

Original Research Article

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Bio-efficacy, Persistence and Residual Toxicity of Different Insecticides against Soybean Leaf Miner *Aproaerema modicella* (Deventer) 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 *A. modicella* infesting soybean at the Research Farm of Department of Agril. Entomology, College of Agriculture, Latur (MS). The results proved that all the insecticidal treatments were significantly superior over untreated control in minimizing *A. modicella* infestation on soybean. Among the treatments, chlorantraniliprole 0.004 per cent was exhibited to be the most effective insecticide in minimizing population of *A. modicella* on soybean (2.11 larvae per mrl) followed by emamectin benzoate 0.001 per cent (2.67 larvae per mrl), indoxacarb 0.010 per cent (2.89 larvae per mrl), quinalphos 0.050 per cent (3.33 larvae per mrl), profenophos 0.100 per cent (3.34 larvae per mrl), ethion 0.100 per cent (4.00 larvae per mrl) and triazophos 0.050 per cent (4.22 larvae per mrl) after application of insecticides. The highest grain yield was registered by chlorantraniliprole 0.004 per cent (34.87 q per ha) while quinalphos 0.050 per cent (1:19.72) recorded highest incremental cost benefit ratio. The results on residual toxicity of different insecticides against *A. modicella* infesting soybean indicated that chlorantraniliprole 0.004 per cent and emamectin benzoate 0.001 per cent illustrated highest persistent toxicity index (PT) (915.46 and 870.24, respectively) and LT₅₀ values (7.78 and 6.89, respectively) against *A. modicella* after spray as compared to the other insecticides.

Keywords

Soybean, soybean leaf miner, *Aproaerema modicella* (Deventer), Bio-efficacy, Residual toxicity, Persistence, LT₅₀

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Introduction

Soybean (*Glycine max* (L.) Merrill) is one of the most important oilseed crops belonging to family Leguminaceae. It is well known as the wonder bean, the miracle golden bean, the

pearl of the Orient, the Cinderella crop of the century, the meat that grows on vines, the protein hope of the future and the salvation crop (Lawrence, 2011). It is world's most remarkable seed legume with the unique chemical composition and nutritionally 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). Soybean is not only a source of nutrients to human being but also to animals, poultry birds and fishes. The key benefits are related to their excellent protein content (contains all 8 essential amino acids), high levels of essential fatty acids, numerous vitamins and minerals, isoflavones, and fiber (Dwevedi and Kayastha, 2011).

Soybean is instrumental in bringing the yellow revolution. Worldwide, soybean is cultivated on an area of 126.95 million ha with total production of 362.64 million MT and an average productivity of 2860 kg per ha (USDA, 2020). 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). 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).

Despite having made rapid stride for both coverage and total production, soybean still suffers on productivity front (Agarwal *et al.*, 2013). 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), amongst 20 insect pest species are significant in India (Singh and Singh, 1990) and 13 in Marathwada region of Maharashtra (Bhamare *et al.*, 2018 and Phatak and Bhamare *et al.*, 2019).

The insect-pest complex of soybean registered 30.8 per cent avoidable seed yield losses (Ahirwar *et al.*, 2014). While, the yield losses ranged from 20 to 100 per cent due to individual disease or insect or weed species (Sharma *et al.*, 2014).

The soybean leaf miner, *Aproaerema modicella* Deventer (Lepidoptera: Gelichiidae) is one of the most important devastating oligophagous pests of soybean, groundnut and some weeds in the peninsular India. This species is widely distributed in south and south-east Asia. In early stage of the crop growth, leaf miner larvae initially mine into the leaflets, feed on the mesophyll and form small brown blotches on the leaf. Afterward larvae web the leaflets together and feed on them, remaining within the folds (Kolhe *et al.*, 2015). Heavy infestations cause subsequent loss of leaves which in turn reduces the photosynthetically active area leading to yield loss (Du Plessis and Van Denberg, 2011). Leaf miner causes 30-50 per cent losses in grain yield and 75 per cent loss in the leaflets (Shetgar and Thombre, 1984 and; Shirale *et al.*, 2010).

The insecticides are the first option that farmers choose for the control of insect-pests infesting soybean in India and hence several chemical insecticides have been recommended by CIB and RC. However, these label claimed insecticides need to be revalidated periodically for the effective management of *A. modicella* 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.

The duration of effectiveness was evaluated on the basis of PT values denoting persistent toxicity and LT₅₀ values (Sarup *et al.*, 1970). Thus these values can serve as ready recknor for quick selection of persistent pesticides. Under this background, the present investigation was planned to study the bio-efficacy, persistence and residual toxicity of different insecticides against *A. modicella* infesting soybean.

Materials and Methods

Bio-efficacy of different insecticides against *A. modicella* infesting soybean

The field experiment on bio-efficacy of different insecticides against *A. modicella* 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 (Vasantao 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 total number of *A. modicella* larvae were recorded on one meter row length from each treatment at three randomly selected places at one day before and 1, 3, 7 and 14 days after application of insecticides. The data on larval population were transformed into square root transformation before statistical analysis to know the significance of difference among different treatments. At maturity the crop was harvested and weight of grain per plot was recorded separated from each treatment. Plot wise yield was computed on hectare basis for statistical interpretation. The economics of the treatment was also computed based on grain yield and cost of protection. The incremental cost benefit ratio (ICBR) was computed based on cost of protection and gross profit. The data in respect of bio-efficacy and economics of different insecticides against *A. modicella* 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).

Persistence and residual toxicity of different insecticides against *A. modicella* infesting soybean

The toxicity of different insecticides was studied against third instar larvae of *A. modicella* at 1, 3, 7 and 14 days after application of insecticides. Due care was taken to cover the entire plant while application of insecticides. The required numbers of leaves 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 were brought into the laboratory at the prescribed day intervals. The treated leaves were kept into plastic containers separately. The stalk of leaves was covered with moistened cotton wool in order to retain their turgidity for 24 hours. Then the laboratory reared third instar larvae of *A. modicella* were released on treated leaves of soybean separately. 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 test insects 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) 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.

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).

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) and elaborated further by Pradhan (1967), Sarup *et al.*, (1970) and; Kolhe *et al.*, (2015) was utilized.

Results and Discussion

Effect of different insecticides on population of soybean leaf miner, *A. modicella*

Data pertaining to the effect of different insecticides on larval population of *A. modicella* infesting soybean after spray are presented in Table 1.

The results revealed that all the insecticides were found to be significantly superior over untreated control in reducing larval population of *A. modicella* at 1, 3, 7 and 14 days after application of insecticides.

At one day after spray, significantly minimum larval population of *A. modicella* was registered from the plots treated with chlorantraniliprole 0.004 per cent (1.11 per mrl) followed by emamectin benzoate 0.001 per cent (1.22 per mrl) and indoxacarb 0.010 per cent (1.33 per mrl). All these treatments

were statistically at par with each other. Subsequently effective treatments were quinalphos 0.050 per cent (2.11 larvae per mrl), profenophos 0.100 per cent (2.22 larvae per mrl), triazophos 0.050 per cent (2.78 larvae per mrl) and ethion 0.100 per cent (2.33 larvae per mrl). At three days after spray, chlorantraniliprole 0.004 per cent (1.22 per mrl), emamectin benzoate 0.001 per cent (1.78 per mrl) and indoxacarb 0.010 per cent (1.88 per mrl) recorded equally effective treatments in lowering larval population of *A. modicella*. The next efficient treatments in minimizing larval population of leaf miner were quinalphos 0.050 per cent (2.67 per mrl), profenophos 0.100 per cent (2.77 per mrl), triazophos 0.050 per cent (3.11 per mrl) and ethion 0.100 per cent (3.33 per mrl).

At seven days after spraying, significantly least larval population of *A. modicella* was evidenced from the plots treated with chlorantraniliprole 0.004 per cent (1.78 per mrl) and emamectin benzoate 0.001 per cent (2.33 per mrl). Both these treatments were found to be statistically at par with each other. The subsequent order of effectiveness was indoxacarb 0.010 per cent (2.56 larvae per mrl), quinalphos 0.050 per cent (2.89 larvae per mrl), profenophos 0.100 per cent (3.22 larvae per mrl), triazophos 0.050 per cent (3.56 larvae per mrl) and ethion 0.100 per cent (3.78 larvae per mrl). At 14 days after spraying, chlorantraniliprole 0.004 per cent exhibited significantly lowest population of *A. modicella* (2.11 per mrl). However, emamectin benzoate 0.001 per cent (2.67 larvae per mrl) and indoxacarb 0.010 per cent (2.89 larvae per mrl) observed to be next effective treatments. However, quinalphos 0.050 per cent (3.33 larvae per mrl), profenophos 0.100 per cent (3.44 larvae per mrl), ethion 0.100 per cent (4.00 larvae per mrl), and triazophos 0.050 per cent (4.22 larvae per mrl) were subsequently effective treatments.

Table.1 Effect of different insecticides on larval population of *A. modicella*, grain yield and ICBR of soybean

Treatments	Mean larval population of <i>A. modicella</i> per mrl					Main grain yield q/ha	ICBR
	I st spray						
	One day before spray	Days after spraying					
	1	3	7	14			
Profenophos 0.100 per cent	6.89 (2.68)*	2.22 (1.59)	2.77 (1.66)	3.22 (1.77)	3.44 (1.85)	20.46	1:6.77
Triazophos 0.050 per cent	6.22 (2.45)	2.78 (1.66)	3.11 (1.75)	3.56 (1.86)	4.22 (2.05)	20.96	1:11.69
Quinalphos 0.050 per cent	5.89 (2.42)	2.11 (1.43)	2.67 (1.62)	2.89 (1.68)	3.33 (1.82)	29.63	1:19.72
Indoxacarb 0.010 per cent	6.22 (2.49)	1.33 (1.14)	1.88 (1.36)	2.56 (1.59)	2.89 (1.69)	31.25	1:11.24
Ethion 0.100 per cent	5.89 (2.41)	2.33 (1.52)	3.33 (1.82)	3.78 (1.94)	4.00 (1.99)	16.43	1:3.51
Chlorantraniliprole 0.004 per cent	6.67 (2.57)	1.11 (1.05)	1.22 (1.09)	1.78 (1.33)	2.11 (1.45)	34.87	1:7.95
Emamectin benzoate 0.001 per cent	6.89 (2.62)	1.22 (1.09)	1.78 (1.32)	2.33 (1.52)	2.67 (1.62)	31.55	1:9.87
Untreated Control	6.44 (2.52)	6.67 (2.58)	6.89 (2.62)	7.22 (2.68)	7.56 (2.74)	12.09	-
S.E ±	-	0.07	0.07	0.08	0.05	0.02	-
C.D. at 5 per cent	NS	0.23	0.21	0.24	0.15	0.08	-
C.V.	-	8.76	7.20	7.71	4.61	0.61	-

* Figures in parentheses are angular transformed values

N.S.: Non-significant

Table.2 Persistence of different insecticides in/on leaves of soybean applied as first spray against third instar larvae of *A. modicella*

Insecticides	Corrected percentage mortality after different intervals (days)				P	T	PT	R.E.	O.R.E.
	1	3	7	14					
Profenophos 0.100 per cent	85.76	67.88	51.70	10.51	53.96	14	755.47	1.10	5
Triazophos 0.050 per cent	82.11	67.88	48.29	10.81	52.27	14	731.81	1.07	6
Quinalphos 0.050 per cent	89.29	71.13	55.22	14.34	57.49	14	804.93	1.17	4
Indoxacarb 0.010 per cent	89.29	75.05	55.22	14.34	58.47	14	818.65	1.19	3
Ethion 0.100 per cent	78.58	64.34	44.88	7.17	48.74	14	682.39	1.00	7
Chlorantraniliprole 0.004 per cent	94.46	82.73	62.84	21.52	65.39	14	915.46	1.34	1
Emamectin benzoate 0.001 per cent	92.82	69.31	58.63	17.88	62.16	14	870.24	1.27	2

Table.3 Relative efficacy of different insecticides against third instar larvae of *A. modicella* on soybean leaves applied as first spray

Insecticides	Heterogeneity		Regression Equation (y=.....)	Log LT ₅₀ ± S.Em	LT ₅₀ (days)	Fiducial Limit (days)	R.E.	O.R.E.
	d.f.	χ ²						
Profenophos 0.100 per cent	2	1.009	y = 0.1311 - 1.7787 x	0.7046±0.1318	5.06	1.09 12.33	1.25	5
Triazophos 0.050 per cent	2	0.996	y = -0.1065 - 1.6757 x	0.6272±0.1377	4.70	1.07 11.87	1.16	6
Quinalphos 0.050 per cent	2	0.808	y = 0.1661 - 1.8448 x	0.7667±0.1303	5.84	1.17 14.92	1.44	4
Indoxacarb 0.010 per cent	2	0.897	y = 0.1870 - 1.8899 x	0.7809±0.1287	6.03	1.18 15.26	1.49	3
Ethion 0.100 per cent	2	1.227	y = -0.0655 - 1.6542 x	0.6065±0.1387	4.04	0.97 9.48	1.00	7
Chlorantraniliprole 0.004 per cent	2	0.379	y = 0.2126 - 2.2456 x	0.8914±0.1181	7.78	1.29 19.52	1.92	1
Emamectin benzoate 0.001 per cent	2	0.656	y = 0.2096 - 2.0192 x	0.8383±0.1252	6.89	1.24 17.68	1.70	2

The results of present finding on the effectiveness of different insecticides against leaf miner are in conformity with those of Kothalkar *et al.*, (2015) who revealed that emamectin benzoate 5 SG at the rate of 0.002 per cent and triazophos 40 EC at the rate of 0.06 per cent were proved to be significantly effective treatments in managing the soybean leaf miner. However, Dhurgude *et al.*, (2015) and Shirale *et al.*, (2010) noticed that triazophos 40 EC registered lowest larval population of leaf miner on soybean. According to Shali Raju *et al.*, (2013) rynaxypyr 20 SC (chlorantraniliprole) at the rate of 100 ml per ha was significantly effective treatment against soybean defoliators and on par with commonly recommended insecticides *viz.* 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 and recorded less than 1 larva per mrl. While, Joshi and Patel (2011) reported that quinalphos 0.05 per cent, triazophos 0.06 per cent and emamectin benzoate at the rate of 5 g per 10 litre were most effective for the control of leaf miner (*A. modicella*) infesting soybean. Similarly, Mutkule *et al.*, (2010) investigated that emamectin benzoate and quinalphos were effective against groundnut leaf miner.

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 on 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 registered 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). The result of present investigation are in agreement with the findings of Patil *et al.*, (2014) 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) 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.

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 achieved 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 analogous to the findings of Wagh *et al.*, (2015) who documented 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) 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) observed highest ICBR (1:9.6) in triazophos; however, indoxacarb and emamectin benzoate noticed ICBR of 1: 4.5 and 1: 4.1, respectively.

Residual toxicity of different insecticides against soybean leaf miner, *A. modicella*

The data on the average percentage mortality of third instar larvae *A. modicella* on soybean leaves against spray recorded at 1, 3, and 7 and 14 days intervals are presented in Table 2.

The result of spray evidenced that chlorantraniliprole 0.004 per cent and emamectin benzoate 0.001 per cent concentrations showed comparatively high percentage mortality of third instar larvae of *A. modicella* to the tune of 65.39 and 62.16 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 (915.46) > emamectin benzoate 0.001 per cent (870.24) > indoxacarb 0.010 per cent (818.65) > quinalphos 0.050 per cent (804.93) > profenophos 0.100 per cent (755.47) > triazophos 0.050 per cent (731.81) > ethion 0.100 per cent (682.39).

The data on LT₅₀ values of insecticides against third instar larvae of *A. modicella* on soybean leaves receiving spray are presented in Table 27 and depicted in Fig 26.

The data revealed that chlorantraniliprole 0.004 per cent exhibited highest LT₅₀ value (7.78 days) against third instar larvae of *A. modicella* on soybean leaves receiving first application of insecticides followed by emamectin benzoate 0.001 per cent (6.89 days), indoxacarb 0.010 per cent (6.03 days), quinalphos 0.050 per cent (5.84 days), profenophos 0.100 per cent (5.06 days),

triazophos 0.050 per cent (4.70 days) and ethion 0.100 per cent (4.04 days).

Thus, it indicates that chlorantraniliprole 0.004 per cent followed by emamectin benzoate 0.001 per cent illustrated higher residual toxicity to third instar larvae *A. modicella* as compare to other insecticides. These results are analogous to the findings of Kolhe *et al.*, (2015) who revealed that effective treatments in terms of PT and LT₅₀ values were by quinalphos 0.07 per cent and emamectin benzoate 0.002 per cent. However, Joshi and Patel, (2011) indicated that quinalphos 0.05 per cent, triazophos 0.06 per cent and emamectin benzoate at the rate of 5 gm per 10 litre were efficacious insecticides registered higher mortality of leaf miner on soybean. Jain *et al.*, (2012) revealed that profenophos and ethion persisted more than 11 days on leaves and 9 days on pods of soybean.

In conclusion the overall results proved that chlorantraniliprole 0.004 per cent was the most efficacious insecticide against *A. modicella* infesting soybean followed by emamectin benzoate 0.001 per cent and indoxacarb 0.010 per cent. Similarly, the higher residual toxicity was exhibited by these insecticides against third instar larvae of *A. modicella* on soybean.

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