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Bio-efficacy, persistence and residual toxicity of different insecticides against girdle beetle, *Obereopsis brevis* (Swedenborg) infesting soybean

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Abstract

An investigation was undertaken to study the bio-efficacy, persistence and residual toxicity of different insecticides viz., chlorantraniliprole 0.004 per cent, ethion 0.100 per cent, triazophos 0.050 per cent, indoxacarb 0.010 per cent, emamectin benzoate 0.001 per cent, quinalphos 0.050 per cent and profenophos 0.100 per cent against *Obereopsis brevis* (Swedenborg) infesting soybean at the Research Farm of Department of Agril. Entomology, College of Agriculture, Latur (MS). The result revealed that all the insecticidal treatments were significantly superior over untreated control in minimizing the per cent plant infestation due to *O. brevis*. Among the treatments, chlorantraniliprole 0.004 per cent was found to be the most effective insecticide in minimizing infestation due to *O. brevis* on soybean (6.10 and 3.77 per cent per mrl) followed by ethion 0.100 per cent (6.52 and 4.58 per cent per mrl), triazophos 0.050 per cent (7.33 and 4.60 per cent per mrl), indoxacarb 0.010 per cent (7.44 and 4.63 per cent per mrl), emamectin benzoate 0.001 per cent (7.44 and 5.11 per cent per mrl), quinalphos 0.050 per cent (7.59 and 5.33 per cent per mrl) and profenophos 0.100 per cent (8.55 and 5.99 per cent per mrl) after first and second sprays, respectively. The highest grain yield was achieved by chlorantraniliprole 0.004 per cent (34.87 q per ha) while quinalphos 0.050 per cent (1:19.72) documented highest incremental cost benefit ratio. The results on residual toxicity of different insecticides against *O. brevis* infesting soybean indicated that chlorantraniliprole 0.004 per cent and ethion 0.100 per cent illustrated highest persistent toxicity index (PT) (851.86 and 817.14 and; 833.80 and 827.96, respectively) and LT₅₀ values (6.48 and 6.14 and; 6.48 and 6.10 days, respectively) against early instar grubs of *O. brevis* after first and second sprays as compared to the other insecticides.

Keywords: Soybean, Girdle beetle, *Obereopsis brevis* (Swedenborg), bio-efficacy, residual toxicity, persistence, LT₅₀

Introduction

Soybean [*Glycine max* (L.) Merrill] a wonder crop of the twentieth century belongs to family Leguminaceae is becoming ideal food for the globe on account of a number of nutraceutical and functional compounds. Nutritionally 100 g of soybean contents energy (446 Kcal), carbohydrates (30.16 g), protein (36.49 g), fat (19.34 g), dietary fiber (9.3 g), ash (4.87 g), various vitamins, electrolytes, minerals, phyto-nutrients (USDA, 2019) [28]. Soybean is world's most important seed legume with the unique chemical composition which renders the health benefits to the human being (Agarwal *et al.* 2013) [2]. Besides this, soybean contributes 55 per cent to the global vegetable oil production and provides about 50 per cent of the world's protein concentrate for livestock, poultry and fish feeding (Pratap *et al.* 2016) [15].

Globally, soybean is cultivated on an area of 126.95 million ha with total production of 362.64 million MT and an average yield of 2860 kg per ha (USDA, 2020) [29]. In last four decades India has observed unprecedented expansion in area and production of soybean crop due to minimum input and management cost (Sharma *et al.* 2014) [23]. In India, the area under soybean crop is 11.13 million ha with 13.26 million MT of total production and 1192 kg per ha of an average productivity (SOPA, 2020) [26]. Soybean is mainly grown in the states of Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh, Gujarat and Chhattisgarh. In Maharashtra, soybean is cultivated on area of 0.40 million ha with 0.45 million MT of total production and an average productivity of 1125 kg per ha (SOPA, 2020) [26]. Despite having made rapid stride for both coverage and total production, soybean still suffers on productivity front (Agarwal *et al.* 2013) [2].

The several biotic and abiotic factors are found responsible for low productivity. Soybean is reported to be attacked by 273 species of insects (Rawat and Kapoor, 1968)^[18], amongst 20 insect pest species are significant in India (Singh and Singh, 1990)^[24] and 13 in Marathwada region of Maharashtra (Bhamare *et al.* 2018)^[4]. The insect-pest complex of soybean registered 30.8 per cent avoidable seed yield losses (Ahirwar *et al.* 2014)^[3]. While, the yield losses ranged from 20 to 100 per cent due to individual disease or insect or weed species (Sharma *et al.* 2014)^[23].

The girdle beetle, *Obereopsis brevis* (Swedenborg) is one of the significant hidden pests of soybean in Marathwada region of Maharashtra (Bhamare *et al.* 2018)^[4]. The incidence of the pest initially starts in the last week of July to the first fortnight of August. The pest remains active from July to October, damaging the crop most severely during August and September. The occurrence of *O. brevis* is observed with presence of 2 circular cuts on the branch or stem at the seedling stage. The main damage is caused by the grub stage which after hatching from the egg bore into the stem forming tunnels within the stem. The infested part above the circular cut is parched up in the want of nourishment and subsequently detached off at about 15 to 25 cm above the ground (Sharma, 2012)^[22]. In case of heavy incidence yield may reduce by up to 40 per cent (Thipse, 2012)^[27].

The several chemical insecticides have been recommended and used for the control of *O. brevis* by CIB and RC in India. However, these label claimed insecticides need to be revalidated from time to time for the effective management of *O. brevis* infesting soybean. In addition, the residual toxicity resulting from foliar application of insecticides could be of great significance in indicating an effective periods over which an insecticide could persist in biologically active stage under field conditions. In the view of these facts, the present investigation was planned to study the bio-efficacy, persistence and residual toxicity of different insecticides against *O. brevis* infesting soybean.

Materials and Methods

Bio-efficacy of different label recommended insecticides against *O. brevis* infesting soybean

The field experiment on bio-efficacy of different label recommended insecticides against *O. brevis* infesting soybean using variety MAUS-71 was conducted in RBD with eight treatments including untreated control replicated three times at the Research Farm of Department of Agril. Entomology, College of Agriculture, Latur (Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani) (MS)-India during *Kharif* 2015. Soybean was grown with all recommended package of practices recommended by VNMKV, Parbhani for raising the crop except insect-pest management. The first application of insecticide spray was done at ETL. The observations on per cent plant infestation due to grubs of *O. brevis* were recorded by counting total number of healthy and girdled plants in one meter row length from each treatment at three randomly selected places at 1 day before and 1, 3, 7 and 14 days after first and second application of insecticides. The data on per cent plant infestation were transformed into angular transformation before statistical analysis to know the significance of difference among different treatments. After crop attained maturity, it was harvested and weight of grain per plot was recorded separated in each treatment. Plot wise yield was computed on hectare basis for statistical interpretation. The economics of the treatment was also

worked out based on grain yield and cost of protection. Based on cost of protection and gross profit, the incremental cost benefit ratio (ICBR) was worked out. The data in respect of bio-efficacy and economics of different insecticides against *O. brevis* infesting soybean were statistically analyzed by standard 'analysis of variance'. The null hypothesis was tested by 'F' test of significance at 5 per cent level (Gomez and Gomez, 1984)^[7].

Persistence and residual toxicity of different label recommended insecticides against *O. brevis* infesting soybean

The toxicity of different insecticides was studied against early instar grubs of *O. brevis* at 1, 3, 7 and 14 days after first and second application of insecticides. Due care was taken to cover the entire plant while application of insecticides. The required numbers of branches or stems receiving application of insecticides were tagged for investigations on residual toxicity of insecticides. The number of test insects used for the bioassay studies were ten for each treatment in each replication. The tagged branches and stems were brought into the laboratory at the prescribed day intervals. The treated branches and stems were kept into plastic containers separately. The stalk of branch and stem was covered with moistened cotton wool in order to retain their turgidity for 24 hours. Then the early instar grubs of *O. brevis* collected from unsprayed soybean plots were released in or on dissected branch or stem of soybean. The numbers of dead or moribund test insects were counted after 24 hours of exposure. Similarly control mortality of test insects was also observed by releasing them on untreated substrate of soybean plant.

Correction on percentage mortality

The observations on mortality of *O. brevis* were converted into percentage mortality. The average percentage mortality was calculated from the observations in 3 replications. The observations on percentage mortality thus obtained were corrected with Abbott's (1925)^[1] formula as follows.

$$P = \frac{T - C}{100 - C} \times 100$$

Whereas

P = Corrected percentage mortality,
T = Percentage mortality in treatment,
C = Percentage mortality in control.

LT₅₀ values

The values of LT₅₀ (time required to give 50 per cent mortality) for different insecticides applied on soybean plants were calculated by using software of Probit analysis as suggested by Finney (1971)^[6].

PT values

The product (PT) of average residual toxicity (T) and the period (P) for which the toxicity persisted was used as an index of persistent toxicity. The values of corrected percentage mortalities at various specified periods were added. This sum was then divided by number of observations in order to obtain residual toxicity (T). The procedure followed by Saini (1959)^[19] and elaborated further by Pradhan (1967)^[14], Sarup *et al.* (1970)^[20] and; Sonune and Bhamare (2016)^[25] was utilized.

Results and Discussion**Effect of different insecticides on infestation of soybean girdle beetle, *O. brevis***

Data pertaining to effect of different insecticides on per cent infestation due to *O. brevis* on soybean after first and second spray are presented in Table 1.

Table 1: Effect of different insecticides on per plant infestation due to *O. brevis*, grain yield and ICBR of soybean

Treatments	Per cent plant infestation due to grub of girdle beetle per mrl										Main grain yield q/ha	ICBR
	I st spray					II nd spray						
	One day before spray	Days after spraying				One day before spray	Days after spraying					
1		3	7	14	1		3	7	14			
Profenophos 0.100 per cent	11.00 (19.36)*	10.74 (19.13)	10.66 (19.06)	7.89 (16.29)	8.55 (17.00)	10.96 (19.36)*	10.67 (19.06)	10.50 (18.90)	5.07 (13.01)	5.99 (14.15)	20.46	1:6.77
Triazophos 0.050 per cent	11.21 (19.55)	10.33 (18.75)	10.23 (18.65)	6.67 (14.95)	7.33 (15.70)	11.05 (19.41)	10.20 (18.62)	10.14 (18.57)	4.07 (11.63)	4.60 (12.42)	20.96	1:11.69
Quinalphos 0.050 per cent	11.10 (19.66)	10.70 (19.09)	10.50 (18.90)	7.38 (15.76)	7.59 (15.98)	11.00 (19.36)	10.40 (18.81)	10.30 (18.51)	5.00 (12.92)	5.33 (13.44)	29.63	1:19.72
Indoxacarb 0.010 per cent	11.80 (20.08)	10.41 (18.82)	10.30 (18.71)	6.90 (15.20)	7.44 (15.81)	11.66 (19.97)	10.25 (18.67)	10.21 (18.65)	4.37 (12.05)	4.63 (12.41)	31.25	1:11.24
Ethion 0.100 per cent	11.20 (20.17)	10.26 (18.68)	10.15 (18.57)	6.51 (14.91)	6.52 (14.78)	11.29 (19.33)	10.18 (18.61)	10.11 (18.54)	3.96 (11.58)	4.58 (11.99)	16.43	1:3.51
Chlorantraniliprole 0.004 per cent	11.90 (20.17)	10.20 (18.62)	10.09 (18.52)	6.04 (14.22)	6.10 (14.29)	11.30 (19.64)	10.00 (18.43)	9.98 (18.45)	3.65 (11.01)	3.77 (11.14)	34.87	1:7.95
Emamectin benzoate 0.001 per cent	11.67 (19.96)	10.64 (19.06)	10.40 (18.81)	7.00 (15.34)	7.44 (15.82)	11.30 (19.41)	10.33 (18.75)	10.27 (18.70)	4.44 (12.13)	5.11 (13.06)	31.55	1:9.87
Untreated Control	11.44 (19.76)	11.44 (19.76)	10.70 (20.00)	11.81 (20.09)	12.11 (20.36)	12.11 (20.36)	12.11 (20.50)	12.33 (20.55)	12.36 (20.58)	12.55 (20.74)	12.09	-
S.E ±	-	0.09	0.03	0.31	0.32	-	0.08	0.06	0.23	0.39	0.02	-
C.D. at 5 per cent	N.S.	0.28	0.15	0.93	0.96	NS	0.26	0.19	0.70	1.17	0.08	-
C.V.	2.25	0.87	0.47	3.37	3.40	2.49	0.79	0.58	3.05	4.89	0.61	-

* Figures in parentheses are angular transformed values

N.S.: Non-significant

First spray

The results revealed that all the insecticides were significantly superior over untreated control in reducing per cent infestation due to *O. brevis* infesting soybean at 1, 3, 7 and 14 days after first application of insecticides.

At one day after first spray, chlorantraniliprole 0.004 per cent recorded significantly lowest per cent plant infestation due to *O. brevis* (10.20 per mrl) followed by ethion 0.100 per cent (10.26 per mrl), triazophos 0.050 per cent (10.33 per mrl), indoxacarb 0.010 per cent (10.41 per mrl). All these treatments were significantly superior and statistically at par with each other. The next effective treatments were emamectin benzoate 0.001 per cent (10.64 per mrl), quinalphos 0.050 per cent (10.70 per mrl) and profenophos 0.100 per cent (10.74 per mrl).

At three days after first spray, significantly lowest per cent plant infestation due to *O. brevis* (10.09 per mrl) was registered from the plots treated with chlorantraniliprole 0.004 per cent followed by ethion 0.100 per cent (10.15 per mrl) and triazophos 0.050 per cent (10.23 per mrl). All these treatments were found equally effective in reducing *O. brevis* infestation. The subsequently effective treatments were indoxacarb 0.010 per cent (10.30 per mrl), emamectin benzoate 0.001 per cent (10.40 per mrl), quinalphos 0.050 per cent (10.50 per mrl) and profenophos 0.100 per cent (10.66 per mrl).

Similarly, at seven days after first spray, chlorantraniliprole 0.004 per cent, ethion 0.100 per cent and triazophos 0.050 per cent noticed significantly lowest per cent plant infestation due to *O. brevis* to the tune of 6.04, 6.51 and 6.67 per mrl, respectively. All these treatments were equally effective. Nevertheless, the next order of effectiveness was indoxacarb 0.010 per cent (6.90 per cent per mrl), emamectin benzoate

0.001 per cent (7.00 per cent per mrl), quinalphos 25 per cent (7.38 per cent per mrl) and profenophos 50 per cent (7.89 per cent per mrl).

At 14 days after first spray, chlorantraniliprole 0.004 per cent (6.10 per mrl) and ethion 0.100 per cent (6.52 per mrl) exhibited significantly minimum per cent plant infestation due to *O. brevis*. Both these treatments were also found statistically at par with each other. The subsequently effective treatments were triazophos 0.050 per cent (7.33 per mrl), indoxacarb 0.010 per cent (7.44 per mrl), emamectin benzoate 0.001 per cent (7.44 per mrl), quinalphos 25 per cent (7.59 per mrl) and profenophos 50 per cent (8.55 per mrl).

Second spray

The results revealed that all the insecticides were significantly superior over untreated control in reducing the per cent plant infestation due to *O. brevis* on soybean at 1, 3, 7 and 14 days after second application of insecticides.

At one day after second spray, chlorantraniliprole 0.004 per cent registered significantly lowest per cent infestation due to *O. brevis* (10.00 per mrl) followed by ethion 0.100 per cent (10.18 per mrl), triazophos 0.050 per cent (10.20 per mrl), indoxacarb 0.010 per cent (10.25 per mrl). All these treatments were statistically at bar with each other. The next effective treatments were emamectin benzoate 0.001 per cent (10.33 per cent per mrl), quinalphos 0.050 per cent (10.40 per cent per mrl) and profenophos 0.100 per cent (10.67 per cent per mrl). At three days after second spray, significantly minimum per cent plant infestation due to *O. brevis* (9.98 per mrl) was recorded from the plots treated with chlorantraniliprole 0.004 per cent followed by ethion 0.100 per cent (10.11 per mrl) and triazophos 0.050 per cent (10.14 per mrl). All these treatments were equally effective.

Subsequently effective treatments were indoxacarb 0.010 per cent (10.21 per mrl), emamectin benzoate 0.001 per cent (10.27 per mrl), quinalphos 0.050 per cent (10.30 per mrl) and profenophos 0.100 per cent (10.50 per mrl).

Analogously, at seven days after second spray, lowest *O. brevis* infestation was recorded from the plots treated with chlorantraniliprole 0.004 per cent (3.65 per cent per mrl), ethion 0.100 per cent (3.96 per cent per mrl) and triazophos 0.050 per cent (4.07 per cent per mrl). All these treatments were significantly superior and statistically at par with each other. The next effective treatments were indoxacarb 0.010 per cent (4.37 per mrl), emamectin benzoate 0.001 per cent (4.44 per mrl), quinalphos 0.050 per cent (5.00 per mrl) and profenophos 0.100 per cent (5.07 per mrl).

At 14 days after second spray, chlorantraniliprole 0.004 per cent (3.77 per mrl) and ethion 0.100 per cent (4.58 per mrl) evidenced to be equally effective treatments in minimizing per cent plant infestation due to *O. brevis*. The subsequent order of effectiveness was triazophos 0.050 per cent (4.60 per cent per mrl), indoxacarb 0.010 per cent (4.63 per cent per mrl), emamectin benzoate 0.001 per cent (5.11 per cent per mrl), quinalphos 0.050 per cent (5.33 per cent per mrl) and profenophos 0.100 per cent (5.99 per cent per mrl).

These findings are in accordance with the results of Raut *et al.* (2015) [17] who revealed that triazophos 40 EC at the rate of 0.04 per cent, chlorantraniliprole 18.5 SC at the rate of 0.006, emamectin benzoate 5 SG at the rate of 0.002 per cent, chlorantraniliprole 18.5 per cent SC at the rate of 0.0019 and indoxacarb 15.8 EC at the rate of 0.01 per cent were emerged as successful treatment in minimizing *O. brevis* infestation on soybean. Kothalkar *et al.* (2015) [8] revealed that emamectin benzoate 5 SG + triazophos 40 EC, emamectin benzoate 5 SG, triazophos 40 EC and flubendiamide 20 WG + triazophos 40 EC were significantly effective treatments in managing *O. brevis* infestation. Raghuvanshi *et al.* (2014) [16] observed that triazophos was found most effective against *O. brevis* followed by indoxacarb and emamectin benzoate. Patil and Phad (2014) [13] evidenced that triazophos 40 EC, indoxacarb 14.5 SL and chlorantraniliprole 18.5 SC were effective insecticides in reducing the damage due to *O. brevis*. According to More *et al.* (2014) [10] Virtako 40 WG (chlorantraniliprole 20 per cent + thiamethoxam 20 per cent) at the rate of 50 g a.i. per ha was found to be the most effective treatment against *O. brevis* (2.82 per cent) followed by lower doses of Virtako 40 WG and chlorantraniliprole 18.5 per cent SC (7.26 per cent). Shali Raju *et al.* (2013) [21] revealed that significantly minimum plant infestation caused by *O. brevis* in rynaxypyr 20 SC at the rate of 100 ml per ha, profenophos 50 EC at the rate of 1250 ml per ha, triazophos 40 EC at the rate of 800 ml per ha and quinalphos 25 EC at the rate of 1500 ml per ha treated plots. Mehghwal and Chaudhary (2013) [9] stated that profenophos 50 EC and triazophos 40 EC were effective treatments in reducing per cent infestation due to *O. brevis*. Chaudhary *et al.* (2012) [5] documented that triazophos 40 EC at the rate of 625 ml per ha was most effective against *O. brevis* recorded 5.00 per cent infestation after 5 days of application followed by profenophos 50 EC at the rate of 1250 ml per ha (6.67 per cent) and quinalphos 25 EC at the rate of 1500 ml per ha (11.11 per cent).

Effect of different insecticides on grain yield and incremental cost benefit ratio (ICBR) of soybean

The results in respect of effect of different insecticides on grain yield and ICBR of soybean are presented in Table 1.

The data regarding grain yield of soybean revealed that all the treatments were statistically significant in increasing grain yield over untreated control. The grain yield of soybean due to different treatments varied from 12.09 to 34.87 q per ha. The significantly highest grain yield of soybean was recorded in chlorantraniliprole 0.004 per cent (34.87 q per ha) which was followed by emamectin benzoate 0.001 per cent (31.55 q per ha), indoxacarb 0.010 per cent (31.25 q per ha), quinalphos 0.050 per cent (29.63 q per ha), triazophos 0.050 per cent (20.96 q per ha), profenophos 0.100 per cent (20.46 q per ha) and ethion 0.100 per cent (16.43 q per ha). However, the lowest grain yield (12.09 q per ha) was registered in untreated control. The result of present investigation are in harmony with the findings of Patil *et al.* (2014) [11] who reported that significantly highest seed yield of soybean (19.88 q per ha) was obtained in chlorantraniliprole (30 g a.i. per ha). Kothalkar *et al.* (2015) [8] revealed that emamectin benzoate 5 SG at the rate of 0.002 per cent + triazophos 40 EC at the rate of 0.06 per cent, emamectin benzoate 5 SG at the rate of 0.002 per cent, triazophos 40 EC at the rate of 0.06 per cent and flubendiamide 20 WG at the rate of 0.01 per cent + triazophos 40 EC at the rate of 0.06 per cent obtained comparatively highest yield. Patil and Mohite (2015) [12] found that emamectin benzoate 1.9 EC at the rate of 200 ml per ha and indoxacarb 14.5 SC at the rate of 500 ml per ha obtained higher yield of soybean. Patil and Phad (2014) [13] highest soybean seed yield was noticed in triazophos 20 EC, chlorantraniliprole 18.5 SC and indoxacarb 14.5 SL.

The data on ICBR evidenced that all the insecticidal treatments were economical and most remunerative. Among all the treatments, highest incremental cost benefit ratio (1:19.72) was attained by quinalphos 0.050 per cent which was followed by triazophos 0.050 per cent (1:11.69), indoxacarb 0.005 per cent (1:11.24), emamectin benzoate 0.001 per cent (1:9.87), chlorantraniliprole 0.004 per cent (1:7.95), profenophos 0.100 per cent (1:6.77) and ethion 0.100 per cent (1:3.51). These results are comparable to the findings of Wagh *et al.* (2015) [30] who reported that highest cost benefit ratio of 1:6.43 was observed in profenophos 0.100 EC followed by quinalphos (1:6.24) in soybean. Kothalkar *et al.* (2015) [8] revealed that emamectin benzoate 5 SG at the rate of 0.002 per cent + triazophos 40 EC at the rate of 0.06 per cent, emamectin benzoate 5 SG at the rate of 0.002 per cent, triazophos 40 EC at the rate of 0.06 per cent and flubendiamide 20 WG at the rate of 0.01 per cent + triazophos 40 EC at the rate of 0.06 per cent were obtained comparatively highest ICBR. Raghuvanshi *et al.* (2014) [16] observed highest ICBR (1:9.6) in triazophos; however indoxacarb and emamectin benzoate noticed ICBR of 1: 4.5 and 1: 4.1, respectively. Thus, these results endorse the present finding.

Residual toxicity of different insecticides against soybean girdle beetle, *O. brevis*

The data on the average percentage mortality of grubs of *O. brevis* in soybean branch or stem receiving first and second spray recorded at 1, 3, and 7 and 14 days intervals are presented in Table 2.

Table 2: Persistence of different insecticides in branch or stem of soybean applied as first and second spray against grubs of *O. brevis*

Treatments	I st spray									II nd spray								
	Corrected percentage mortality after different intervals (days)				P	T	PT	R.E.	O.R.E.	Corrected percentage mortality after different intervals (days)				P	T	PT	R.E.	O.R.E.
	1	3	7	14						1	3	7	14					
Profenophos 0.100 per cent	75.90	51.70	35.76	17.26	45.15	14	632.17	1.00	7	75.05	50.00	34.53	13.85	43.36	14	607.04	1.00	7
Triazophos 0.050 per cent	89.65	62.04	50.00	24.19	56.47	14	790.58	1.25	3	89.29	64.34	48.29	20.68	55.65	14	779.10	1.28	3
Quinalphos 0.050 per cent	79.31	55.22	42.93	17.26	48.68	14	681.52	1.07	6	78.58	53.64	37.95	17.26	46.85	14	656.00	1.08	6
Indoxacarb 0.010 per cent	86.24	58.63	50.00	20.68	53.88	14	754.42	1.19	4	85.76	60.78	44.88	20.68	53.02	14	742.35	1.22	4
Ethion 0.100 per cent	93.07	62.56	53.64	24.20	58.36	14	817.14	1.29	2	92.82	67.88	51.70	24.19	59.14	14	827.96	1.36	2
Chlorantraniliprole 0.004 per cent	96.58	68.97	53.64	24.20	60.84	14	851.86	1.34	1	94.46	67.88	51.70	24.19	59.55	14	833.80	1.37	1
Emamectin benzoate 0.001 per cent	82.73	58.63	46.46	20.68	52.12	14	729.75	1.15	5	82.11	57.17	41.36	17.26	49.47	14	692.65	1.14	5

First spray

The result of first spray evident that chlorantraniliprole 0.004 per cent and ethion 0.100 per cent concentration showed comparatively high percentage mortality of grubs of *O. brevis* to the tune of 24.20 and 24.20 per cent, respectively at 14 days after spraying. On the basis of PT values the descending order of persistent toxicity was chlorantraniliprole 0.004 per cent (851.86) > ethion 0.100 per cent (817.14) > triazophos 0.050 per cent (790.58) > indoxacarb 0.010 per cent (754.42) > emamectin benzoate 0.001 per cent (729.75) > quinalphos 0.050 per cent (681.52) > profenophos 0.100 per cent (632.17).

The data pertaining to LT₅₀ values of insecticides against grubs of *O. brevis* in soybean branch or stem are presented in Table 3.

The data revealed that chlorantraniliprole 0.004 per cent registered highest LT₅₀ value (6.48 days) against the grubs of *O. brevis* in soybean branch or stem receiving first application of insecticides. The descending relative order of efficacy of insecticides in days was found to be chlorantraniliprole 0.004 per cent (6.48) > ethion 0.100 per cent (6.14) > triazophos 0.050 per cent (5.55) > indoxacarb 0.010 per cent (4.94) > emamectin benzoate 0.001 per cent (4.56) > quinalphos 0.050 per cent (3.86) > profenophos 0.100 per cent (3.23).

Table 3: Relative efficacy of different insecticides against grubs of *O. brevis* in soybean branch or stem applied as first and second spray

Treatments	I st Spray									II nd Spray								
	Heterogeneity		Regression Equation (y=.....)	Log LT ₅₀ ± S.Em	LT ₅₀ (days)	Fiducial Limit (days)	R.E.	O.R.E.	Heterogeneity		Regression Equation (y=.....)	Log LT ₅₀ ± S.Em	LT ₅₀ (days)	Fiducial Limit (days)	R.E.	O.R.E.		
	d.f.	χ ²							d.f.	χ ²								
Profenophos 0.100 per cent	2	0.142	y=-0.1032-1.3863x	0.5103±0.1653	3.23	0.93 8.53	1.00	7	2	0.151	y=-0.1220-1.5129x	0.4823±0.1553	3.03	0.84 6.98	1.00	7		
Triazophos 0.050 per cent	2	0.356	y=0.079-1.6061x	0.7444±0.1455	5.55	1.24 17.66	1.71	3	2	0.200	y=0.0675-1.7572x	0.7231±0.1339	5.28	1.33 13.59	1.74	3		
Quinalphos 0.050 per cent	2	0.422	y=-0.023-1.4277x	0.5867±0.1576	3.86	1.04 10.98	1.19	6	2	0.102	y=-0.0693-1.5047x	0.5532±0.1520	3.57	0.95 08.92	1.17	6		
Indoxacarb 0.010 per cent	2	0.589	y=0.0556-1.5293x	0.6941±0.1494	4.94	1.18 15.45	1.52	4	2	0.132	y=0.0290-1.6237x	0.6757±0.1416	4.73	1.10 12.72	1.56	4		
Ethion 0.100 per cent	2	0.480	y=-0.1124-1.7635x	0.7888±0.1368	6.14	1.25 18.00	1.90	2	2	0.170	y=-0.1027-1.8370x	0.7854±0.1319	6.10	1.21 16.45	2.01	2		
Chlorantraniliprole 0.004 per cent	2	0.465	y=0.0972-2.0102x	0.8121±0.1236	6.48	1.21 16.21	2.00	1	2	0.465	y=0.0972-2.0102x	0.8121±0.1236	6.48	1.21 16.21	2.13	1		
Emamectin benzoate 0.001 per cent	2	0.365	y=0.0324-1.4422x	0.6592±0.1561	4.56	1.17 14.95	1.41	5	2	0.176	y=-0.0192-1.5957x	0.6072±0.1433	4.04	1.00 10.02	1.33	5		

Second spray

The result of second spray evident that chlorantraniliprole 0.004 per cent and ethion 0.100 per cent observed comparatively high percentage mortality of grubs of *O. brevis* (24.19 per cent) at 14 days after spraying. On the basis of PT values the descending order of persistent toxicity was chlorantraniliprole 0.004 per cent (833.80) > ethion 0.100 per cent (827.96) > triazophos 0.050 per cent (779.10) > indoxacarb 0.010 per cent (742.35) > emamectin benzoate 0.001 per cent (692.65) > quinalphos 0.050 per cent (656.00) > profenophos 0.100 per cent (607.04).

The data pertaining to LT₅₀ values of insecticides against

grubs of *O. brevis* in soybean branch or stem are presented in Table 3.

The data revealed that chlorantraniliprole 0.004 per cent showed highest LT₅₀ value (6.48 days) against the grubs of *O. brevis* in soybean branch or stem receiving second application of insecticides. The descending relative order of efficacy of insecticides in days was chlorantraniliprole 0.004 per cent (6.48) > ethion 0.100 per cent (6.10) > triazophos 0.050 per cent (5.28) > indoxacarb 0.010 per cent (4.73) > emamectin benzoate 0.001 per cent (4.04) > quinalphos 0.050 per cent (3.57) > profenophos 0.100 per cent (3.03).

Thus, it indicates that chlorantraniliprole 0.004 per cent

followed by ethion 0.100 per cent illustrated higher residual toxicity to grubs of *O. brevis* as compare to other insecticides. The results persistence and residual toxicity of different insecticides against *O. brevis* could not be discussed in the want of pertinent literature on persistence and residual toxicity of insecticides against *O. brevis*.

Conclusion

The overall results concluded that chlorantraniliprole 0.004 per cent was the most efficacious insecticide against *O. brevis* infesting soybean followed by ethion 0.100 per cent and triazophos 0.050 per cent. Similarly, the higher residual toxicity was exhibited by these insecticides against grubs of *O. brevis* on soybean.

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