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Bio-efficacy of selective eco-friendly insecticides and bio pesticides against shoot and fruit borer, *Leucinodes orbonalis* (Guenee) in brinjal

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Abstract
A field experiment was conducted to determine the bio-efficacy of Emamectin benzoate 5 SG, Buprofezin 25 SC, *Beauveria bassiana*, Spinosad 45 SC, Cypermethrin 25 EC, Rynaxypyr (Chlorantraniliprole) 20 SC and Neem oil 1500 ppm against shoot and fruit borer, *Leucinodes orbonalis* in brinjal at Crop Research Center, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), India during *Kharif* 2017. All the treatments were found effective in reducing the infestation of shoot and fruit borer in comparison to control. Application of Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha was found most effective in reducing the incidence of shoot and fruit borer at all observational interval and it was followed by Emamectin benzoate 5 SG @ 200 gm/ha and Spinosad 45 SC @ 200 ml/ha. The *Beauveria bassiana* @ 2.5 kg/ha was recorded least effective.

Keywords: Bio efficacy, bio rationals, bio pesticides, *Leucinodes orbonalis*, brinjal

Introduction
Brinjal (*Solanum melongena* L.) is an important vegetable crop of India, grown throughout the year. Brinjal crop is attacked with plethora of insect-pests right from seedling stage to physiological maturity. It harbours more than 140 species of insect-pests (Prempong and Bauhim, 1977 and Sohi, 1996, Butani and Verma, 1976 and Nayar *et al.*, 1976) [13, 17, 2, 9] have however, listed only 36 and 53 insects, respectively on this crop. The brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) is the most obnoxious, detrimental and ubiquitous pest of brinjal and damage both, vegetative as well as reproductive stages. The larvae in early instars bore into petioles, midribs of large leaves and tender shoots, resulting in dead heart and dropping of plants is the typical symptom produced. Later they bore into developing fruits which become unmarketable. One larva damages four to six fruits during its complete larval development. A full grown larva before going for pupation comes out from the fruit by making exit hole. Pupation take place in boat shaped silken cocoon in the fallen leaves or soil. It is estimated that the economic injury level equals to 6 per cent infestation of shoot and fruit in India (Alam *et al.*, 2003) [1]. The apparent yield loss varying from 20-90 per cent in various parts of the country (Raju *et al.*, 2007), 85–90 per cent have been reported by (Patnaik, 2000; Misra, 2008 and Jagginavar *et al.*, 2009) [11, 8, 3].
Farmers are currently using wide variety of toxic chemicals and applying these more frequently with an aim to control the brinjal shoot and fruit borer. Due to the frequent pickings, the use of chemicals for management of this pest started proving to be detrimental to the health of consumers owing to the residue of the chemicals in the produce and also posed other problems like environmental pollution, disruption of natural enemies, resistance development and resurgence of pests (Mehrotra, 1990) [7]. But the new generation biorational pesticide molecules have been claimed to be effective as well as safer for non-target organisms (Sontakke *et al*., 2007; Misra, 2008) [8, 18]. In this context, present study has been undertaken.

Materials and Methods
The experiment was carried out during *Kharif* 2017 at Crop Research Center, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.), India; in a randomize block design (RBD) with three replications. Thirty days old seedling of brinjal variety BR-112 were planted at 60×60 cm in a plot size of 5x3 m^2. In all, there were eight treatments including control. All the agronomic practices, except the package recommended for insect pest management were adopted to raise a good crop. Each treatment in the form of spray was applied thrice during the crop season.

For the control of shoot and fruit damage, first spray was given at 30 days after transplanting. The subsequent second and third spray was applied at an interval of 15 days. Observations on shoot and fruit damage were recorded from five randomly selected plants one day before and 7 and 14 days after each application of treatments. Yield of healthy fruits was taken at each picking.

Results and Discussion

Effect of treatments on shoot damage caused by *L. orbonalis*

The results revealed that all the treatments were significantly effective in reducing the infestation of shoot borer and thus increasing the yield significantly as compared to control. The initial shoot and fruit borer infestation recorded as shoot damage, which ranged from 8.30 to 8.80 per cent before the spray and did not differ significantly (Table 1). Data recorded 7th day after spraying showed that, the minimum shoot damage (3.53 per cent) was recorded in the plots treated with Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha gave superior control, over all other treatments followed by Emamectin benzoate 5 SG @ 200 gm/ha showing (4.57 per cent) shoot infestation. Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha showing (4.77 per cent) shoot infestation and next best treatment Cypermethrin 25 EC @ 150 ml/ha showing (6.70 per cent) shoot infestation followed by Buprofezin 25 SC @ 800 ml/ha (8.20 per cent) shoot infestation, Neem oil 1500 ppm @ 3lit/ha (9.70 per cent) shoot infestation and *Beauveria bassiana* @ 2.5 kg/ha (11.33 per cent) shoot infestation and maximum shoot damage (14.67 per cent) was recorded in control plot. 14th day after the first application data revealed that Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha maintained its effectiveness in reducing the shoot damage infestation (4.10 per cent shoot damage). It was significantly superior to rest of the treatments. Emamectin benzoate 5 SG @ 200 gm/ha (6.30 percent shoot damage) was the next effective treatment. The treatment Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha (6.67 per cent shoot damage), next order found effective were Cypermethrin 25 EC @ 150 ml/ha (8.20 per cent shoot damage), Buprofezin 25 EC @ 800 ml/ha (9.70 per cent shoot damage), Neem oil 1500 ppm @ 3 lit/ha (11.00 per cent shoot damage), and least effective *Beauveria bassiana* @ 2.5 kg/ha (13.50 per cent shoot damage). The highest infestation (17.00 per cent shoot damage) was recorded in control plot. A similar trend of bioefficacy was recorded after second application at each time interval. After 7th day of insecticidal application, all the treatments were found significantly superior than the control. The minimum shoot damage (3.67 per cent shoot damage) was recorded with Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha**.** The treatment Emamectin benzoate 5 SG @ 200 gm/ha had 5.80 per cent shoot damage. The treatment Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha, (shoot damage 5.90 per cent) and next effective treatments Cypermethrin 25 EC @ 150 ml/ha (7.77 per cent shoot damage), Buprofezin 25 SC @ 800 ml/ha (9.23 per cent shoot damage), Neem oil 1500 ppm @ 3 lit/ha (11.10 percent shoot damage) and *Beauveria bassiana* @ 2.5 kg/ha (13.73 per cent shoot damage). Maximum shoot damage (22.37 per cent) was recorded in control plot. Observation recorded on 14th day after the second application revealed that Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha maintained its effectiveness in reducing the shoot damage infestation (5.00 per cent shoot damage). It was significantly superior to rest of the treatments. Emamectin benzoate 5 SG @ 200 gm/ha (7.40 percent shoot damage) was the next effective treatment. Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha (7.80 per cent shoot damage), in next order found effective treatments Cypermethrin 25 EC @ 150 ml/ha (10.20 per cent shoot damage), Buprofezin 25 SC @ 800 ml/ha (12.53 per cent shoot damage), Neem oil 1500 ppm @ 3 lit/ha (14.87 per cent shoot damage) and least effective *Beauveria bassiana* @ 2.5 kg/ha was recorded (17.40 per cent shoot damage). The highest infestation (33.70 per cent shoot damage) was recorded in control plot. A similar trend in reduction of shoot damage was recorded after the third spray and all the treatments prove better than the control. After 7th day of third application, Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha gave the best performance and recorded lowest (3.80 per cent) shoot damage as compared to other treatments. The next effective treatment was Emamectin benzoate 5 SG @ 200 gm/ha (6.20 per cent shoot damage) and it was found at par with Spinosad 45 SC @ 200 ml/ha (6.60 per cent shoot damage), followed by Cypermethrin 25 EC @ 150 ml/ha (8.70 per cent shoot damage), Buprofezin 25 SC @ 800 ml/ha (11.83 per cent shoot damage), Neem oil 1500 ppm @ 3 lit/ha (14.40 per cent shoot damage), and least effective *Beauveria bassiana* @ 2.5 kg/ha was recorded (17.13 per cent shoot damage), but it was better than control in managing the shoot borer damage. Maximum damage (37.70 per cent) was recorded in control plot. The observation recorded at 14th day after third application showed that all the treatments maintained their efficacy and significance over control, at this stage also Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha gave the best performance and recorded minimum shoot damage (4.44 per cent) as compared to other treatments. The next effective treatment was Emamectin benzoate 5 SG @ 200 gm/ha in which 6.77 per cent shoot damage was recorded. Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha (7.22 per cent shoot damage), followed by Cypermethrin 25 EC @ 150 ml/ha (9.45 per cent shoot damage), Buprofezin 25 SC @ 800 ml/ha (12.33 per cent shoot damage), Neem oil 1500 ppm @ 3 lit/ha (15.66 per cent shoot damage) and least effective *Beauveria bassiana* @ 2.5 kg/ha was recorded (21.23 per cent shoot damage) but it was better than control in managing the shoot borer damage. Maximum damage (37.20 per cent) was recorded in control plot.

Table 1: Effect of various treatments on shoot damage caused by *L. orbonalis*

S. No.	Treatment	Dose (kg/gm/ml)/ha	Mean per cent shoot damage						
			1 DBS	First spray		Second spray		Third spray	
				7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS
1	Emamectin benzoate 5 SG	200 gm/ha	8.40 (16.83)	4.57 (12.33)	6.30 (14.52)	5.80 (13.92)	7.40 (15.76)	6.20 (14.36)	6.77 (15.07)
2	Buprofezin 25 SC	800 ml/ha	8.30 (16.72)	8.20 (16.63)	9.70 (18.13)	9.23 (17.67)	12.53 (20.70)	11.83 (20.08)	12.33 (20.50)
3	*Beauveria bassiana*	2.5 kg/ha	8.70 (17.14)	11.33 (19.66)	13.50 (21.54)	13.73 (21.72)	17.40 (24.63)	17.13 (24.43)	21.23 (27.41)
4	Spinosad 45 SC	200 ml/ha	8.40 (16.83)	4.77 (12.59)	6.67 (14.94)	5.90 (14.04)	7.80 (16.20)	6.60 (14.87)	7.22 (15.58)
5	Cypermethrin 25 EC	150 ml/ha	8.50 (16.94)	6.70 (14.96)	8.20 (16.63)	7.77 (16.15)	10.20 (18.60)	8.70 (17.09)	9.45 (17.89)
6	Rynaxypyr 20 SC	150 ml/ha	8.60 (17.04)	3.53 (10.79)	4.10 (11.67)	3.67 (11.03)	5.00 (12.88)	3.80 (11.23)	4.44 (12.15)
7	Neem oil 1500 ppm	3.0 litre/ha	8.80 (17.23)	9.70 (18.13)	11.00 (19.36)	11.10 (19.44)	14.87 (22.66)	14.40 22.27)	15.66 (23.28)
8	Control	-	8.30 (16.70)	14.67 (22.49)	17.00 (24.32)	22.37 (28.19)	33.70 (35.46)	37.70 (37.86)	37.20 (37.56)
	Sem (±) CD at 5%		0.405 **N.S.**	0.479 1.468	0.392 1.202	0.482 1.476	0.624 1.910	0.694 2.125	0.554 1.697

*****Figures in parentheses are angular transformed values, N.S. - Non significant; DBS- Days before Spray, DAS- Days after Spray, Significant at 5%

Effect of treatments on fruit damage (weight basis) caused by *L. orbonalis*

To evaluate the efficacy of various insecticides and bio pesticides against *L. orbonalis* on fruit of brinjal crop, the weight of total and damaged fruits were recorded and the percentage of fruit damage was calculated. Pre-treatment observations recorded a day before first insecticidal and bio-pesticidal application indicated that the fruit borer infestation was similar throughout the experimental field and ranged from 7.80 to 8.80 per cent and it was non-significant. However, fruit damage data was also recorded at 7th and 14th day after spraying. The data recorded 7th day after application of insecticide and it showed that all insecticides and bio-pesticides were found effective and significantly superior than control (Table 2). Among all the treatments Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha was found most effective with (4.07 per cent fruit damage) and it was closely followed by Emamectin benzoate 5 SG @ 200 gm/ha (6.10 per cent fruit damage), The treatment Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha was recorded (6.30 per cent fruit damage) followed by Cypermethrin 25 EC @ 150 ml/ha where fruit damage was recorded (7.90 per cent). The next effective treatments were Buprofezin 25 SC @ 800 ml/ha and Neem oil 1500 ppm @ 3 lit/ha in which fruit damage ranged from 9.47 to 11.13 per cent, respectively. The *Beauveria bassiana* @ 2.5 kg/ha with 12.93 per cent fruit damage was less effective. The highest fruit damage (16.80 per cent) was recorded in control plot. Observation recoded after 14th day of first application revealed that Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha again proved most effective insecticide showing minimum (5.30 per cent) fruit damage. The second most effective treatment was Emamectin benzoate 5 SG @ 200 gm/ha (8.47 per cent fruit damage). Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha (8.70 per cent fruit damage), followed by Cypermethrin 25 EC @ 150 ml/ha (11.07 per cent fruit damage), Buprofezin 25 SC @ 800 ml/ha (13.53 per cent fruit damage), Neem oil 1500 ppm @ 3 lit/h (16.37 per cent fruit damage), and *Beauveria bassiana* @ 2.5 kg/ha (19.13 per cent fruit damage). However, maximum fruit damage (24.73 per cent) was recorded in control plot. A similar trend in relation of fruit damage was recorded after the second spray and all the treatments proved better over the control. After 7th day of second application, Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha gave the best performance and recorded lowest fruit damage (4.70 per cent) as compared to other treatments. The next in order of effectiveness of treatments are, Emamectin benzoate 5 SG @ 200 ml/ha (6.47 per cent). The treatment Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha (6.70 per cent fruit damage). The next effective treatments are Cypermethrin 25 EC @ 150 ml/ha, Buprofezin 25 SC @ 800 ml/ha and Neem oil 1500 ppm @ 3 lit/h with 8.30, 10.80 and 12.90 per cent fruit damage, respectively. *Beauveria bassiana* @ 2.5 kg/ha was found least effective (20.79 per cent fruit damage) but it was better than control in managing the brinjal fruit borer damage. Maximum damage (30.80 per cent fruit damage) was recorded in control plot. Similar trend was recorded 14th day after second application i.e. Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha proved best treatment (5.30 per cent fruit damage). It was followed by, Emamectin benzoate 5 SG @ 200 gm/ha (7.47 per cent fruit damage). Emamectin benzoate 5 SG @ 200 ml/ha is at par wih Spinosad 45 SC @ 200 ml/ha (7.80 per cent fruit damage) and next effective treatments, Cypermethrin 25 EC @ 150 ml/ha, Buprofezin 25 SC @ 800 ml/ha, Neem oil 1500 ppm @ 3 lit/ha, and *Beauveria bassiana* @ 2.5 kg/ha in which fruit borer infestation ranged from 9.77, 11.87, 14.13 and 23.43 per cent fruit damage, respectively. Maximum fruit borer infestation (37.30 per cent fruit damage) was recorded in control plot. The third insecticidal spray was applied 15th day after second application and data recorded. A similar trend of efficacy of insecticides as in first and second application on reduction of fruit damage was recorded. Data recorded after 7th day of insecticidal application, all the treatments were found significantly superior than the control. The minimum (3.90 per cent) fruit damage was recorded with Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha. The second most effective treatment was Emamectin benzoate 5 SG @ 200 gm/ha (5.60 per cent fruit damage). Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha (5.80 per cent fruit damage). The next effective treatments are Cypermethrin 25 EC @ 150 ml/ha followed by Buprofezin 25 SC @ 800 ml/ha, Neem oil 1500 ppm @ 3 lit/h, and *Beauveria bassiana* @ 2.5 kg/ha, 7.70, 9.40, 11.30, and 22.50 fruit damage, respectively. However, maximum fruit damage (36.67 per cent fruit damage) was recorded in untreated plot. Observation recorded on 14th day after the third application revealed that Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha maintained its effectiveness in reducing the fruit borer infestation (4.20 per cent fruit damage). Emamectin benzoate 5 SG @ 200 gm/ha was the next effective treatment. Emamectin benzoate 5 SG @ 200 ml/ha is at par with Spinosad 45 SC @ 200 ml/ha, followed by Cypermethrin 25 EC @ 150 ml/ha, Buprofezin 25 SC @ 800 ml/ha, Neem oil 1500 ppm @ 3 lit/ha. Treatment Neem oil 1500 ppm @ 3 lit/ha, and *Beauveria bassiana* @ 2.5 kg/ha was recorded least effective (12.40 and 23.37 per cent fruit damage, respectively). The highest infestation (35.27 per cent fruit damage) was recorded in control plot.

Table 2: Effect of various treatments on fruit damage (weight basis) caused by *L. orbonalis*

S. No.	Treatment	Dose (kg/gm/ml) / ha	Mean per cent fruit damage						
			1 DBS	First spray		Second spray		Third spray	
				7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS
1	Emamectin benzoate 5 SG	200 gm/ha	8.10 (16.51)	6.10 (14.29)	8.47 (16.89)	6.47 (14.72)	7.47 (15.84)	5.60 (13.68)	6.10 (14.28)
2	Buprofezin 25 SC	800 ml/ha	8.60 (17.04)	9.47 (17.90)	13.53 (21.53)	10.80 (19.17)	11.87 (20.11)	9.40 (17.84)	10.30 (18.68)
3	*Beauveria bassiana*	2.5 kg/ha	8.80 (16.20)	12.93 (21.06)	19.13 (25.92)	20.79 (27.11)	23.43 (28.93)	22.50 (28.30)	23.37 (28.89)
4	Spinosad 45 SC	200 ml/ha	7.93 (16.33)	6.30 (14.52)	8.70 (17.13)	6.70 (14.95)	7.80 (16.20)	5.80 (13.92)	6.40 (14.64)
5	Cypermethrin 25 EC	150 ml/ha	7.90 (16.31)	7.90 (16.29)	11.07 (19.41)	8.30 (16.73)	9.77 (18.20)	7.70 (16.07)	8.30 (16.72)
6	Rynaxypyr 20 SC	150 ml/ha	8.20 (16.63)	4.07 (11.61)	5.30 (13.22)	4.70 (12.51)	5.30 (13.27)	3.90 (11.38)	4.20 (11.77)
7	Neem oil 1500 ppm	3.0 litre/ha	7.80 (17.24)	11.13 (19.46)	16.37 (23.84)	12.90 (21.03)	14.13 (22.06)	11.30 (19.60)	12.40 (20.60)
8	Control	-	8.80 (17.23)	16.80 (24.18)	24.73 (29.80)	30.80 (33.68)	37.30 (37.61)	36.67 (37.24)	35.27 (36.41)
	Sem (±) CD at 5%		0.384 **N.S.**	0.499 1.528	0.662 2.027	0.492 1.507	0.586 1.796	0.544 1.667	0.581 1.779

*****Figures in parentheses are angular transformed values, N.S.- Non significant ; DAS- Days After Spray, DBS- Days Before Spray, Significant at 5%

Effect of treatments on fruit damage (Number basis) caused by *L. orbonalis*

Efficacy of different insecticides on the fruit infestation of *L. orbonalis* in brinjal is presented in Table 3. The results indicated that all the treatments were significantly effective in reducing the infestation of shoot and fruit borer and thus increasing the yield significantly as compared to control. The initial shoot and fruit borer infestation recorded as fruit damage, which ranged from 7.80 to 8.40 per cent before the spray and did not differ significantly. Data recorded 7th day after spraying, the minimum fruit damage was recorded in the plots treated with Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha gave superior control, among all the treatments with 4.30 per cent fruit damage followed by Emamectin benzoate 5 SG @ 200 gm/ha showing 6.40 per cent fruit damage. Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha showing 6.60 per cent fruit damage and next best treatment was Cypermethrin 25 EC @ 150 ml/ha showing 8.70 per cent fruit infestation followed by Buprofezin 25 SC @ 800 ml/ha (10.73 per cent fruit damage), Neem oil 1500 ppm @ 3 lit/ha (12.90 per cent fruit damage), and *Beauveria bassiana* @ 2.5 kg/ha (15.30 per cent fruit damage) and maximum fruit damage (18.20 per cent fruit damage) was recorded in control plot. Observation recorded on 14th day after the first application revealed that Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha again proved most effective insecticide showing 5.40 per cent fruit damage. It was significantly superior to rest of the treatments. Emamectin benzoate 5 SG @ 200 gm/ha (7.50 per cent fruit damage) was the next effective treatment. Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha (7.80 per cent fruit damage), followed by Cypermethrin 25 EC @ 150 ml/ha, Buprofezin 25 SC @ 800 ml/ha, Neem oil 1500 ppm @ 3 lit/ha and *Beauveria bassiana* @ 2.5 kg/ha as fruit damage 9.83, 12.07, 14.47 and 17.07 per cent fruit damage, respectively. However, the maximum fruit damage (24.20 per cent fruit damage) was recorded in control plot. The second insecticide and bio pesticide sprays was applied at 15th days after first application. A similar trend of efficacy of insecticides as in first application on reduction of fruit damage infestation was recorded. After 7th day of insecticidal application, all the treatments were found significantly superior than the control. The minimum fruit damage (4.20 per cent fruit damage) was recorded with Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha**.** The next best treatment Emamectin benzoate 5 SG @ 200 gm/ha had 6.10 per cent fruit damage. Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha, (6.50 per cent fruit damage), followed by Cypermethrin 25 EC @ 150 ml/ha (8.10 per cent fruit damage), Buprofezin 25 SC @ 800 ml/ha (9.77 per cent fruit damage), Neem oil 1500 ppm @ 3 lit/ha (11.97 per cent fruit damage), and *Beauveria bassiana* @ 2.5 kg/ha (20.20 per cent fruit damage). Maximum fruit damage (32.40 per cent fruit damage) was recorded in control plot. Observation recorded on 14th day after the second application revealed that Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha maintained its effectiveness in reducing the fruit damage (5.10 per cent fruit damage). It was significantly superior to rest of the treatments. Emamectin benzoate 5 SG @ 200 gm/ha (7.10 percent fruit damage) was the next effective treatment. Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha (7.50 per cent fruit damage), next order found effective treatments Cypermethrin 25 EC @ 150 ml/ha (9.20 per cent fruit damage), Buprofezin 25 SC @ 800 ml/ha (11.30 per cent fruit damage), Neem oil 1500 ppm @ 3 lit/ha (13.70 per cent fruit damage) and least effective *Beauveria bassiana* @ 2.5 kg/ha was recorded (22.70 per cent fruit damage). The highest damage (37.73 per cent fruit damage) was recorded in control plots. A similar trend in reduction of fruit damage was recorded after the third spray and all the treatments prove better than the control. After 7th day of third application, Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha gave the best performance and recorded lowest (4.10 per cent) fruit damage as compared to other treatments. The next effective treatment was Emamectin benzoate 5 SG @ 200 gm/ha (5.60 per cent fruit damage). Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha (5.80 per cent fruit damage), followed by Cypermethrin 25 EC @ 150 ml/ha (7.50 per cent fruit damage), Buprofezin 25 SC @ 800 ml/ha (10.10 per cent fruit damage), Neem oil 1500 ppm @ 3 lit/ha (11.97 per cent fruit damage), and least effective *Beauveria bassiana* @ 2.5 kg/ha was recorded (22.10 per cent fruit damage), but it was better than control in managing the fruit borer damage. Maximum damage (39.17 per cent fruit damage) was recorded in control plot. The observation recorded at 14th day after third application showed that all the treatments maintained their efficacy and significance over control, at this stage also Rynaxypyr (Chlorantraniliprole) 20 SC @ 150 ml/ha gave the best performance and recorded minimum fruit damage (4.23 per cent) as compared to other treatments. The next effective treatment was Emamectin benzoate 5 SG @ 200 gm/ha in which 6.10 per cent fruit damage was recorded. The treatment Emamectin benzoate 5 SG @ 200 gm/ha is at par with Spinosad 45 SC @ 200 ml/ha in which 6.40 per cent fruit damage was recorded. The Neem oil 1500 ppm @ 3 lit/ha was found less effective where 12.33 per cent fruit damage were recorded and *Beauveria bassiana* @ 2.5 kg/ha was found least effective treatment in in which fruit damage recorded with 23.37 percent but it was significantly superior than control (40.67 per cent fruit damage). In other treatments the fruit damage was 8.20 and 10.37 per cent, respectively.

It is evident from the above findings that all the treatments were effective in reducing shoot and fruit damage at different intervals after each spray in comparison to untreated control. Rynaxypyr (Chlorantraniliprole) proved most effective treatment for the control of shoot and fruit borer in present study. The second best treatment in reducing the fruit damage (both by weight basis and by number basis) was Emamectin benzoate and which was found at par with Spinosad. The present findings are supported by Saha *et al*., (2014), Patra *et al.*, (2016), Kushwaha and Painkra (2016) and Sarnabati and Ray (2017) [15, 12, 5, 16] who also reported that chlorantraniliprole (Rynaxypyr) was most effective treatment in reducing the shoot and fruit damage in brinjal. Kameshwaran and Kumar (2015) [4] also reported that chlorantraniliprole (Rynaxypyr) had highest percentage of reduction shoot and fruit damage followed by Emamectin benzoate. The present findings are also supported by Mainali *et al.*, (2014), Tripura *et al*., (2017) and Niranjana *et al*., (2017) [6, 19, 10] who reported that chlorantraniliprole (Rynaxypyr) was most effective that significantly reduced the shoot and fruit damage infestation followed by Spinosad.

Table 3: Effect of various treatments on fruit damage (number basis) caused by *L. orbonalis.*

S. No.	Treatment	Dose (kg/gm/ml) / ha	Mean per cent fruit damage						
			1 DBS	First spray		Second spray		Third spray	
				7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS
1	Emamectin benzoate 5 SG	200 gm/ha	7.80 (16.17)	6.40 (14.61)	7.50 (15.88)	6.10 (14.29)	7.10 (15.42)	5.60 (13.68)	6.10 (14.24)
2	Buprofezin 25 SC	800 ml/ha	8.20 (16.63)	10.73 (19.11)	12.07 (20.29)	9.77 (18.20)	11.30 (19.63)	10.10 (18.51)	10.37 (18.76)
3	*Beauveria bassiana*	2.5 kg/ha	8.10 (16.52)	15.30 (22.99)	17.07 (20.29)	20.20 (26.69)	22.70 (28.43)	22.10 (28.02)	23.37 (28.89)
4	Spinosad 45 SC	200 ml/ha	8.40 (16.80)	6.60 (14.87)	7.80 (16.16)	6.50 (14.75)	7.50 (15.88)	5.80 (13.90)	6.40 (14.64)
5	Cypermethrin 25EC	150 ml/ha	7.90 (16.31)	8.70 (17.14)	9.83 (18.26)	8.10 (16.52)	9.20 (17.64)	7.50 (15.86)	8.20 (16.63)
6	Rynaxypyr 20 SC	150 ml/ha	8.10 (16.52)	4.30 (11.96)	5.40 (13.43)	4.20 (11.77)	5.10 (13.04)	4.10 (11.67)	4.23 (11.85)
7	Neem oil 1500 ppm	3.0 litre/ha	8.30 (16.73)	12.90 (21.03)	14.47 (22.34)	11.97 (20.22)	13.70 (21.70)	11.97 (20.22)	12.33 (20.54)
8	Control	-	8.40 (16.83)	18.20 (25.20)	24.20 (29.43)	32.40 (34.66)	37.73 (37.87)	39.17 (38.53)	40.67 (39.25)
	Sem (±) CD at 5%		0.470 **N.S.**	0.614 1.881	0.655 2.005	0.532 1.630	0.482 1.476	0.553 1.707	0.471 1.442

*****Figures in parentheses are angular transformed values, N.S. - Non significant; DAS- Days after Spray, DBS- Days before Spray, Significant at 5%

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