International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 2429-2433

Received: 08-07-2019
Accepted: 12-08-2019

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Evaluation of alternative and effective management options for brinjal shoot and fruit borer *Leucinodes orbonalis* Guenee

SS Ajabe, NE Jayewar and RB Ambad

Abstract
A field study was conducted to find out the effectiveness of eight management options: i) Border (Coriander) + Intercrop (Fenugreek), ii) NSKE 5%, iii) Pongamia oil 5%, iv) *Verticillium lecanii* 1.5% WP, v) Pruning of infested shoot and fruit, vi) Emamectin Benzoate 5% SG, vii) Application of ash on plant, viii) Water spray (untreated control) for suppressing brinjal shoot and fruit borer during-2018 at Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.).The treatments were arranged in a randomized block design with three replications. Results indicated that Emamectin Benzoate 5% SG superior over all treatments followed by NSKE 5%, Pruning of infested shoot and fruits and highest shoot infestation found in Water spray (untreated control) on the basis of incremental cost benefit ratio the treatment Pruning of infested shoot and fruit found better.

Keywords: Brinjal shoot and fruit borer, *Verticillium lecanii*, intercrop, Pongamia oil

Introduction
Brinjal (*Solanum melongena* L.) belongs to the family Solanaceae and is native of India. It is the third most important vegetable crop grown throughout the year in all parts of India and it's contributes 17.8 per cent to the total production of vegetables in the country. Brinjal has been a staple vegetable in our diet since ancient time due to its nutritional value hundred grams of edible part of brinjal has a potential to supply 40g carbohydrate, 1.4 g proteins, 0.3 g minerals, (including phosphorus 47 mg, calcium 18mg, potassium 2.0mg and iron 0.9 mg) and vitamins A, B and C (Arycord, 1983) [2]. Brinjal also has medicinal value against liver complaints, toothache, diabetes and it is also a good appetizer (Choudhary, 1977) [3] hence it has wide spectrum of use for maintaining human health and primarily a source for building economic trading of farmer.

Being high in economic value it is grown in all seasons which provides cumulative and continuous source of income to the farmers. After China, India is second largest producer of vegetable in the world, in India, area under brinjal cultivation is at 0.733 million ha with production of 12.510 million metric tons in Maharashtra this crop occupied 3.19 ha with production 23.63 MT and productivity 19.5qt/ha The major growing brinjal states in India are Andhra Pradesh, Bihar, Karnataka, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh and West Bengal (Anonymous, 2017) [1].

Nowaday's, cultivation of brinjal is becoming the menace to the farmer because of the attack of the insect pests. Among the several problems for brinjal productivity and quality, heavy losses caused by insect pests are the major ones. It is attacked by number of insect pests right from seedling stage till harvest. Vevai (1970) [13] has reported that the 26 pests which attacked by brinjal in India, whereas 140 species belonging to 50 families from 10 orders reported on this crop in the world (Frengpong and Buohing, 1978) [4]. Brinjal is subjected to severe damage by numbers of insect pests leading to significant loss in yield. Due to these insect pests which invade this crop regularly are brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.), brinjal stem borer (*Euzophera perticella* Peg.), brinjal hadda beetle (*Epilachna dodecastigma* Wise L.), leafhopper (*Amrasca bigutulla* Ishida.), aphid (*Aphis gossypii* Glov. and *Myzus persicae* Sulz.), whitefly (*Bemisia tabaci* Genn.) and red spider mites (*Tetranychus telericus*, L.)

Among these pests, brinjal shoot and fruit borer is the most detrimental and ubiquitous pest. The caterpillar bores into young growing shoots, petioles, midrib of leaves and fruits leaving

no sign of entry. It riddles the plants parts, feeds on internal tissue causing the plants to fade and wither resulting into drying and drooping of growing shoot which is the typical symptom produced. Once the fruit setting begins, caterpillar borer into fruits by entering under calyx and feed inside. One larva can capable to cause damage four to six fruits. A full grown larva before going for pupation comes out of the fruit by making exist holes. Pupation take place in boat shaped silken cocoon in the fallen leaves or soil. Larval stage of this pest causes the loss ranging from 1 to 90 per cent of yield in India. (Kalloo, 1988) [7]. Several workers have recommended the chemical insecticides to combat the pest's infestation on this crop. Although pesticides are generally profitable on direct crop return basis but complete dependence on chemical insecticides in the pest management strategies and their excessive and indiscriminate use have often resulted in to problems such as insecticides resistance, pest resurgence, residual toxicity, destruction of natural enemies and fauna, accidental poisoning to human and livestock. Due to these pesticides hazards we have to adopt new and safest or alternative options to control this pest. The alternative options like cultural management options, mass trapping and bio-pesticides play an important role in insect pest management by their various inhibitory actions on insect physiology and behaviour. They are locally available, relatively cheap, biodegradable and easy to handle, which is able to minimize input cost. Similarly, safer and compatible alternative method of pest control available in order to save the crop from this disastrous pest and safeguard to the consumer by a utilization of some botanical, microbial insecticides, mechanical and various cultural practices. Newer and safer insecticides can be use for effective management against target pest are under studies.

Materials and Methods

The field experiment was conducted in Randomized Block Design with eight treatments including untreated control. The brinjal crop was transplanted on 07th July, 2018. The row to row and plant to plant distance was maintained at 75 x 75 cm. All the treatments were replicated three times. The insecticides were applied at 15 days' interval starting from 30 days after transplanting and total four sprays were given.

Method of recording observations

A. Per cent shoot infestation

For recording shoot infestation, healthy and infested shoots were recorded from 5 randomly selected plants from each plot. Observations were recorded one day before spray, 7 and 14 days after treatment. All the infested shoots from selected plants were marked using a ribbon tied around the shoot to avoid recounting during the next observation. Per cent shoot infestation was calculated by using the following formula

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

B) Per cent fruit infestation

i) On number basis

One day before each application of insecticides all infested fruits were harvested from all plots. Picking wise observations were recorded on the number of infested fruits and number of marketable fruits on five randomly selected plants from each plot. The per cent fruit damage was worked out using following formula.

$$\text{Per cent fruit infestation (Number basis)} = \frac{\text{No. of infested fruit}}{\text{Total no. of fruits}} \text{ x } 100$$

ii) On weight basis

Picking wise observations were also recorded on the weight of infested fruits and weight of marketable fruits on five randomly selected plants from each plot. The per cent fruit damage was worked out using following formula.

$$\text{Per cent fruit infestation (Weight basis)} = \frac{\text{Weight of infested fruit}}{\text{Weight of total fruits}} \text{ x } 100$$

Statistical analysis

The data obtained in number was subjected to transformation using Poisson formula $\sqrt{x + 0.5}$ and per cent data was transformed using arc sine transformation before further statistical analysis. The mean data on efficacy were statistically analyzed and subjected to the analysis of variance by adopting the appropriate methods as outlined by Panse and Sukhatme (1978) and Gomez and Gomez (1984) [12, 5] by adopting "Fishers analysis of variance technique".

Yield

The yield data was obtained by weighing the healthy fruits in each plot separately treatment wise during every picking. The yield of all pickings was computed and expressed in kg per plot from which the yield in quintals per hectare was calculated. The yield data of marketable fruits at different pickings in each treatment were recorded separately and subjected to statistical analysis to test the significance of mean yield in different treatments. The increase in yield over control in each treatment was calculated by using the following formula.

$$\text{Increase yield over control} = \frac{\text{Yield in treatment plot} - \text{Yield in control plot}}{\text{Yield in control plot}} \times 100$$

Benefit: Cost Analysis

The total yield of brinjal per hectare was calculated by multiplying the yield of brinjal per plot in different treatments due to fluctuation in prices throughout the season, the average price per kilogram of the produce was fixed at Rs. 15.0 per kg for the calculation of benefit cost ratio. Total income per hectare was calculated by multiplying the total yield of brinjal crop with per kg price. For calculating crop protection expenses, the recommended dose of treatments per hectare were recorded and cost per spray was worked out. The total seasonal crop protection expenses were calculated by multiplying per spray expenses with total number of spray throughout the season. The benefit per hectare was calculated by subtracting plant protection expenses from per hectare total income of control plot from the total income. The products were divided by per hectare expenses. The remaining values were said as benefit cost ratio. The economics of the treatment was worked out based on yield and cost of protection. Based on cost of protection and gross profit, the incremental cost benefit ratio (ICBR) was worked out.

Results and Discussion

Effectiveness of management options on brinjal shoot and fruit borer

Shoot infestation after first spraying

The data presented on per cent infestation of shoot caused by shoot borer after first spraying in (Table 1) revealed that, the

result was statistically significant over control in reducing shoot damage

On 7th DAS, the minimum shoot infestation (3.30%) where found in treatment of emamectin benzoate 5% sg which were significantly superior all over the treatment followed by NSKE 5% (5.83%) and pruning of infested shoot and fruit (6.53%), pongamia oil 5% (7.00%). The next effective treatment *Verticillium lecanii (licanicillium)* 1.5% WP, border (coriander) +intercrop (fenugreek) and application of ash on plant 11.33, 12.43, 15.23 per cent shoot infestation were observed respectively and all were at par with each other. Whereas water spray recorded highest shoot infestation i.e. 17.97 per cent.

On 14th DAS, the data presented in Table 9 shows the lowest shoot infestation (5.80%) in the treatment of emamectin benzoate 5%SG followed by NSKE 5% (8.83%) and pruning of infested shoot and fruit (9.23%) which all were statistically at par with each other. Next better treatment was observed pongamia oil 5% (11.40%) followed by *Verticillium lecanii* 1.5% WP, border (coriander) + intercrop (fenugreek) and application of ash on plant 12.10,13.57,14.37 per cent shoot infestation were observed respectively and all were at par with each other. Highest shoot infestation i.e. 17.53 per cent was recorded in untreated control.

Shoot infestation after second spraying

On 7th DAS, the lowest 6.83 per cent number of shoot infestation was recorded in treatment of emamectin benzoate 5%SG, followed by NSKE 5% (7.27%) and pruning of infested shoot and fruit (9.77%) however these were statistically at par with each other. The next effective treatments were pongamia oil 5% (10.83%), *Verticillium lecanii* 1.5% WP, application of ash on plant and border (coriander) + intercrop (fenugreek) with 11.17, 11.60, 13.73 per cent shoot infestation respectively. Highest shoot infestation i.e. 18.33 per cent was recorded in the treatment of water spray.

On 14th DAS, the data presented in (Table 1) revealed that 9.23% of shoot infestation was observed in the treatment of emamectin benzoate 5% SG followed by NSKE 5% (11.93%) which all were statistically at par with each other. The next effective treatments were pruning of infested shoot and fruit, pongamia oil 5%, *Verticillium lecanii* 1.5% WP, border (coriander) + intercrop (fenugreek) and application of ash on plant with 13.67,14.37,14.87,15.37,15.80 per cent shoot infestation respectively. Water spray (control) was recorded highest shoot infestation i.e. 19.37 per cent. Jyoti and Basavanagoud (2008) [6] reported that for management of brinjal shoot and fruit borer, lowest mean shoot infestation was recorded in emamectin benzoate 5 SG (11.8%). Kalmegh (2008) [8] studies on effect of some insecticides and botanicals against brinjal shoot and fruit borer, *Leucinodes orbonalis* The effectiveness of neem based materials against the brinjal shoot and fruit borer was reported by earlier workers Kavita *et al*., (2008); Murugesan and Murugesh (2009). Mandal *et al*., (2008) [9, 11, 10] reported that mechanical shoot clipping reduces the infestation brinjal shoot and fruit borer.

Table 1: Effect of alternative management option for brinjal shoot and fruit borer

Tr. No.	Treatment	Conc. (%)	Average shoot infestation (%)				
			First spray			Second spray	
			PTC	7 DAS	14DAS	7DAS	14DAS
T1	Border (coriander)+ intercrop (fenugreek)	-	11.90 (20.15)*	12.43 (20.60)	13.57 (21.56)	13.73 (21.69)	15.37 (22.98)
T2	NSKE	5	16.73 (24.09)	5.83 (13.95)	8.83 (17.21)	7.27 (15.62)	11.93 (20.15)
T3	Pongamia oil	5	13.23 (21.30)	7.00 (15.24)	11.40 (19.65)	10.83 (19.17)	14.37 (22.26)
T4	*Verticillium lecanii* 1.5%WP	0.05	13.17 (21.16)	11.33 (19.65)	12.10 (20.24)	11.17 (19.47)	14.87 (22.65)
T5	Pruning of infested shoot and fruit	-	11.37 (19.63)	6.53 (14.78)	9.23 (17.67)	9.77 (18.08)	13.67 (21.68)
T6	Emamectin benzoate 5% SG	0.002	17.90 (24.55)	3.30 (9.83)	5.80 (13.91)	6.83 (15.01)	9.23 (17.63)
T7	Application of ash on plant	-	14.33 (22.16)	15.23 (22.87)	14.37 (22.24)	11.60 (19.83)	15.80 (23.36)
T8	Water spray	-	13.73 (21.69)	17.97 (25.04)	17.53 (24.51)	18.33 (25.30)	19.37 (26.03)
SE(m)±			1.66	1.31	1.46	1.16	1.05
C.D. at 5%			NS	4.01	4.49	3.55	3.24
C.V. %			13.18	12.80	12.96	10.42	8.29

*Figures in parentheses are arcsine transformed values, NS- Non- significant

Fruit infestation on number basis

The perusal of data on per cent fruit infestation presented in (Table 2) revealed significant difference among the treatments within all the picking of brinjal fruits. A treatment of emamectin benzoate 5% SG found most effective in reducing fruit infestation. The next best treatment was NSKE 5% and both of these treatments were at par with each other in all picking. The effective treatments were pruning of infested shoot and fruit, pongamia oil 5%, *Verticillium lecanii* 1.5% WP, border (coriander) + intercrop (fenugreek) and application of ash on plant. All this treatment significantly superior over water spray (control). The highest number of fruit infestation recorded in water spray.

Table 2: Effect of alternative management option for brinjal shoot and fruit borer (Number basis)

Tr. No.	Treatment	Conc. (%)	Fruit infestation (Number basis)		
			I Picking	II picking	III Picking
T1	Border (coriander) + intercrop (fenugreek)	-	44.68 (41.90)*	45.60 (42.45)	50.11 (45.04)
T2	NSKE	5	14.57 (22.42)	15.47 (23.14)	18.43 (25.41)
T3	Pongamia oil	5	29.71 (32.47)	31.29 (33.88)	37.56 (37.75)
T4	*Verticillium lecanii* 1.5%WP	0.05	40.43 (39.46)	45.21 (42.22)	49.90 (44.92)
T5	Pruning of infested shoot and fruit	-	27.10 (30.82)	22.55 (28.32)	30.42 (33.36)
T6	Emamectin benzoate 5% SG	0.002	8.90 (17.31)	12.33 (20.52)	13.15 (21.21)
T7	Application of ash on plant	-	46.42 (42.93)	48.15 (43.92)	51.67 (45.94)
T8	Water spray	-	52.70 (46.53)	56.56 (48.75)	62.13 (52.57)

SE(m)±	2.67	1.26	2.76
C.D. at 5%	8.20	3.87	8.46
C.V. %	13.54	6.18	12.57

*Figures in parentheses are arcsine transformed values

Fruit infestation on (weight basis)

The data on per cent fruit infestation presented in (Table 3) revealed significant difference among the treatments within all the picking of brinjal fruits. The treatment of emamectin benzoate 5% SG found significantly superior all picking and recorded lowest number of fruit infestation. Thereafter best treatment was NSKE 5%, pruning of infested shoot and fruit, pongamia oil 5%, border (coriander) +Intercrop (fenugreek) *Verticillium lecanii* 1.5% WP and application of ash on plant. All these treatments were significantly superior over water spray (control). The highest number of fruit infestation recorded in water spray.

Table 3: Effect of alternative management option for brinjal shoot and fruit borer (weight basis)

Tr. No.	Treatment	Conc. (%)	Fruit infestation (Weight basis)		
			I picking	II picking	III picking
T1	Border (coriander) + intercrop (fenugreek)	-	40.78 (39.61)*	40.37 (39.42)	37.66 (37.77)
T2	NSKE	5	12.70 (20.80)	16.20 (23.65)	22.33 (28.17)
T3	Pongamia oil	5	33.95 (35.53)	31.82 (34.32)	34.24 (35.52)
T4	*Verticillium lecanii* 1.5%WP	0.05	39.22 (38.75)	43.08 (40.99)	45.64 (42.46)
T5	Pruning of infested shoot and fruit	-	27.98 (31.80)	24.74 (29.65)	27.16 (31.39)
T6	Emamectin benzoate 5% SG	0.002	7.13 (15.48)	9.78 (18.20)	11.27 (19.56)
T7	Application of ash on plant	-	44.10 (41.57)	47.70 (43.62)	40.00 (39.16)
T8	Water spray	-	46.30 (42.86)	49.42 (44.65)	55.27 (48.02)
SE(m)±			1.79	1.77	1.94
C.D. at 5%			5.49	5.42	5.95
C.V. %			9.33	8.93	9.55

*Figures in parentheses are arcsine transformed values

Effect of different treatments on fruit yield of brinjal

The data presented in respects of yield influenced by various treatments was presented in (Table 4) revealed that, all the treatments were found effective in bringing the significant increase in the yield as compared to the water spray. The treatments with emamectin benzoate 5%SG recorded the highest yield of brinjal fruits (98.76 q/ha) and it appeared most promising treatment in getting brinjal fruit yield. Followed by NSKE 5%, pruning of infested shoot and fruit, pongamia oil 5%, *Verticillium lecanii* 1.5% WP, border (coriander) +intercrop (fenugreek) and application of ash on plant. All these treatments were significantly superior over water spray (control). In treatment water spray recorded lowest yield i.e. (22.76 q/ha).

Table 4: Effect of various treatments on yield

Tr. No.	Treatment	Yield per plot (kg)	Yield (q/ha)	Increased yield (q/ha) Over water spray
T1	Border (coriander) + intercrop (fenugreek)	7.33	36.19	13.44
T2	NSKE 5%	14.40	71.11	48.35
T3	Pongamia oil 5%	10.33	51.01	28.25
T4	*Verticillium lecanii* 1.5% WP	8.33	41.13	18.37
T5	Pruning of infested shoot and fruit	12.33	60.88	38.12
T6	Emamectin benzoate 5% SG	20.00	98.76	76.00
T7	Application of ash on plant	5.41	26.71	3.95
T8	Water spray	4.61	22.76	-
SE(m) ±		0.96		
C.D. 5%		2.93		

Incremental cost benefit ratio as influenced by different treatments

a. **Gross returns (Rs/ha):** The (Table 5) represents the economics of different treatment used against brinjal shoot and fruit borer during *kharif*- 2018. The treatment emamectin benzoate 5%SG recorded the highest gross returns (114000 Rs). Thereafter NSKE 5%, pruning of infested shoot and fruit, pongamia oil 5%, *Verticillium lecanii* 1.5% WP, Border (coriander) + Intercrop (fenugreek). 72525, 57180, 42375, 27555, 20160 Rs/ha respectively. The lowest gross returns were obtained in application of ash on plant i.e. 5925 Rs/ha

b. **Net returns (Rs/ha):** The treatment emamectin benzoate 5%SG were recorded highest net returns 105300 Rs/ha followed by NSKE 5%, pruning of infested shoot and fruit, pongamia oil 5%, *Verticillium lecanii* 1.5% WP, border (coriander) +intercrop (fenugreek). 65505, 54480, 37320, 24930, 18760 Rs/ha respectively.

c. **ICBR:** The highest benefit cost ration was noticed in treatment pruning of infested shoot and fruit (1:20.17). Followed by border (coriander) +intercrop (fenugreek) (1:13.4), emamectin benzoate 5% SG (1:12.10), *V. lecanii* 1.5%WP (1:9.49), NSKE 5% (1:9.33), pongamia oil 5% (1:7.38) and lowest benefit cost ratio obtained in application of ash on plant i.e. (1:1.19)

Table 5: Effect of different treatment on economics of brinjal

Tr. No.	Treatments	Fruit Yield (q/ha)	Increase In yield over Control (q/ha)	Cost of treatment(Rs/ha)		Total cost (Rs/ha)	Value of additional yield over untreated control (Rs/ha)	Net profit (Rs/ha)	ICBR	Rank
				Cost of Insecticides (3 spray) /seed price of border + intercrop	Labour + Sprayer charges for three spraying					
T_1	Border+ intercrop	36.19	13.44	Border crop(Rs 150) +inter crop (Rs 450)	900	1400	20160	18760	1:13.4	II
T_2	NSKE 5%	71.11	48.35	5520	1500	7020	72525	65505	1:9.33	V
T_3	Pongamia oil 5%	51.01	28.25	3555	1500	5055	42375	37320	1:7.38	VI
T_4	*V. lecanii*1.5%WP	41.13	18.37	1125	1500	2625	27555	24930	1:9.49	IV
T_5	Pruning of infested shoot and fruit	60.88	38.12	-	2700	2700	57180	54480	1:20.17	I
T_6	Emamectin benzoate 5% SG	98.76	76.00	7200	1500	8700	114000	105300	1:12.10	III
T_7	Application of ash on plant	26.71	3.95	300	2700	3000	5925	3225	1:1.07	VII
T_8	Water spray (control)	22.76	-	-	-	-	-	-	-	

Rates: i) NSKE 5% Rs 1840/1lit, ii) Pongamia oil Rs 400/1lit, iii) *V. lecanii*1.5%WP Rs 150/Kg, iv) Emamectin benzoate 5% SG Rs 600. /50g., v) Ash Rs 5/ kg, vi) labour charge Rs 300/day/labour, vii) sprayer charge Rs 200/day, Viii) Marketable price brinjal Rs 15 /kg.

Conclusion

From the study, it could be concluded that the treatment with emamectin benzoate 5% SG was found to be the most effective and superior followed by followed by NSKE 5% which was equally effective. The highest yield of brinjal fruit was obtained from the treatment emamectin benzoate 5% SG being superior to next effective treatments NSKE 5%, pruning of infested shoot and fruit, pongamia oil 5%. On the basis of ICBR among the effective treatment pruning of infested shoot and fruit was appeared to be the most economically viable treatment followed by border (coriander) + intercrop (fenugreek), emamectin benzoate 5% SG, *Verticillium lecanii* 1.5% WP, NSKE 5%.

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