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Bio-efficacy of newer insecticides against shoot and fruit borer, *Leucinodes orbonalis* (L.) Guen. on brinjal

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Abstract
The present experiment was conducted at Khanzada Agriculture Farm, Tando Allahyar, on brinjal crop during Kharif, season 2016. The data revealed that on 3rd day of the first spray all the treatments were found significantly superior over untreated control. However, significant difference existed among them. The chlorantraniliprole (0.002%) was found most effective resulted in minimum shoot infestation (8.25%) followed by acephate (0.05%), and both treatments were differed non-significant. On the 7th day of second spray the minimum shoot infestation was recorded in the treatment of T3, T6, T4, T1 and T5, respectively. All the treatments were also found significantly superior over untreated control on 10th day of second spray. The maximum infestation was recorded in the treatment of malathion which was differed non-significant with spinosad. The similar trends of efficacy of insecticides were also observed on 15th day of first spray. The overall efficacy of insecticides against shoot and fruit borer on brinjal at different time intervals in the third spray indicated that chlorantraniliprole, acephate and emamectin benzoate were found most effective with 5.95, 6.66 and 7.11 percent fruit infestation on number basis and 5.50, 6.31 and 6.58 on weight basis, respectively and these were differed non-significant.

Keywords: Insecticides, brinjal, *Leucinodes orbonalis* fruit borer, shoot borer

1. Introduction
Brinjal, *Solanum melongena* (L.) also known as eggplant, belongs to family Solanceae. The brinjal is of much importance in the warm areas of Far East, being grown extensively in India, Bangladesh, Pakistan, China and Philippines. It is also popular in Central, South and South East Asia, some parts of Africa and Central America [1]. It is native of India and is grown throughout the country except in higher altitudes [2]. In production and productivity, India is second in the world after China. In India the total area under brinjal cultivation is 7.11 lac hectares with an annual production of 135.57 lac tones (Anonymous, 2014 A) and Rajasthan occupied 55.39 thousand hectare area with an annual production of 23.21 million tone [3]. It is generally grown in all the districts of Rajasthan during summer and rainy season. The brinjal is rich source of minerals (calcium, magnesium, phosphorus, sodium, potassium, chlorine, iron etc.), vitamins and also has some medicinal importance [4].
The brinjal crop is attacked by a number of insect-pests right from germination to harvesting of the crop *viz.*, shoot and fruit borer, *Leucinodes orbonalis* (L.) Guen., jassid, *Amrasca biguttula biguttula* (Ishida), aphid, *Aphis gossypii* Glover, lace wing bug, *Urentius echinus* Distant, epilachna beetle, *Epilachna vigintioctopunctata* Fab. and stem borer, *Euzophera perticella* Ragonot, among these insects, shoot and fruit borer, *L. orbonalis* is one of the major constraints in achieving potential yield and remain active throughout the year with many overlapping generations [5]. This pest is reported from all brinjal growing areas of world including Germany, Burma, USA, Srilanka and india. The shoot and fruit borer inflicting yield losses as high as 85-90 percent [6] has now been considered as the key pest of brinjal [7].
Crop losses have been reported to the tune of 20-89 percent in various parts of India by this pest [8]. The caterpillar of the pest initially attacks the terminal shoot and bore inside as a result of which, drooping and wilting of the shoots occur. In the later stage, it also bores into the young fruits by making holes and feeds inside. Such fruits, being partially unfit for human consumption and lose their market value [9]. In order to prevent the infestation of the pest and to produce a quality crop, it is essential to manage the pest population at appropriate time with

suitable control measures. Keeping these points in view the present study will be undertaken to evolve the management strategy against *L. orbonalis* through new safer insecticidal molecules. In this context use of insecticides in combination with other control measures has always more effective than using insecticides alone [10]. Thus in the present study efforts will be made to evaluate the efficacy of some newer safe insecticidal molecules. The main objective of the study was effect of newer insecticides against *L. orbonalis* on brinjal.

2. Material and Method

2.1 Site and location of experiment

The present investigations were conducted at Khanzada Agriculture Farm, Tando Allahyar, on brinjal crop during Kharif, season 2016.

2.2 Layout and design

The experiment was laid out in a simple Randomized Block Design (RBD) with eight treatments (insecticides) including untreated control, each replicated thrice. The plot size was 3x3 M^2 keeping row to row and plant to plant distance of 60 and 50 cm, respectively. Transplanted on 22 August, 2016. The recommended packages of practices were followed to raise the crop.

2.3 Common name Formulations Concentration (%)

T^1 = Spinosad 45 SC 0.01
T^2 = Indoxacarb 14.5 SC 0.002
T^3 = Chlorantraniliprole 18.5 SC 0.002
T^4 = Emamectin benzoate 5 SG 0.002
T^5 = Cartap hydrochloride 50 SP 0.05
T^6 =Acephate 75 SP 0.05
T^7 = Malathion 50 EC 0.05
T^8 = Control (untreated)

All the treatments 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 sprays were given when sufficient infestation of *L. orbonalis* on fruits was observed.

2.4 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. The percent infestation in shoots and fruits were calculated and data were subjected to statistical analysis after angular transformation.

3. Results

Total Three sprays were applied to protect the crop from shoot and fruit borer infestation. The observations on shoot damage were recorded in first and second sprays and on fruit damage both on number and weight basis in third sprays one day before and on 3rd, 7th, 10th and 15th days of application of insecticides.

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

First spray

The data presented in table 1 which revealed that on 3rd day of first spray all the treatments were found significantly superior over untreated control; however, significant difference existed among them. The treatment of chlorantraniliprole (0.002%) was found most effective resulted in minimum shoot infestation (8.25%) followed by acephate (0.05%) registered 9.24 percent shoot infestation and both treatments were differed non-significant. The next effective non-significant group of insecticides was emamectin benzoate (0.002%) followed by cartap hydrochloride (0.05%) and indoxacarb (0.002%) exhibited, 10.37, 10.77 and 11.59 percent shoot infestation. The maximum shoot infestation (12.29%) was recorded in malathion (0.05%) and spinosad (0.01%) with 11.85 infestation and both were at par with each other however, spinosad was also found at par with indoxacarb. Among the treatments, chlorantraniliprole and acephate was also found most effective on 7th day of first spary resulted in 4.91 and 5.70 percent infestation, respectively.

On the other hand, the highest infestation was also recorded in malathion (8.64%) and spinosad (7.91%), however, both were differed non-significantly with indoxacarb. On 10th day of first spray, the treatment of chlorantraniliprole (6.42%) proved most effective followed by emamectin benzoate (7.28%) and acephate (7.50%) and these were differed non-significantly. From the above findings revealed that next effective treatments were emamectin benzoate (8.09%) followed by cartap hydrochloride (8.84%) and indoxacarb (9.46%), however, later one differed significantly with emamectin benzoate. The maximum infestation was recorded in the treatment of malathion and spinosad which resulted in 10.70 and 9.99 percent infestation, respectively.

Second spray

The furthermore results discussed in table 2 on 3rd day of second spray all the treatments were found significantly superior over untreated control; however, significant difference existed among them. The treatment of chlorantraniliprole was found most effective resulted in minimum shoot infestation (7.54%) followed by acephate and emamectin benzoate registered 8.01 and 8.63 percent shoot infestation, respectively and these treatments were differed non-significant. The next effective nonsignificant group of insecticides was cartap hydrochloride followed by spinosad and indoxacarb with 9.72, 10.71 and 12.19 percent shoot infestation, respectively, however, the treatment of cartap hydrochloride was comparable with the most effective treatment acephate.

Among the treatments, maximum infestation was recorded in the treatment of malathion (7.67%) followed by indoxacarb (7.16%) and both were differed non-significant with the treatment of cartap hydrochloride. All the treatments were also found significantly superior over untreated control on 10th day of second spray. Moreover, the treatment of chlorantraniliprole was found most effective resulted in minimum shoot infestation (4.93%) followed by emamectin benzoate (5.79%). From the above findings it was revealed that the highest infestation (9.89%) was recorded in malathion and indoxacarb with 8.57 percent infestation and indoxacarb was also found at par with spinosad. The maximum infestation was recorded in the treatment of indoxacarb (10.27%) followed by malathion (9.70%) and both were also at par with each other. The data indicated that on the basis of mean of all the observations that chlorantraniliprole and acephate were proved most effective with 5.74 and 6.66 percent shoot infestation, respectively.

3.3 Percent infestation of *L. orbonalis* on fruits of brinjal. Third spray

The data presented in table 3 on 3rd day of spray all the treatments were found significantly superior over untreated control against *L. orbonalis* on brinjal based on fruit damage, both on number and weight basis however, significant difference existed among them. The treatment of chlorantraniliprole was found most effective with minimum fruit infestation (7.21% on number basis and 6.79% on weight basis) followed by emamectin benzoate (7.75 and 7.64%) and acephate (7.86 and 7.70%) and these treatments were at par with each other. The maximum infestation was recorded in the treatment of malathion (10.83 and 10.25%) however, it was at par with indoxacarb. The treatment of chlorantraniliprole and acephate were also found most effective on 7th day of third spary resulted in 4.17 and 4.82 fruit infestation on number basis and 3.76 and 4.15 percent on weight basis and both were at par. On 10th day of third spary the treatment of chlorantraniliprole was found most effective resulted in minimum fruit infestation (5.77 and 5.03%) followed by acephate (6.46 and 6.16%) and both were stood at par. The next effective non-significant group of insecticides was emamectin benzoate followed by indoxacarb and cartap hydrocloride exhibited 7.38, 7.90 and 8.06 percent fruit infestation on number basis and 5.70, 7.39 and 7.68 fruit infestation on weight basis, respectively.

However, cartap hydrochloride was also comparable with the most effective treatment emamectin benzoate. The maximum fruit infestation was recorded in the treatments of malathion (11.84 and 10.36%) and spinosad (10.80 and 9.75%) and both were differed non-significant with indoxacarb. Moreover, the overall efficacy of insecticides against shoot and fruit borer on brinjal at different time intervals in the third spray indicated that chlorantraniliprole, acephate and emamectin benzoate were found most effective with 5.95, 6.66 and 7.11 percent fruit infestation on number basis and 5.50, 6.31 and 6.58 percent on weight basis, respectively and these were differed non-significant. The descending order of efficacy of insecticides against shoot and fruit borer on mean basis was: chlorantraniliprole > acephate > emamectin benzoate > cartap hydrochloride > indoxacarb > spinosad > malathion.

Table 1: Effect of newer insecticides against *Leucinodes orbonalis* (L.) Guen. on brinjal

First Spray					
Treatments	**3rd**	**7th**	**10th**	**15th**	**Mean**
Spinosad 45 SC	11.85	7.91	9.88	10.35	9.99
Indoxacarb 14.5 SC	11.59	7.16	9.47	9.64	9.46
Chlorantraniliprole 18.5 SC	8.25	4.91	6.42	7.53	6,77
Emamectin benzoate 5SG	10.37	6.09	7.28	8.64	8.09
Cartaphydrochloride 50 SP	10.77	6.47	8.65	9.48	8,84
Acephate 75 SP	9.24	5.70	7.50	7.93	7.59
Malathion 50 EC	12.29	8.64	11.18	10.72	10.70
Control	24.26	32.59	37.63	45.28	34.94
S.Em±	0.40	0.36	0.44	0.38	0.39
CD (P= 0.05)	1.20	1.08	1.34	1.16	1.19

Table 2: Effect of newer insecticides against *Leucinodes orbonalis* (L.) Guen. on brinjal

Second Spray					
Treatments	**3rd**	**7th**	**10th**	**15th**	**Mean**
Spinosad 45 SC	10.71	6.01	7.51	9.17	8.35
Indoxacarb 14.5 SC	12.19	7.16	8.57	10.27	9.54
Chlorantraniliprole 18.5 SC	7.54	3.87	4.93	6.62	5.74
Emamectin benzoate 5SG	8.63	5.73	5.79	8.09	7.06
Cartaphydrochloride 50 SP	9.72	6.53	6.81	8.47	7.88
Acephate 75 SP	8.01	4.78	6.58	7.28	6.66
Malathion 50 EC	12.61	7.67	9.89	9.70	9.96
Control	51.21	46.78	42.68	38.44	44.77
S.Em±	0.47	0.45	0.42	039.	0.43
CD (P= 0.05)	1.44	1.37	1.28	1.18	1.31

Table 3: Effect of newer insecticides against *Leucinodes orbonalis* (L.) Guen. on brinjal

Third Spray					
Treatments	**3rd**	**7th**	**10th**	**15th**	**Mean**
Spinosad 45 SC	9.08	7.68	8.46	10.80	9.00
Indoxacarb 14.5 SC	9.76	6.57	7.90	10.40	8.65
Chlorantraniliprole 18.5 SC	7.21	4.17	5.77	6.67	5.95
Emamectin benzoate 5SG	7.75	5.48	7.38	7.84	7.11
Cartaphydrochloride 50 SP	9.71	5.89	8.06	9.08	8.18
Acephate 75 SP	7.86	4.82	6.46	7.51	6.66
Malathion 50 EC	10.83	7.16	9.17	11.84	9.75
Control	31.66	35.31	47.88	55.47	42.58
S.Em±	0.53	0.43	0.45	0.47	0.47
CD (P= 0.05)	1.60	1.39	1.37	1.42	1.44

4. Discussion

The data revealed that on 3rd day of first spray all the treatments were found significantly superior over untreated control. Similar observation was made by [11] whom tested the results on the basis of damaged fruits and percent loss of yield pointed out that chlorantraniliprole, flubendiamide and indoxacarb had resulted better as compared with chlofenapyr and Lufenuron on tomato crop heavily infested by *H armigera*, although the difference was statistically non significant. The present results were also found next effective non-significant group of insecticides was emamectin benzoate. However, emamectin benzoate was also found comparable with the most effective insecticide acephate. Another researcher found significantly resulted [12] such as chlorantraniliprole 20% SC, indoxacarb 15%EC,chlofenapyr 36% SC mixed with indoxacarb 15%EC, spinosad 24%SC, emamectin benzoate 50% SG and imidacloprid 11 20% SC provided excellent control against *T. absoluta*, while a biopesticide *Bacillus thuringiensis* gave moderate control. Our results discussed that the maximum infestation was recorded in the treatment of malathion which was differed non-significant with spinosad. The similar trends of efficacy of insecticides were also observed on 15th day of first spray. But these results aren't agreements by [13] evaluated all the tested insecticides had significantly affected the insect population but the malathion did not effective for reduction of infestation *T. absoluta* in tomato field. However, it is recommended that acephate and chlorantraniliprole in controlling this insect according to their potency.

The further data pertaining on 3rd day of second spray the treatment of chlorantraniliprole was found most effective resulted in minimum shoot infestation followed by acephate and emamectin benzoate. On the other hand, present result differ from the observation of [14] who noted the two higher doses of cyantraniliprole 10% OD i.e. 90 and 105 g a.i./ha was found highly effective in managing the population of aphid, thrips and whitefly during both the year compared to endosulfan and indoxacarb. In that order, on the 7th day of second spray the minimum shoot infestation was recorded in the treatment of T3, T6, T4, T1 and T5, respectively. Moreover, accordingly [15] assessed the the results of the present study indicated that novel insecticides, especially cyantraniliprole, may be better suited to sustainable integrated management programmes of the brinjal leaf miner.

The results which determined that on 3rd day of spray, the treatment of chlorantraniliprole was found most effective with minimum fruit infestation, followed by cartap hydrochloride and indoxacarb, respectively. These results were corroborated with the results of [16] whom recorded among nine insecticides, chlorantraniliprole (0.006%), spinosad (0.018%) and emamectin benzoate (0.002%) proved highly effective and statistically at par with each other in protecting the groundnut crop from the infestation of both pests. On the other hand, the maximum infestation was recorded in the treatment of malathion, on 7th day of third spary resulted in percent fruit infestation on number basis percent on weight basis and both were at par. This investigation also obtained by [17] whom observed that the all the tested treatments, except malathion, which were not effective to control *T. absoluta* on 10th spry, the pest complex, the best treatment mainly because of the best overall performance on the serpentine leafminer *Liriomyza* spp. Similar trend of percent fruit infestation on number and weight basis was recorded on 15th day of third spray. Accordingly to [18] the results demonstrated that chlorpyrifos and spinosad were effective against third instar *H. armigera* larvae both on contact and by ingestion. Flubendiamide, acephate, methomyl, *Bacillus*, dimethoate, chlorantraniliprole and fipronil had good response to control of *H. armigera*. Another researcher [19] tested the, *L. trifolii* results revealed that cyantraniliprole 10% OD @ 90 and 105 g *a.i*. /ha was significantly record of lowest number of serpentine leafminer adults/5 plants (0.66-0.74 in 2009–10 and 0.77-0.85 in 2010–11) at 7 days after spraying in comparison to other treatments registering a mean of 80.65-82.61% reduction in adult population over control.

5. Conclusions

The bio-efficacy of chlorantraniliprole (0.002%) was found most effective against shoot and fruit borer, followed by acephate (0.05%), whereas, malathion (0.05%) and spinosad (0.01%) were found to be least effective.

The remaining treatments *viz.*, emamectin benzoate (0.002%), followed by cartap hydrochloride (0.05%) and indoxacarb (0.002%) were found moderately effective.

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