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Bio-efficacy, persistence and residual toxicity of different insecticides against jassid *Empoasca kerri* (Pruthi) 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 *Empoasca kerri* (Pruthi) infesting soybean at the Research Farm of Department of Agril. Entomology, College of Agriculture, Latur (MS). The overall results concluded that all the insecticides under investigation were significantly superior over untreated control in minimizing the population of *E. kerri*. Among the treatments, profenophos 0.100 per cent was found to be the most effective insecticide in minimizing the population of *E. kerri* on soybean (3.83 and 2.60 jassids per three leaves) followed by quinalphos 0.050 per cent (4.03 and 2.90 jassids per three leaves), triazophos 0.050 per cent (4.47 and 3.50 jassids per three leaves), chlorantraniliprole 0.004 per cent (5.03 and 3.60 jassids per three leaves), indoxacarb 0.010 per cent (7.20 and 5.00 jassids per three leaves), emamectin benzoate 0.001 per cent (7.40 and 5.40 jassids per three leaves) and ethion 0.100 per cent (7.67 and 5.50 jassids per three leaves) 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) exhibited highest incremental cost benefit ratio. The results on residual toxicity of different insecticides against *E. kerri* infesting soybean indicated that profenophos 0.100 per cent and quinalphos 0.050 per cent illustrated highest persistent toxicity index (PT) (864.67 and 873.18 and; 815.74 and 822.85, respectively) and LT_{50} values (6.80 and 7.02 and; 5.91 and 6.11 days, respectively) against *E. kerri* after first and second sprays as compared to other insecticides.

Keywords: Soybean, jassids, *Empoasca kerri* (Pruthi), bio-efficacy, residual toxicity, persistence, LT_{50}

Introduction
Soybean [*Glycine max* (L.) Merrill] a miracle golden bean of the twentieth century belongs to family Leguminaceae is not only a crop of oil production but it has great therapeutic and nutritional potential. Soybean is numero uno seed legume with the unique chemical composition. Nutritionally soybean (per 100 g) is rich in 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]. High protein content of soybean seeds is great source of vegetable protein to eradicate the curse of malnutrition from the globe (IISR, 2020) [10]. Soybean also 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) [19].

Globally, soybean is one of the important 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 India, soybean is grown on an area of 11.13 million ha with 13.26 million MT of total production and 1192 kg per ha of an average productivity (SOPA, 2020) [27]. 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) [27]. Soybean has established as a major kharif crop in the rainfed agro-ecosystem of central and peninsular India. Introduction of soybean in these areas has led to a shift in the cropping system from rainy season fallow followed by post-rainy season wheat or chickpea (fallow-wheat/chickpea) to soybean followed by wheat or chickpea (soybean-wheat/chickpea) system. This has resulted in an improvement in the cropping intensity and resultant increase in the profitability per unit land area (DSR, 2015) [6].

The several biotic and abiotic stresses impede to harness the full yield potential of soybean. Moreover, the climatic adversities, disease and pest attack in soybean has appeared to be almost epidemic in nature (IISR, 2020) [10]. In India, soybean is reported to be attacked by 273 species of insects (Rawat and Kapoor, 1968) [21], out of these 20 insect pest species are most significant at national level (Singh and Singh, 1990) [26] and 13 insect pest species in respect to Marathwada region of Maharashtra (Bhamare *et al*. 2018) [3]. It is reported that the yield losses due to individual disease or insect or weed species ranged from 20 to 100 per cent (Sharma *et al*. 2014) [25].

The soybean jassid, *Empoasca kerri* (Pruthi) is emerged as one of the significant sucking insect-pests of soybean in Marathwada region of Maharashtra (Bhamare *et al*. 2018) [3]. The main damage is caused by the nymphs and adults of *E. kerri*. The pest remains active during vegetative growth stage, damaging the crop most severely by sucking the plant sap from tender leaves and stem. The attacked leaves turn pale and then rust red with change in appearance; the leaves also curl, dry up and fall to the ground (Khanzada *et al*. 2013) [12]. The occurrence of *E. kerri* is noticed with yellowing of leaf margins followed by hopper burn symptoms. The increased temperature and dry spells experiences multiplication of *E. kerri* infesting soybean (Sable *et al*. 2018) [22]. In case of heavy incidence of sucking pests of soybean (jassid, whitefly and thrips) yield may reduce by up to 32.16 per cent (Chaudhary *et al*. 2018) [4].

In India, only one chemical insecticide imidacloprid 48.00 FS is label claimed by CIB and RC against *E. kerri* on soybean. However, farmers are using several chemical insecticides against *E. kerri* which are recommended for other insect-pests of soybean. Hence, these label recommended insecticides need to be evaluated for their efficacy against *E. kerri* 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. Keeping this in the view, the present investigation was planned to study the bio-efficacy, persistence and residual toxicity of different insecticides against *E. kerri* infesting soybean.

Materials and Methods

Bio-efficacy of different insecticides against *E. kerri* infesting soybean

The field experiment on bio-efficacy of different insecticides against *E. kerri* infesting soybean using variety MAUS-71 was carried out 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 cultivated 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 observation on total number of *E. kerri* was recorded on top, middle and bottom leaves of five randomly selected plants from each treatment at one day before treatment and 1, 3, 7 and 14 days after first and second application of insecticides. The data on jassid population were transformed into square root 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 *E. kerri* 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) [9].

Persistence and residual toxicity of different insecticides against *E. kerri* infesting soybean

The toxicity of different insecticides was studied against nymphs of *E. kerri* 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 leaves or trifoliates 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 leaves or trifoliates were brought into the laboratory at the prescribed day intervals. The treated leaves or trifoliates were kept into plastic containers separately. The stalk of leaf or trifoliate was covered with moistened cotton wool in order to retain their turgidity for 24 hours. The nymphs of jassid were slightly disturbed allowing them to draw their proboscis from the host plant. Then the nymphs of *E. kerri* collected from unsprayed soybean plots and released on treated leaves or trifoliates which were kept in the plastic container.The numbers of dead or moribund jassids were counted after 24 hours of exposure. Similarly control mortality of jassids was also observed by releasing them on untreated substrate of soybean plant.

Correction on percentage mortality

The observations on mortality of jassids 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.

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

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

LT_{50} values

The values of LT_{50} (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) [7].

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) [23] and elaborated further by Pradhan (1967) [18], Sarup *et al.* (1970) [24] and; Dake and Bhamare (2019) [5] was utilized.

Results and Discussion

Effect of different insecticides on population of *Empoasca kerri* Pruthi) infesting soybean

The data pertaining to effect of different insecticides on population of *E. kerri* infesting soybean after first and second spray are presented in Table 1. The results revealed that all the insecticides were found to be significantly superior over untreated control in reducing population of soybean jassid at 1, 3, 7 and 14 days after first and second application of insecticides.

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

Treatments	Mean number of jassid per three leaves										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	9.20 (3.02)*	3.27 (1.80)	3.37 (1.83)	3.47 (1.86)	3.83 (1.95)	8.83 (2.97)*	2.03 (1.41)	2.11 (1.45)	2.37 (1.53)	2.60 (1.61)	20.46	1:6.77
Triazophos 0.050 per cent	10.47 (3.23)	3.53 (1.85)	3.73 (1.92)	4.00 (2.07)	4.47 (2.23)	8.01 (2.82)	2.15 (1.46)	2.23 (1.49)	3.00 (1.72)	3.50 (1.86)	20.96	1:11.69
Quinalphos 0.050 per cent	9.67 (3.10)	3.40 (1.84)	3.60 (1.89)	3.80 (1.96)	4.03 (1.99)	8.01 (2.94)	2.10 (1.44)	2.17 (1.47)	2.50 (1.57)	2.90 (1.70)	29.63	1:19.72
Indoxacarb 0.010 per cent	9.67 (3.10)	4.67 (2.15)	4.80 (2.19)	6.07 (2.46)	7.20 (2.68)	9.20 (3.03)	4.00 (1.99)	4.07 (2.01)	4.53 (2.12)	5.00 (2.23)	31.25	1:11.24
Ethion 0.100 per cent	10.53 (3.24)	4.93 (2.22)	5.13 (2.26)	6.42 (2.54)	7.67 (2.76)	10.03 (3.16)	4.47 (2.11)	4.50 (2.11)	5.00 (2.23)	5.50 (2.34)	16.43	1:3.51
Chlorantraniliprole 0.004 per cent	9.73 (3.11)	3.57 (1.87)	3.93 (1.98)	4.67 (2.15)	5.03 (2.23)	9.70 (2.90)	2.23 (1.49)	3.10 (1.76)	3.30 (1.81)	3.60 (1.89)	34.87	1:7.95
Emamectin benzoate 0.001 per cent	10.00 (3.15)	4.80 (2.19)	5.07 (2.25)	6.27 (2.49)	7.40 (2.72)	9.35 (3.05)	4.07 (2.01)	4.10 (2.02)	4.90 (2.21)	5.40 (2.32)	31.55	1:9.87
Untreated Control	10.87 (3.29)	10.93 (3.20)	10.93 (3.33)	11.00 (3.33)	11.45 (3.38)	11.60 (3.40)	11.73 (3.30)	11.77 (3.42)	12.00 (3.46)	12.40 (3.51)	12.09	-
S.E ±	-	0.06	0.04	0.06	0.07	-	0.05	0.04	0.04	0.05	0.02	-
C.D. at 5 per cent	NS	0.20	0.14	0.18	0.23	NS	0.16	0.13	0.13	0.17	0.08	-
C.V.	-	5.30	3.67	4.40	5.44	-	4.98	3.90	3.72	4.52	0.61	-

* Figures in parentheses are angular transformed values
N.S.: Non-significant

First spray

At one day after first spray, significantly minimum population of jassid (3.27 per three leaves) was recorded from the plots treated with profenophos 0.100 per cent followed by quinalphos 0.050 per cent (3.40 per three leaves), triazophos 0.050 per cent (3.53 per three leaves), chlorantraniliprole 0.004 per cent (3.57 per three leaves). All these treatments proved significantly superior and statistically at par with each other. The next effective treatments were indoxacarb 0.010 per cent (4.67 jassids per three leaves), emamectin benzoate 0.001 per cent (4.80 jassids per three leaves) and ethion 0.100 per cent (4.93 jassids per three leaves).

At three days after first spray, profenophos 0.100 per cent recorded significantly lowest population of jassid (3.37 per three leaves) followed by quinalphos 0.050 per cent (3.60 per three leaves) and triazophos 0.050 per cent (3.73 per three leaves). All these treatments were found to be statistically at par with other. The subsequent order of effectiveness was chlorantraniliprole 0.004 per cent (3.93 jassids per three leaves), indoxacarb 0.010 per cent (4.80 jassids per three leaves), emamectin benzoate 0.001 per cent (5.07 jassids per three leaves) and ethion 0.100 per cent (5.13 jassids per three leaves).

At seven days after first spraying, profenophos 0.100 per cent evidenced significantly effective treatment in minimizing jassid population (3.47 per three leaves) which was followed by quinalphos 0.050 per cent (3.80 per three leaves). Both these treatments were found to be significantly superior and statistically at par with each other. Subsequently effective treatments in reducing jassid population on soybean were triazophos 0.050 per cent (4.00 per three leaves), chlorantraniliprole 0.004 per cent (4.67 per three leaves), indoxacarb 0.010 per cent (6.07 per three leaves), emamectin benzoate 0.001 per cent (6.27 per three leaves) and ethion 0.100 per cent (6.42 per three leaves).

At 14 days after first spraying, significantly lowest population of jassid was noticed in profenophos 0.100 per cent (3.83 per three leaves) followed by quinalphos 0.050 per cent (4.03 per three leaves). Both these treatments were statistically on par with each other. Triazophos 0.050 per cent, chlorantraniliprole 0.004 per cent, indoxacarb 0.010 per cent, emamectin benzoate 0.001 per cent and ethion 0.100 per cent observed to be subsequently effective insecticides with 4.47, 5.03, 7.20, 7.40 and 7.67 jassids per three leaves, respectively.

Second spray

At one day after second spray, significantly minimum population of jassid (2.03 per three leaves) was recorded from the plots treated with profenophos 0.100 per cent followed by quinalphos 0.050 per cent (2.10 per three leaves), triazophos 0.050 per cent (2.15 per three leaves) and chlorantraniliprole 0.004 per cent (2.23 per three leaves). All these treatments were found to be statistically at bar with each other. The subsequently effective treatments were indoxacarb 0.010 per cent (4.00 jassids per three leaves), emamectin benzoate 0.001 per cent (4.07 jassids per three leaves) and ethion 0.100 per cent (4.47 jassids per three leaves).

At three days after second spray, profenophos 0.100 per cent recorded significantly lowest population of jassid (2.11 per three leaves) followed by quinalphos 0.050 per cent (2.17 per three leaves), triazophos 0.050 per cent (2.23 per three leaves). All these treatments were found to be equally effective in reducing jassid population. The subsequent order of effectiveness was chlorantraniliprole 0.004 per cent (3.10 jassids per three leaves), indoxacarb 0.010 per cent (4.07 jassids per three leaves), emamectin benzoate 0.001 per cent

(4.10 jassids per three leaves) and ethion 0.100 per cent (4.50 jassids per three leaves).

At seven days after second spray, significantly least population of jassid was evidenced from plots treated with profenophos 0.100 per cent (2.37 per three leaves) and quinalphos 0.050 per cent (2.50 per three leaves). Both these treatments were found to be statistically at par with each other. The plots treated with triazophos 0.050 per cent (3.00 jassids per three leaves), chlorantraniliprole 0.004 per cent (3.30 jassids per three leaves), indoxacarb 0.010 per cent (4.53 jassids per three leaves), emamectin benzoate 0.001 per cent (4.90 jassids per three leaves) and ethion 0.100 per cent (5.00 jassids per three leaves) were noticed subsequently effective treatments.

Analogously at 14 days after second spray, significantly minimum population of jassid was registered from the plots treated with profenophos 0.100 per cent (2.60 per three leaves) and quinalphos 0.050 per cent (2.90 per three leaves). Both these treatments were statistically on par with each other. The next effective treatments were triazophos 0.050 per cent (3.50 jassids per three leaves), chlorantraniliprole 0.004 per cent (3.60 jassids per three leaves), indoxacarb 0.010 per cent (5.00 jassids per three leaves), emamectin benzoate 0.001 per cent (5.40 jassids per three leaves) and ethion 0.100 per cent (5.50 jassids per three leaves).

The trend of results found in the present investigation coincides with the findings of Andi *et al.* (2011) [2] who reported that profenophos was effective insecticide for suppressing adult population of leaf hopper on soybean. However, Joshi and Patel (2010) [11] documented that triazophos 0.06 per cent and quinalphos 0.05 per cent were most effective insecticides for the control of jassids on soybean. While, Kothalkar *et al*. (2015) [14] proved that emamectin benzoate 0.001 SG at the rate of 0.002 per cent + triazophos 0.050 EC at the rate of 0.06 per cent, emamectin benzoate 0.001 SG at the rate of 0.002 per cent, triazophos 0.050 EC at the rate of 0.06 per cent and flubendiamide 20 WG at the rate of 0.01 per cent + triazophos 0.050 EC at the rate of 0.06 per cent were significantly effective insecticides in managing soybean jassids.

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 percent (31.25 q per ha), quinalphos 0.050 per cent (29.63 q per ha), triazophos 0.050 per cent (20.96 q per), 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) [15] 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) [14] 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 *et al*. (2015) [16] 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) [17] 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) [14] 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) [20] 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 jassid (*Empoasca kerri* Pruthi)

The data on the average percentage mortality of nymphs of *E. kerri* on soybean leaves 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 on leaves of soybean applied as first and second spray against *E. kerri*

Treatments	Ist spray									IInd 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	92.82	71.41	58.63	24.19	61.76	14	864.67	1.55	1	93.07	75.05	57.17	24.19	62.37	14	873.18	1.39	1
Triazophos 0.050 per cent	85.76	64.34	51.78	20.68	55.64	14	778.96	1.39	3	86.24	67.88	50.00	20.68	56.20	14	786.80	1.25	3
Quinalphos 0.050 per cent	89.29	67.88	55.22	20.68	58.26	14	815.74	1.46	2	89.65	71.13	53.64	20.68	58.77	14	822.85	1.31	2
Indoxacarb 0.010 per cent	78.58	57.17	44.88	17.26	49.47	14	692.58	1.24	5	82.73	60.70	42.93	17.26	50.90	14	712.60	1.13	5
Ethion 0.100 per cent	71.41	46.46	27.61	13.85	39.83	14	557.65	1.00	7	75.90	53.64	35.76	13.85	44.78	14	627.02	1.00	7
Chlorantraniliprole 0.004 per cent	82.11	57.17	48.32	17.26	52.12	14	714.00	1.28	4	86.24	64.34	46.46	17.26	53.57	14	750.05	1.19	4
Emamectin benzoate 0.001 percent	75.85	54.71	37.95	17.26	46.44	14	650.19	1.16	6	79.31	57.17	39.29	13.85	47.40	14	663.67	1.05	6

First spray

The result of first spray evident that profenophos 0.100 per cent and quinalphos 0.050 per cent concentration showed comparatively high percentage mortality of nymph of *E. kerri* to the tune of 24.19 and 20.68 per cent, respectively at 14 days after spraying. On the basis of PT values the descending order of persistent toxicity was profenophos 0.100 per cent (864.67) > quinalphos 0.050 per cent (815.74) > triazophos 0.050 per cent (778.96) > chlorantraniliprole 0.004 per cent (714.00) > indoxacarb 0.010 per cent (692.58) > emamectin benzoate 0.001 per cent (650.19) > ethion 0.100 per cent (557.65).

The data pertaining to LT_{50} values of insecticides against nymphs of *E. kerri* on soybean leaves are presented in Table 3.

The data revealed that profenophos 0.100 per cent showed highest LT_{50} value (6.80 days) against the nymphs of jassid on soybean leaves receiving first application of insecticides. The descending relative order of efficacy of insecticides in days was found to be profenophos 0.100 per cent (6.80) > quinalphos 0.050per cent (5.91) > triazophos 0.050 per cent (5.32) > chlorantraniliprole 0.004 per cent (4.37) > indoxacarb 0.010 per cent (4.02) > emamectin benzoate 0.001 per cent (3.38) > ethion 0.100 per cent (2.72).

Second spray

The result of second spray evident that profenophos 0.100 per cent and quinalphos 0.050 per cent concentration showed comparatively high percentage mortality of nymphs of *E. kerri* to the tune of 24.19 and 20.68 per cent, respectively at 14 days after spraying. On the basis of PT values the descending order of persistent toxicity was profenophos 0.100 per cent (873.18) > quinalphos 0.050 per cent (822.85) > triazophos 0.050 per cent (786.80) > chlorantraniliprole 0.004 per cent (750.05) > indoxacarb 0.010 per cent (712.60) > emamectin benzoate 0.001 per cent (663.67) > ethion 0.100 per cent (627.02).

The data pertaining to LT_{50} values of insecticides against nymphs of *E. kerri* on soybean leaves receiving second spray are presented in Table 3.

The data revealed that profenophos 0.100 per cent was found to be highest (7.02 days) against nymphs of *E. kerri* on soybean leaves receiving second spray followed by quinalphos 0.050 per cent (6.11 days), triazophos 0.050 per cent (5.52 days), chlorantraniliprole 0.004 per cent (4.90 days), indoxacarb 0.010 per cent (4.37 days), emamectin benzoate 0.001 per cent (3.73 days) and ethion 0.100 per cent (3.28 days).

Thus, it indicates that profenophos 0.100 per cent followed by quinalphos 0.050 per cent illustrated higher residual toxicity to nymphs of *E. kerri* as compare to other insecticides. These results are parallel with the findings of Dake and Bhamare (2019) [5] who evidenced that that indoxacarb 0.05 per cent, chlorantraniliprole 0.0055 per cent and emamectin benzoate 0.0022 per cent revealed the highest persistent toxicity index (PT) value of (729.21, 692.65 and 593.91 and; 756.45, 706.86 and 619.78) and LT_{50} values (4.74, 4.19 and 3.00 and; 4.93, 4.38 and 3.23 days) against nymphs of jassid after first and second spray, respectively as compared to the other insecticides. However, Kolhe *et al*. (2015) [13] revealed that quinalphos 0.07 per cent recorded higher PT and LT_{50} values against groundnut jassids, *E. kerri*. Ghadage *et al*. (2012) [8] reported that profenophos 0.05 per cent achieved 65.68-72.77 per cent mortality of jassids.

Table 3: Relative efficacy of different insecticides against *E. kerri* on soybean leaves applied as first and second spray

Treatments	Ist Spray								IInd Spray							
	Heterogeneity		Regression Equation	Log LT_{50} ± S.Em	LT_{50} (days)	Fiducial Limit (days)	R.E.	O.R.E.	Heterogeneity		Regression Equation	Log LT_{50} ± S.Em	LT_{50} (days)	Fiducial Limit (days)	R.E.	O.R.E.
	d.f.	χ^2	(y=……)						d.f.	χ^2	(y=……)					
Profenophos 0.100 per cent	2	0.444	y=-0.1032-1.3863x	0.8330±0.1363	6.80	1.31 20.69	2.50	1	2	0.403	y=0.1993-1.8748x	0.8463±0.1342	7.02	1.31 20.84	2.14	1
Triazophos 0.050 per cent	2	0.436	y=0.079-1.6061x	0.7266±0.1462	5.32	1.21 16.55	1.95	3	2	0.457	y=-0.1262-1.6152x	0.7420±0.1447	5.52	1.23 17.05	1.68	5
Quinalphos 0.050 per cent	2	0.549	y=-0.023-1.4277x	0.7718±0.1383	5.91	1.23 17.15	2.17	2	2	0.552	y=0.1659-1.7646x	0.7860±0.1367	6.11	1.24 17.52	1.86	2
Indoxacarb 0.010 per cent	2	0.406	y=0.0556-1.5293x	0.6047±0.1554	4.02	1.06 11.55	1.47	5	2	0.341	y=0.0294-1.5799x	0.6408±0.1443	4.37	1.06 11.52	1.33	5
Ethion 0.100 per cent	2	0.188	y=0.1124-1.7635x	0.4358±0.1704	2.72	0.81 6.51	1.00	7	2	0.318	y=-0.0752-1.4859x	0.5163±0.1551	3.28	0.89 7.94	1.00	7
Chlorantraniliprole 0.004 per cent	2	0.556	y=0.0972-2.0102x	0.6410±0.1489	4.37	1.08 12.28	1.85	4	2	0.442	y=0.0763-1.7000x	0.6908±0.1365	4.90	1.09 12.52	1.49	4
Emamectin benzoate 0.001 per cent	2	0.148	y=0.0324-1.4422x	0.5301±0.1623	3.38	0.95 9.03	1.60	6	2	0.440	y=-0.0197-1.5676x	0.5719±0.1459	3.73	0.95 9.01	1.13	6

Conclusion

The overall results concluded that profenophos 0.100 per cent was the most efficacious insecticide against *E. kerri* infesting soybean followed by quinalphos 0.050 per cent and triazophos 0.050 per cent. Similarly, the higher residual toxicity was exhibited by these insecticides against nymph of *E. kerri* on soybean.

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