.87) and Tobacco extract 5% (1:1.27).

The present study revealed that the bio-insecticide, Emamectin benzoate 5 SG was found to be most effective against brinjal shoot and fruit borer. Lowest shoot and fruit infestation, high yield and maximum cost-benefit ratio was observed in case of plots treated with Emamectin benzoate 5 SG followed by Spinosad 45 SC. The results suggested that the use of bio-insecticides (insecticides derived from the biological origin) is most suitable for the management of brinjal shoot and fruit borer population. The study finds support from the findings of Singh *et al.* (2016) [21] who found that Emamectin benzoate 5 SG @ 12.5g a.i./ha treated plots showed lowest infestation and gave higher fruit yield (253.12) followed by Spinosad 45 SC @ 73g a.i./ha. Maximum fruit yield was also noted in case of plots treated with Emamectin benzoate 5 SG. Similarly, Anwar *et al.* (2015) [4] reported that Emamectin benzoate was most effective against brinjal fruit borer and resulted in lower infestation (40.1%). They recommend the use of Emamectin benzoate for effective control of brinjal fruit borer. Similarly, the total number of drooping shoots was minimum (4.17) in Emamectin benzoate as compared to Spinosad (9.17). In terms of reduction in fruit infestation, Emamectin benzoate (0.002%) was highly effective followed by Spinosad (0.0024%) (Anil and Sharma, 2010) [2]. Similarly, Ghosal *et al.* (2013) [8] observed that most effective treatment was Emamectin benzoate @ 18 g a.i./ha. (8.63% shoot and 15.73% fruit infestation in brinjal and 5.61% mean shoot and fruit infestation in okra) followed by spinosad @ 75 g a.i. ha-1 (9.39, 16.21 and 5.87%).

Contradictory to the present study, Awal *et al.* (2017) [6] found that Tracer-45 SC was found to be highly effective in reducing 88.22% and 84.41% shoot infestation over control during summer and winter, respectively followed by Proclaim-5 SG (74.12% in summer and 64.36% in winter). The highest number of healthy fruits per plant (22.38 in summer and 35.69 in winter, respectively) and the highest yield of eggplant per hectare (19.94 t/ha in summer and 24.79 t/ha in winter) were obtained from Tracer-45 SC treated plots. Similarly, Al Mamun *et al.* (2014) [1] found that Spinosad (libsen 45SC) was most effective against shoot and fruit borer damage. The minimum percent of shoot infestation at first spray and percent fruit infestation at second spray were observed in Spinosad with 4.78% and 6.38% respectively. Spinosad recorded significantly highest marketable fruit yield of 222.0 q/ha followed by other botanicals (Sahana and Tayde, 2017) [18]. Similarly, the findings of Kalawate and Dethe (2012) [11] suggested that both Spinosad and Emamectin benzoate were effective in managing the shoot and fruit borer population. They found that Spinosad 72 g a.i./ha. treated plot showed lowest fruit infestation. They also reported that NSKE 5% crude extract was also effective against brinjal shoot and fruit borer as compared to untreated control. Similarly, the lowest mean shoot as well as fruit infestation (7.47 and 9.88%) was recorded in the plots treated with spinosad 2.5 SC (50 g a.i./ha) followed by emamectin benzoate 5 SG 15 g a.i./ha. (10.95 and 16.66%), respectively (Patra *et al.*, 2009) [14].

Present study suggested that the use of various botanicals against brinjal shoot and fruit borer found to be effective. It resulted in lowering the shoot and fruit damage and in turn leads to respectable fruit yield. Among botanicals NSKE 5% showed lowest infestation followed by Karanj seed extract 5%, Onion extract 5%, Garlic extract 5%, Tobacco extract 5%, Cannabis leaf extract 5% and Wood ash. They were less effective as compared to bio-insecticides. Similar results were reported by Ashadul *et al.* (2014) [5] who found that Neem leaf extract had highest number of total shoots, healthy shoots, total fruits, healthy fruits and fruit yield. Dehariya *et al.* (2016) [7] evaluated several botanical pesticides and found that

all treatments were effective as compared to untreated control. Among them Neem oil 1% treated plots recorded lowest shoot and fruit damage followed by NSKE 3%, Karanj oil 1%. Contrary to the present study, Sultana *et al.* (2018) [23] observed that Neem oil (71.90%, 44.30% and 69.50%) was found to be more effective in lowering the fruit infestation over control at different fruiting stages *viz.* Early, mid and late fruiting stage respectively. Tobacco leaf extract (57.40%, 58.20% and 58.70%) is the next best treatment followed by Neem leaf extract (43.90%, 41.10% and 38.90%). The lowest percent fruit infestation reduction over control was found in garlic extract (17.40%, 9.06% and 9.80%). Similarly, Rahman *et al.* (2009b) [17] who reported that highest shoot and fruit infestation reduction was found in case of neem oil + neem cake treated plots followed by neem oil and karanj oil. The least effective treatment was neem cake. Contradictory to the present study, Malsawmzuali *et al.* (2013) [12] evaluated several ecofriendly insecticides *viz.*, juice of garlic (18g), ginger (9g) and chilli (9g) mixture @ 3ml/lit; ash dust @ 100g and 150g/plant; tobacco extract @ 2ml and 3 ml/lit; neem oil @ 2ml and 3 ml/lit. Among them the best treatment was Tobacco extract @ 3ml/lit followed by ash dust @ 150 g/plant.

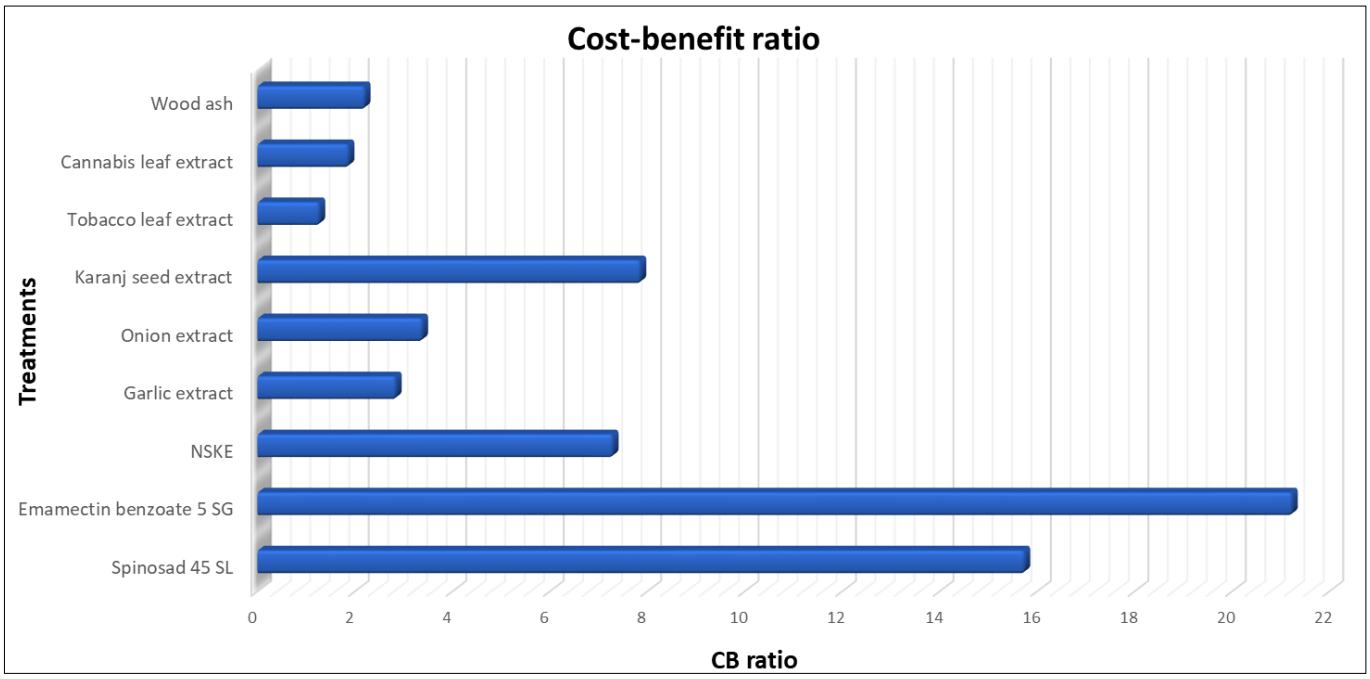

Fig 4: Cost-benefit ratio of the treatments against brinjal shoot and fruit borer during *Kharif* season, 2017-18

Conclusion

Thus, it is concluded from the present study that the newer molecules of pesticides that are derived from the biological origin like emamectin benzoate and spinosad were effective in managing the brinjal shoot and fruit borer population. They also gave the highest fruit yield and were economically better than other treatments. The effectiveness of various bio-insecticides and botanicals were as follows: Emamectin benzoate 5 SG > Spinosad 45 SC> NSKE 5% > Karanj seed 5% > Onion extract 5% > Garlic extract 5% > Tobacco extract 5% > Cannabis leaf extract 5% > Wood ash 10 g/plant. Different botanicals applied were also superior over control. Based on the present investigation we recommend the use of bio-insecticides and botanicals for management of brinjal shoot and fruit borer.

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