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Suman Kumari
Department of Entomology, SKN College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan, India

DK Bairwa
Department of Entomology, SKN College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan, India

Arjun Lal Choudhary
Department of Entomology, SKN college of Agriculture (SKNAU) Jobner Jaipur, Rajasthan, India

Priyanka
Department of Entomology, SKN College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan, India

Corresponding Author:
Suman Kumari
Department of Entomology, SKN College of Agriculture (SKNAU), Jobner, Jaipur, Rajasthan, India

Bioefficacy of newer insecticides and botanicals against shoot and fruit borer, *Leucinodes orbonalis* Guen. on Brinjal

Suman Kumari, DK Bairwa, Arjun Lal Choudhary and Priyanka

Abstract
Investigation entitled "Bioefficacy of Newer Insecticides and Botanicals against Shoot and Fruit Borer, *Leucinodes orbonalis* Guen. on Brinjal" was carried out at Horticulture farm, S.K.N. College of Agriculture, Jobner (Rajasthan) in Kharif, 2017. Out of seven newer insecticides and two botanicals tested against shoot and fruit borer on brinjal, flubendiamide 48 SC, chlorantraniliprole 18.5 SC, emamectin benzoate 5 SG and fipronil 5 SC were found most effective. The insecticides *viz*., novaluron 10 EC, acephate 75 SP and malathion 50 EC were found moderate effective, while botanicals (azadirachtin 0.15 EC and NSKE 5%) were found least effective. The maximum fruit yield was obtained in treatments of flubendiamide 48 SC, followed by chlorantraniliprole 18.5 SC, emamectin benzoate 5 SG and fipronil 5 SC. The higher fruit yield was also obtained in the treatment of novaluron 10 EC, acephate 75 SP and malathion 50 EC and minimum was obtained in azadirachtin 0.15 EC and NSKE 5 percent. The maximum net profit was obtained in the treatment of flubendiamide, followed by chlorantraniliprole, emamectin benzoate and fipronil and minimum was in azadirachtin 0.15 EC and NSKE 5 percent. The maximum B:C ratio was obtained in the treatment of malathion and acephate while, it was minimum in emamectin benzoate and novaluron.

Keywords: Bioefficacy, newer insecticides, botanicals, *Leucinodes orbonalis,* brinjal etc

Introduction

Brinjal (*Solanum melongena* L.) also known as eggplant, belong to family Solanceae, is an important vegetable crop grown throughout the world, especially in South Asia and it is the native of India. Brinjal is known for *ayurvedic* medicinal properties, especially white brinjal is said to be good for diabetic patients (Fageria *et al.*, 2003) [4]. It has high nutritive value and contains all the essential minerals, vitamins and amino acids. India stand second in production and productivity in the world after china which is mainly grown in the states like West Bengal, Orissa, Bihar, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Uttar Pradesh and Rajasthan. In India the total area under brinjal cultivation is 6.80 lakh hectares with an annual production of 127.06 lakh tonnes (Anonymous, 2015) [2]. During 2014-15, the area and production of brinjal in Rajasthan was 64.60 thousand hectares and 21.23 million tonnes, respectively. It is generally grown in Alwar, Jaipur, Ajmer, Bharatpur, Bundi, Baran and Kota districts of Rajasthan during summer and rainy season.

The brinjal crop is attacking by a number of insect- pests right from germination to harvesting of the crop *viz.*; shoot and fruit borer, *Leucinodes orbonalis* (L.) Guenee, jassid, *Amrasca biguttula biguttula* (Ishida), aphid, *Aphis gossypii* Glover, whitefly, *Bemisia tabaci* (Genn.), lace wing bug, *Urentius echinus* Distant, epilachna beetle, *Epilachna vigintioctopunctata* Fabr. and stem borer, *Euzophera perticella* Ragonot. Nayar *et al*. (1995) listed 53 insects attacking on brinjal, out of them shoot and fruit borer, *L. orbonalis* is one of the major constraints in achieving potential yield. It remains active throughout the year with many overlapping generations. The caterpillar initially attacks the terminal shoot and bore inside as a result of which, dropping and wilting of shoots occur. In the later stage, it also bores into the young fruits by making holes and feed inside. Such fruits, being partially unfit for human consumption and lose their market value (Butani and Jotwani, 1984) [3]. Crop losses have been reported to the tone of 20-89 percent in various part of India by this pest (Raju *et al*., 2007) [17]. Chemical pesticides are being used extensively to manage this pest, however, indiscriminate use of pesticides has led to several problems like resurgence of secondary pests, resistance in pests against pesticides, health hazards and pesticide residues in edible fruits (Kabir *et al*.,

1996) [7]. Alam *et al*. (2006) [1] reported that over 95 percent of farmers applied more than 40 pesticide sprays per cropping season. Further brinjal shoot and fruit borer are reported to develop resistance to many of insecticides widely used against it. In search of promising alternative to old conventional insecticide, some new insecticides are being tested in the present study to assess the field bio- efficacy against shoot and fruit borer.

Materials and Methods

The experiment was laid out in a simple Randomized Block Design (RBD) with ten treatments (insecticides) including untreated control, each replicated thrice. The plot size was 3.0 x 3.0 m^2 keeping row to row and plant to plant distance of 60 and 50 cm, respectively. The brinjal variety 'Pusa Purple Round' (recommended for this region) was used for the experiment, transplanted on 6th July, 2017. The recommended packages of practices were followed to raise the crop.

Details of insecticides used

S.No.	Common name	Formulations	Concentration (%) or dose
1.	Acephate	75 SP	0.05
2.	Flubendiamide	48 SC	0.0096
3.	Novaluron	10 EC	0.05
4.	Emamectin benzoate	5 SG	0.005
5.	Malathion	50 EC	0.05
6.	Fipronil	5 SC	0.01
7.	Chlorantraniprole	18.5 SC	0.006
8.	Azadirachtin	1500 ppm	0.15
9.	NSKE	Freshly prepared	5 g ai/l
10.	Control (Untreated)	-	-

All the treatments (insecticides) were applied as foliar spray by using pre-calibrated knapsack sprayer. Care was taken to check the drift of insecticides, by putting polythene sheet screen around the each plot at the time of spraying. Total three spray were applied, first spray was applied when the sufficient infestation of L. orbonalis on shoots were observed and second spray were given when infestation increase above 5 percent shoot infestation (ETL level). The third spray was given when sufficient infestation of *L. orbonalis* on fruits was observed. The spray fluid used in various sprays was 500 to 650 litres of water.

The insecticidal solution was prepared according to the following formula:

$$C1\ V1 = C2\ V2$$

Where,
C1 = Concentration of given formulation (%)
V1 = volume / amount of formulation required (ml or gm)
C2 = Concentration of spray fluid required (%)
V2 = Volume / amount of spray fluid (l/ha)

Observations

The percent shoot infestation by *L. orbonalis* were recorded one day prior to spraying and on 3rd, 7th, 10th and 15th days of each spray and mean value of each spray was computed. Fruit infestation was also recorded on 3rd, 7th, 10th and 15th days of both sparys after picking of fruits on number and weight basis and the total yield of uninfested fruit in each treatment was also computed. The percent infestation in shoots and fruits were calculated and data were subjected to statistical analysis after angular transformation.

Results and Discussion

The bio-efficacy of nine newer insecticides and botanicals was evaluated against shoot and fruit borer, *L. orbonalis* on brinjal in *Kharif*, during 2017. Total three sprays were applied to protect the crop from shoot and fruit borer infestation. The observations on shoot infestation were recorded in first spray and on fruit infestation both on number and weight basis in second and third spray on 3rd, 7th, 10th and 15th days of application of insecticides. The infestation of pest on shoots at the time of second and third sprays was negligible, hence not recorded.

Percent infestation of *L. orbonalis* on shoots of brinjal

The data on infestation of *L. orbonalis* on shoots of brinjal after first spray was presented in table 1. The percent shoot infestation in untreated plots showed an increasing trend from 25.51 to 44.89 percent during a span of 15 days covering first spray. All the insecticides were found to be significantly superior over untreated control in reducing incidence of brinjal shoot borer at all the days of observations after first spray. The observations recorded on three days of spray indicated that the plots treated with flubendiamide 48 SC recorded lowest shoot infestation (5.40%), followed by chlorantraniliprole 18.5 SC (5.62%), emamectin benzoate 5 SG (6.41%) and fipronil 5 SC (6.72%) and these treatments were at par to each other in their efficacy. The moderately effective group of insecticides were, novaluron 10 EC (9.65%), acephate 75 SP (10.89%) and malathion 50 EC (11.05%) and these were formed a non significant group of insecticides, however the treatment fipronil 5 SC comparable with novaluron 10 EC. The maximum infestation (14.21%) of pest on shoots was recorded in the treatment of NSKE (5%), followed azadirachtin 0.15 EC with 14.09 percent infestation and were differed non-significantly.

Table 1: Bio-efficacy of newer insecticides and botanicals against *Leucinodes orbonalis* (Guenee) on shoots of brinjal

S. No	Treatments	Concentration (%)	Percent shoot infestation on days of first spray				
			3rd	7th	10th	15th	Mean
1	Acephate 75 SP	0.05	10.89	8.75	10.34	10.61	10.18
			(19.27)	(17.35)	(18.76)	(19.01)	(18.61)
2	Flubendiamide 48 SC	0.0096	5.40	3.51	5.60	5.78	5.07
			(13.44)	(10.80)	(13.69)	(13.91)	(13.02)
3	Novaluron 10 EC	0.05	9.65	7.21	9.89	10.42	9.29
			(18.10)	(15.58)	(18.33)	(18.83)	(17.75)
4	Emamectin benzoate 5 SG	0.005	6.41	4.26	6.21	6.83	5.93
			(14.67)	(11.91)	(14.43)	(15.15)	(14.09)
5	Malathion 50 EC	0.05	11.05	9.07	10.39	10.64	10.29
			(19.42)	(17.53)	(18.80)	(19.04)	(18.82)
6	Fipronil 5 SC	0.01	6.72	4.76	6.71	7.04	6.31
			(15.02)	(12.60)	(15.01)	(15.39)	(14.55)
7	Chlorantraniliprole 18.5 SC	0.006	5.62	3.85	5.88	6.08	5.36
			(13.71)	(11.32)	(14.03)	(14.28)	(13.38)
8	Azadirachtin 0.15 EC	0.00075	14.09	13.27	12.86	12.78	13.25
			(22.05)	(21.36)	(21.01)	(20.95)	(21.32)
9	NSKE	5.0	14.21	13.54	12.91	12.86	13.36
			(22.15)	(21.59)	(21.24)	(21.04)	(21.47)
10	Control (untreated)		25.51	30.60	38.78	44.89	34.97
			(30.33)	(33.58)	(38.58)	(42.07)	(36.25)
		SEm±	0.99	1.08	1.16	1.20	1.14
		CD (P=0.05)	2.94	3.20	3.44	3.57	3.39

Figures in the parentheses are angular transformed values
NSKE: Neem seed kernel extract

On seventh day of spray all the treatments were also found significantly superior over untreated control. The minimum infestation of 3.51 percent on shoots of brinjal was recorded in the treatment of flubendiamide 48 SC, followed by chlorantraniliprole 18.5 SC (3.85%), emamectin benzoate 5 SG (4.26%) and fipronil 5 SC (4.76%) and these treatments were at par to each other in their efficacy and significantly superior over rest over the treatments. The moderately effective treatments were novaluron 10 EC (7.21%), followed by acephate 75 SP (8.75%) and malathion 50 EC (9.07%) and these were formed a non significant group of insecticides. However, the treatment of novaluron 10 EC was also found comparable with the most effective insecticide fipronil 5 SC. The maximum infestation of 13.54 percent was recorded in the treatment of NSKE (5%), followed azadirachtin 0.15 EC with 13.27 percent infestation and both were differed non significantly.

Similarly on tenth day of spray all the treatments were found significantly superior over untreated control. The minimum infestation of 5.60 percent on shoots of brinjal was recorded in the treatment of flubendiamide 48 SC, followed by chlorantraniliprole 18.5 SC (5.88%), emamectin benzoate 5 SG (6.21%) and fipronil 5 SC (6.71%) and these treatments were at par to each other. The moderately effective treatments were novaluron 10 EC (9.89%), followed by acephate 75 SP (10.34%) and malathion 50 EC (10.39%) and these were differed non significantly. The maximum infestation of 12.91 percent was recorded in the treatment of NSKE (5%), followed by azadirachtin 0.15 EC with 12.86 percent infestation and both were at par with each other, however the treatment of acephate 75 SP was found comparable with azadirachtin 0.15 EC.

On fifteen day of spray all the treatments were too found significantly superior over untreated control. The treatment of flubendiamide 48 SC (5.78%) followed by chlorantraniliprole 18.5 SC (6.08%), emamectin benzoate 5 SG (6.83%) and fipronil 5 SC (7.04%) were found most effective against the pest and were at par to each other. The moderately effective treatments were novaluron 10 EC (10.42%), followed by acephate 75 SP (10.61%) and malathion 50 EC (10.64%) and these were differed non significantly however, the treatment emamectin benzoate 5 SG and novaluron 10 EC were also at par with each other. The maximum infestation of 12.86 percent was recorded in the treatment of NSKE (5%), followed by azadirachtin 0.15 EC with 12.78 percent infestation and both were significantly inferior to rest of treatments, however azadirachtin 0.15 EC was comparable with malathion 50 EC.

The data indicated that on the basis of mean of all the observations flubendiamide 48 SC, chlorantraniliprole 18.5 SC, emamectin benzoate 5 SG and fipronil 5 SC were proved most effective with 5.07, 5.36, 5.93 and 6.31 percent shoot infestation, respectively. The next effective treatment was novaluron 10 EC (9.29%), followed by acephate 75 SP (10.18%) and malathion 50 EC (10.29%). The maximum infestation was recorded in the treatment of azadirachtin 0.15 EC and NSKE 5 percent which resulted in 13.25 and 13.36 percent infestation, respectively. The descending order of efficacy of insecticides against shoot and fruit borer on the basis of mean of all the observations was: flubendiamide > chlorantraniliprole > emamectin benzoate > fipronil > novaluron > acephate > malathion > azadiractin > NSKE.

Percent infestation of *L. orbonalis* on fruits of brinjal

The data presented in table 2 and 3 showed that on third day of second spray all the treatments were found significantly superior over untreated control against *L. orbonalis* on brinjal based on fruit infestation, both on number and weight basis however, significant difference existed among them. The treatment of flubendiamide 48 SC, chlorantraniliprole 18.5 SC, emamectin benzoate 5 SG, and fipronil 5 SC was found most effective resulted in minimum infestation of 4.63, 5.13, 5.38, 5.51 percent on number basis and 4.32, 4.65, 4.91, 5.21 percent on weight basis, respectively and these were at par with each other in their efficacy. The moderately effective treatments were novaluron 10 EC, acephate 75 SP and malathion 50 EC which exhibited fruit infestation of 9.15, 9.22, 9.62 percent on number basis and 8.62, 9.17, 9.28 percent on weight basis, respectively and were found statistically at par in their efficacy, however the treatment of fipronil 5 SC differed comparable with novaluron 10 EC. The least effective treatments were NSKE 5 percent (13.89 and 13.26%) and azadirachtin 0.15 EC (13.61 and 12.81%) and both were differed non-significantly, the treatment of malathion 50 EC also found comparable with azadirachtin 0.15 EC.

Table 2: Bio-efficacy of newer insecticides and botanicals against *Leucinodes orbonalis* (Guenee) on fruits of brinjal (Number basis)

S. No	Treatments	Concentration (%)	Percent fruits infestation on days of second spray				
			3rd	7th	10th	15th	Mean
1.	Acephate 75 SP	0.05	9.22 (17.68)	8.69 (17.14)	9.03 (17.49)	9.91 (18.35)	9.21 (17.67)
2.	Flubendiamide 48 SC	0.0096	4.63 (12.43)	3.32 (10.50)	4.21 (11.84)	5.54 (13.61)	4.43 (12.14)
3.	Novaluron 10 EC	0.05	9.15 (17.61)	6.25 (14.48)	7.78 (16.20)	9.80 (18.24)	8.25 (16.69)
4.	Emamectin benzoate 5 SG	0.005	5.38 (13.41)	3.60 (10.94)	5.02 (12.95)	6.23 (14.45)	5.06 (13.00)
5.	Malathion 50 EC	0.05	9.62 (18.07)	9.07 (17.53)	9.31 (17.77)	9.47 (17.92)	9.38 (17.83)
6.	Fipronil 5 SC	0.01	5.51 (13.58)	3.98 (11.51)	5.53 (13.60)	6.82 (15.14)	5.46 (13.51)
7.	Chlorantraniliprole18.5 SC	0.006	5.13 (13.09)	3.56 (10.88)	4.68 (12.49)	5.71 (13.82)	4.77 (12.62)
8.	Azadirachtin 0.15 EC	0.00075	13.61 (21.65)	13.24 (21.34)	12.82 (20.98)	12.76 (20.93)	13.11 (21.23)
9.	NSKE	5.0	13.89 (21.88)	13.70 (21.72)	12.89 (21.04)	12.86 (21.01)	13.34 (21.42)
10.	Control (untreated)		50.69 (45.40)	45.55 (42.45)	13.29 (21.38)	39.41 (38.89)	37.24 (37.60)
		SEm±	1.21	1.14	1.09	1.16	1.15
		CD (P=0.05)	3.61	3.40	3.23	3.44	3.42

Figures in the parentheses are angular transformed values
NSKE: Neem seed kernel extract

Table 3: Bio-efficacy of newer insecticides and botanicals against *Leucinodes orbonalis* (Guenee) on fruits of brinjal (Weight basis)

S. No	Treatments	Concentration (%)	Percent fruit infestation on days of second spray				
			3rd	7th	10th	15th	Mean
1.	Acephate 75 SP	0.05	9.17 (17.63)	7.91 (16.33)	8.97 (17.43)	9.71 (18.42)	9.01 (17.47)
2.	Flubendiamide 48 SC	0.0096	4.32 (12.00)	3.32 (10.50)	4.19 (11.81)	5.37 (13.40)	4.30 (11.97)
3.	Novaluron 10 EC	0.05	8.62 (17.07)	6.23 (14.67)	7.64 (16.05)	8.34 (16.79)	7.75 (16.17)
4.	Emamectin benzoate 5 SG	0.005	4.91 (12.80)	3.57 (10.89)	4.97 (12.88)	6.18 (14.39)	4.91 (12.80)
5.	Malathion 50 EC	0.05	9.28 (17.74)	8.03 (16.46)	8.81 (17.27)	9.22 (18.44)	9.03 (17.49)
6.	Fipronil 5 SC	0.01	5.21 (13.19)	3.79 (11.23)	5.27 (13.27)	6.39 (14.64)	5.17 (13.14)
7.	Chlorantraniliprole 18.5 SC	0.006	4.65 (12.45)	3.53 (10.83)	4.54 (12.30)	5.67 (13.78)	4.60 (12.38)
8.	Azadirachtin 0.15 EC	0.00075	12.81 (20.97)	12.76 (20.93)	12.56 (20.76)	12.34 (20.57)	12.62 (20.81)
9.	NSKE	5.0	13.26 (21.35)	13.11 (21.23)	12.83 (20.99)	12.71 (20.89)	12.91 (21.05)
10.	Control (untreated)		50.42 (45.24)	44.91 (42.08)	42.51 (40.69)	39.01 (38.65)	44.21 (41.68)
		SEm±	1.18	1.12	1.08	1.15	1.02
		CD (P=0.05)	3.52	3.34	3.21	3.41	3.04

Figures in the parentheses are angular transformed values
NSKE: Neem seed kernel extract

On seventh day of spray the minimum infestation in fruits of brinjal was recorded in the treatment of flubediamide 48 SC (3.32 and 3.32%), followed by chlorantraniliprole 18.5 SC (3.56 and 3.53%), emamectin benzoate 5 SG (3.60 and 3.57%) and fipronil 5 SC (3.98 and 3.79%) and these were differed non-significantly with each other. The moderately effective treatments were novaluron 10 EC (6.25 and 6.23%), followed by acephate 75 SP (8.69 and 7.91%) and malathion 50 EC (9.07 and 8.03%) and these were formed a non significant group of insecticides, however the treatment of fipronil 5 SC found comparable with novaluron 10 EC. The least effective treatments were NSKE 5 percent (13.70 and 13.11%) and azadirachtin 0.15 EC (13.24 and 12.76%) and both were statistically at par in their efficacy.

Similarly on tenth day of spray the treatment of flubediamide 48 SC (4.21 and 4.19%), chlorantraniliprole 18.5 SC (4.68 and 4.54%), emamectin benzoate 5 SG (5.02 and 4.97%), and fipronil 5 SC (5.53 and 5.27%) were found most effective and comparable with each other in their efficacy. The moderately effective treatments were novaluron 10 EC (7.78 and 7.64%), acephate 75 SP (9.03 and 8.97%) and malathion 50 EC (9.31 and 8.81%) and these were formed a non significant group of insecticides. The least effective treatments were NSKE 5 percent (12.89 and 12.83%) and azadirachtin 0.15 EC (12.82 and 12.56%) and both were statistically at par. The treatment of malathion 50 EC was comparable with azadirachtin 0.15 EC.

On fifteen day of spray the treatment of flubediamide 48 SC (5.54 and 5.37%), chlorantraniliprole 18.5 SC (5.71 and 5.67%), emamectin benzoate 5 SG (6.23 and 6.18%), and fipronil 5 SC (6.82 and 6.39%) were too found most effective and comparable to each other in their efficacy. The moderately treatments were novaluron 10 EC (9.80 and 8.34%), acephate 75 SP (9.91 and 9.71%) and malathion 50 EC (9.47 and 9.22%) and these were at par with each other. The least effective treatments were NSKE 5 percent (12.86 and 12.71%) and azadirachtin 0.15 EC (12.76 and 12.34%) and both were comparable with each other.

The data indicated that on the basis of mean of all the observations based on fruit damage, both on number and weight basis, the treatment of flubendiamide 48 SC (4.43 and 4.30%), chlorantraniliprole 18.5 SC (4.77and 4.60%), emamectin benzoate 5 SG (5.06 and 4.91%), and fipronil 5 SC (5.46 and 5.17%) were proved most effective. The moderately effective treatments were novaluron 10 EC (8.25 and 7.75%), followed by acephate 75 SP (9.21 and 9.01%) and malathion 50 EC (9.38 and 9.03%). The maximum infestation was recorded in the treatment of NSKE 5 percent and azadirachtin 0.15 EC which resulted in 13.34 and 13.11 percent infestation on number basis and 12.91 and 12.62 percent infestation on weight basis. The descending order of efficacy of insecticides against shoot and fruit borer on the basis of mean of all the observations was: flubendiamide > chlorantraniliprole > emamectin benzoate > fipronil > novaluron > acephate > malathion > Azadiractin > NSKE.

The data presented in table 4 and 5 revealed that the trend of effectiveness of all the insecticidal treatments against shoot and fruit borer on brinjal was found more or less similar as in second spray. On third day of spray all the treatment were found significantly superior over the untreated control against *L. orbonalis* on brinjal based on fruit infestation, both on number and weight basis, however, significant difference existed among them. The treatment of flubediamide 48 SC (4.20 and 3.92%), chlorantraniliprole 18.5 SC (4.62 and 4.30%), emamectin benzoate 5 SG (5.04 and 4.85%) and fipronil 5 SC (5.43 and 5.40%) were proved most effective and these were differed non-significantly to each other, the latter two treatment were comparable with novaluron 10 EC The moderately effective treatments were novaluron 10 EC (7.56 and 7.41%), acephate 75 SP (9.16 and 9.07%) and malathion 50 EC (9.77 and 9.31%) and these were formed a non significant group of insecticides. The least effective treatments were NSKE 5 percent (13.68 and 13.59%) and azadirachtin 0.15 EC (13.47 and 13.26%) and both were statistically at par in their efficacy.

Table 4: Bio-efficacy of newer insecticides and botanicals against *Leucinodes orbonalis* (Guenee) on fruits of brinjal (number basis)

S. No	Treatments	Concentration (%)	Percent shoot infestation on days of third spray				
			3rd	7th	10th	15th	Mean
1.	Acephate 75 SP	0.05	9.16 (17.62)	8.25 (16.69)	8.67 (17.12)	9.87 (18.31)	8.99 (17.45)
2.	Flubendiamide 48 SC	0.0096	4.20 (11.83)	3.21 (10.32)	3.98 (11.51)	5.35 (13.37)	4.19 (11.80)
3.	Novaluron 10 EC	0.05	7.56 (15.96)	7.93 (16.36)	8.04 (16.47)	9.62 (18.07)	8.29 (16.73)
4.	Emamectin benzoate 5 SG	0.005	5.04 (12.97)	3.58 (10.91)	4.67 (12.48)	5.91 (14.07)	4.80 (12.66)
5.	Malathion 50 EC	0.05	9.77 (18.21)	8.75 (17.21)	9.13 (17.59)	10.03 (18.46)	9.42 (17.87)
6.	Fipronil 5 SC	0.01	5.43 (13.48)	3.79 (11.23)	5.62 (13.71)	6.31 (14.55)	5.29 (13.29)
7.	Chlorantraniliprole 18.5 SC	0.006	4.62 (12.41)	3.56 (10.88)	4.26 (11.91)	5.62 (13.71)	4.52 (12.27)
8.	Azadirachtin 0.15 EC	0.00075	13.47 (21.53)	13.28 (21.37)	13.07 (21.19)	12.99 (21.13)	13.20 (21.31)
9.	NSKE	5.0	13.68 (21.71)	13.45 (21.51)	13.27 (21.36)	13.21 (21.31)	13.40 (21.47)
10.	Control (untreated)		32.65 (34.85)	36.66 (37.26)	48.24 (43.99)	51.62 (45.93)	42.29 (40.57)
		SEm±	1.11	1.09	1.18	1.22	1.15
		CD (P=0.05)	3.30	3.25	3.49	3.63	3.42

Figures in the parentheses are angular transformed values
NSKE: Neem seed kernel extract

Table 5: Bio-efficacy of newer insecticides and botanicals against *Leucinodes orbonalis* (Guenee) on fruits of brinjal (Weight basis)

S. No	Treatments	Concentration (%)	Percent fruit infestation on days of third spray				
			3rd	7th	10th	15th	Mean
1.	Acephate 75 SP	0.0096	9.07 (17.53)	8.13 (16.57)	8.49 (16.94)	9.70 (18.15)	8.85 (17.30)
2.	Flubendiamide 48 SC	0.005	3.92 (11.42)	3.16 (10.24)	3.75 (11.17)	4.46 (12.19)	3.82 (11.27)
3.	Novaluron 10 EC	0.006	7.41 (15.80)	6.12 (14.32)	7.81 (16.23)	8.23 (16.67)	7.39 (15.78)
4.	Emamectin benzoate 5 SG	0.05	4.85 (12.72)	3.41 (10.64)	4.27 (11.93)	5.21 (13.19)	4.44 (12.16)
5.	Malathion 50 EC	0.05	9.31 (17.77)	8.54 (16.99)	9.07 (17.53)	9.87 (18.31)	9.20 (17.65)
6.	Fipronil 5 SC	0.05	5.40 (13.44)	3.67 (11.04)	4.68 (12.49)	5.78 (13.91)	4.88 (12.77)
7.	Chlorantraniliprole 18.5 SC	0.01	4.30 (11.97)	3.40 (10.63)	3.80 (11.24)	4.82 (12.68)	4.08 (11.65)
8.	Azadirachtin 0.15 EC	0.00075	13.26 (21.35)	13.17 (21.28)	12.98 (21.12)	12.91 (21.06)	13.08 (21.20)
9.	NSKE	5.0	13.59 (21.63)	13.25 (21.35)	13.17 (21.28)	13.05 (21.18)	13.27 (21.36)
10.	Control (untreated)		29.78 (33.07)	33.69 (35.48)	41.62 (40.18)	49.81 (44.89)	38.73 (38.48)
		SEm±	1.09	1.07	1.13	1.19	1.12
		CD (P=0.05)	3.24	3.17	3.35	3.54	3.33

Figures in the parentheses are angular transformed values
NSKE: Neem seed kernel extract

Similarly on seventh day of spray the treatment of flubediamide 48 SC (3.21 and 3.16%), chlorantraniliprole 18.5 SC (3.56 and 3.40%), emamectin benzoate 5 SG (3.58 and 3.41%), and fipronil 5 SC (3.79 and 3.67%) were found most effective and comparable to each other in their efficacy. The moderately effective treatments were novaluron 10 EC (7.93 and 6.12%), acephate 75 SP (8.25 and 8.13%) and malathion 50 EC (8.75 and 8.54%) and these formed a non significant group of insecticides, however the treatment of fipronil 5 SC was comparable with novaluron 10 EC. The least effective treatments were NSKE 5 percent (13.45 and 13.25%) and azadirachtin 0.15 EC (13.28 and 13.17%) and both were statistically at par.

On the tenth day of spray the treatment of flubediamide 48 SC (3.98 and 3.75%), chlorantraniliprole 18.5 SC (4.26 and 3.80%), emamectin benzoate 5 SG (4.67 and 4.27%), and fipronil 5 SC (5.62 and 4.68%) were found most effective and comparable to each other in their efficacy. The moderately effective treatments were novaluron 10 EC (8.04 and 7.81%), acephate 75 SP (8.67 and 8.49%) and malathion 50 EC (9.13 and 9.07%) and these were differed non significantly. The least effective treatments were NSKE 5 percent (13.27 and 13.17%) and azadirachtin 0.15 EC (13.07 and 12.98%) and both were statistically at par. The treatment of malathion 50 EC was also comparable with azadirachtin 0.15 EC

On the fifteen day of spray the treatment of flubediamide 48 SC (5.35 and 4.46%), chlorantraniliprole 18.5 SC (5.62 and 4.82%), emamectin benzoate 5 SG (5.91 and 5.21%), and fipronil 5 SC (6.31 and 5.78%) were found most effective and comparable to each other in their efficacy. The moderately these were effective treatments were novaluron 10 EC (9.62 and 8.23%), acephate 75 SP (9.87 and 9.70%) and malathion 50 EC (10.03 and 9.87%) and these were formed a non significant group of insecticides, however the treatment of fipronil 5 SC was comparable with novaluron 10 EC. The least effective treatments were NSKE 5 percent (13.21 and 13.05%) and azadirachtin 0.15 EC (12.99 and 12.91%) and both were statistically at par. however, the treatment of azadirachtin 0.15 EC was comparable with the mordantly effective treatment malathion 50 EC.

The overall efficacy of insecticides against shoot and fruit borer at different time intervals in the third spray indicated that flubendiamide 48 SC (4.19 and 3.82%), chlorantraniliprole 18.5 SC (4.52 and 4.08%), emamectin benzoate 5 SG (4.80 and 4.44%), and fipronil 5 SC (5.29 and 4.88%) were proved most effective against shoot and fruit borer in brinjal. The moderately effective treatments were novaluron 10 EC (8.29 and 7.39%), followed by acephate 75 SP (8.99 and 8.85%) and malathion 50 EC (9.42 and 9.20%). The maximum infestation of the pest in fruits of brinjal was recorded in the treatment of NSKE (5%) and azadirachtin 0.15 EC which resulted in 13.40 and 13.27 percent infestation on number basis and 13.20 and 13.08 percent infestation on weight basis and both were at par with each other and significantly inferior to rest of the insecticides. The descending order of efficacy of insecticides against shoot and fruit borer on the basis of mean of all the observations was: flubendiamide > chlorantraniliprole > emamectin benzoate > fipronil > novaluron > acephate > malathion > azadiractin > NSKE.

The effectiveness of most effective insecticides *viz.*, flubeniamide 48 SC, chlorentraniliprol 48 SC, emamectin benzoate 5 SG and fipronil 5 SC are in agreement with that of Ghosh *et al.* (2013) [5] who reported that flubendiamide (2.77% shoots and 15.33% fruits infestation), fipronil (3.43% and 15.85%), and novaluron (4.34%, 18.78%) were most effective against *L. orbonalis* on brinjal. Panda *et al.* (2005) [13] found fipronil, trizophos, and cartap hydrochloride most effective against *L. orbonalis* on brinjal support the present result. The effectiveness of ebamectin benzoate was conformity with that of Wankhede and Kale (2010) [23] who reported that emamectin benzoate was significantly superior, followed by novaluron against *L. orbonalis* on brinjal. Rajavel *et al*. (2011) [16] recorded lowest infestation of *L. orbonalis* on brinjal in the treatment of chlorantraniliprole. Likewise Pareet and Basavanagoud (2012) [14] also reported the effectiveness of emamectin benzoate 5 SG against the pest get support the present findings. Yadav *et al.* (2015) [25] reported emamectin benzoate effective against brinjal shoot and fruit borer. Likewise Yousafi *et al.* (2015) [26] evaluated the selected insecticides *viz.*, flubendiamide 48 SC, emamectin benzoate 1.9 EC and chlorantraniliprole 20 SC and found that all the treatments reduced shoot and fruit infestation significantly as compared to the control fully support the present findings.

The treatments of novaluron 10 EC, acephate 75 SP and malathion 50 EC were found moderately effective in the persent investigation. The results are in agreement with Ghosh *et al.* (2013) [5] who reported flubendiamide (2.77% shoots, 15.33% fruits infestation), fipronil (3.43% and 15.85%), and novaluron (4.34%, 18.78%) most effective against *L. orbonalis* on brinjal. Singh *et al.* (2005) [20] reported acephate effective against the pest and gave higher fruit yield. The effectiveness of malathion was reported against *L. orbonalis* by Yadav and Sharma (2005) [24], Senapati (2006) [19] and Jena *et al.* (2005) [6].

The plants products *viz.*, azadirachtin (0.15 EC) and NSKE (5%) were found least effective against L. orbonalis in present investigation. In contradictory with the present finding Mandal *et al.* (2010) [11] reported NSKE 5 percent most effective treatment in minimizing the pest population and also recorded maximum yield of brinjal. The results are corroborate with Tayde and Simon (2010) [21] who found that amonge neem products NSKE (5%) was superior in terms of efficacy and yield. Kumar *et al.* (2012) [10] reported higher infestation of pest in the treatment of neem seed kernel extract (NSKE).

Effect of insecticides and botanicals on the fruit yield of brinjal

The data presented in table 6 revealed that the fruit yield of brinjal in all the treatments was significantly higher than untreated control (119.65 q ha^{-1}). The maximum fruit yield of 236.22 q ha^{-1} was obtained in the treatment of flubendiamide 48 SC, followed by chlorantraniliprole 18.5 SC (232.40 q ha^{-1}), emamectin benzoate 5 SG (228.68 q ha^{-1}) and fipronil 5 SC (219.92 q ha^{-1}). The fruit yield of 209.87, 204.75 and 185.85 q ha $^{-1}$ was obtained in the moderately effective treatments *viz.*, novaluron 10 EC, acephate 75 SP and malathion 50 EC, respectively. The yield the treatment of acephate 75 SP differed significantly with novaluron 10 EC compatible with fipronil 5 SC. The minimum fruit yield was obtained in the treatment of azadirachtin 0.15 EC (165.85 q ha^{-1}) and NSKE 5 percent (149.75 q ha^{-1}).

Table 6: Comparative economics of newer insecticidal and botanicals against *Leucinodes orbonalis* (Guenee) on brinjal

S. No.	Treatments	Yield of health fruits (q/ha^{-1})	Increase in yield (q/ha)	Gross return (Rs./ha)	Total Expenditure (Rs.)	Net return (Rs./ha)	B.C. Ratio
1.	Acephate 75 SP	204.75	85.10	127650	2430	125220	51.53
2.	Flubendamide 48 SC	236.22	116.57	174855	6765	168090	24.84
3.	Novaluron 10 EC	209.87	90.22	135330	34320	101010	2.94
4.	Emamectin benzoate 5 SG	228.68	109.03	163545	13695	149850	10.94
5.	Malathion 50 EC	185.85	66.20	99300	1732.50	97567.50	56.31
6.	Fipronil 5 SC	219.92	100.27	150405	5230.50	145174.50	27.75
7.	Chlorantraniliprole 18.5 Sc	232.40	112.75	169125	10192.94	158932.06	15.59
8.	Azadirachtine 0.15 EC	165.85	46.20	69300	3052.50	66247.50	21.70
9.	NSKE	149.75	30.10	45150	1760.00	43390	24.65
10.	Control (untreated)	119.65					51.53

Price brinjal at prevailing market at the time of harvesting was Rs. 1500 q^{-1}

Total expenditure includes cost of insecticides and labour charges @ Rs 220/labour / day (6 labour / spray /ha)

The present findings are in agreement with that of Patra *et al*. (2009) [15] reported highest marketable fruit yield of 143.50 q ha^{-1} in spinosad followed by emamectin benzoate (121.30 q ha^{-1}). Wankhede and Kale (2010) [23] recorded the higher yield of healthy fruits in emamectin benzoate and novaluran treated plots to be 24.06, 23.14 and 20.46, 19.71 t ha^{-1} during two seasons, respectively. Pareet and Basavanagoud (2012) [14] reported highest marketable fruit yield in the treatment of emamectin benzoate (158.51 q ha^{-1}) and spinosad (153.51 q ha^{-1}) whereas, lowest marketable fruit yield of 83.93 q ha^{-1} was recorded in untreated control. Kumar *et al.* (2017) also recorded the highest fruit yield from emamectin benzoate 5 SC (229.90 q ha^{-1}). Singh *et al.* (2005) [20] reported that the treatment acephate was effective against the pest and gave higher fruit yield. These results also in agreement with those of Pareet and Basavanagoud (2012) [14] who recorded highest marketable yield in emamectin benzoate.

Economics of insecticidal treatments

The data presented in table 6 indicated that the maximum net profit of rupees 168090 ha^{-1} was obtained in the treatment of flubendimide 48 SC, followed by chlorantraniliprole 18.5 SC (Rs. 158932 ha^{-1}), emamectin benzoate 5 SG (Rs. 149850 ha^{-1}) and fipronil 5 SC (Rs. 145174 ha^{-1}). The moderately effective treatments *viz.*, novaluron 10 EC, acephate 75 SP and malathion 50 EC were gave the net profit of Rs. 101010, 125220 and 97567), respectively. Whereas, the minimum net profit of Rs. 43390 and 66247 ha^{-1} was obtained in the treatment of NSKE 5 percent and azadirachtin 0.15 EC, respectively. The maximum B:C ratio of 56.31 was obtained in the treatment of malathion 50 EC followed by acephate 75 SP (51.53). The higher B:C ratio was also obtained in the treatment of fipronil 5 SC (27.75), flubendimide 48 SC (24.84) and NSKE 5 percent (24.65), azadirachtin 0.15 EC (21.70) and chlorantraniliprole 18.5 SC (15.59), emamectin benzoate 5 SG (10.94) and novaluron 10 EC (2.94).

The present findings are in agreement with those of Tripathy (2005) [22] recorded highest B:C ratio in the treatment of acephate. Similarly, Kameshwaran and Kumar (2015) [8] recorded highest B:C ratio in chlorantraniliprole followed by emamectin benzoate, spinosad and indoxacarb. Sajjan and Rafee (2015) [18] also recorded higher B:C ratio in the treatment of spinosad, chlorantraniliprole, emamectin benzoate and indoxacarb.

Conclusion

On the basis of results it may be concluded that flubendiamide 48 SC, chlorantraniliprole 18.5 SC, emamectin benzoate 5 SG, and fipronil 5 SC were proved most effective against shoot and fruit borer in brinjal in respect to minimum infestation and higher fruit yield.

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