Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; SP-8(4): 103-107

VK Bhamare
Department of Agriculture. Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

GR Wahekar
Department of Agriculture. Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

DR Bankar
Department of Agriculture. Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

PB Hajare
Department of Agriculture. Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

RS Mahajan
Department of Agriculture. Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

BA Thakre
Department of Agriculture. Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
VK Bhamare
Department of Agriculture. Entomology, College of Agriculture, Latur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

International Web-Conference
On
New Trends in Agriculture, Environmental & Biological Sciences for Inclusive Development
(21-22 June, 2020)

Bio-efficacy, persistence and residual toxicity of different insecticides against soybean leaf eating caterpillar *Spodoptera litura* (Fabricius) infesting soybean

VK Bhamare, GR Wahekar, DR Bankar, PB Hajare, RS Mahajan and BA Thakre

DOI: https://doi.org/10.22271/j.ento.2020.v8.i4c.8153

Abstract
The investigations on 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 *Spodoptera litura* (Fabricius) infesting soybean were conducted at the Experimental Farm of Department of Agril. Entomology, College of Agriculture, Latur (MS) during *Kharif* 2015. The overall results exhibited that among the insecticide treatments, chlorantraniliprole 0.004 per cent was found to be the most effective insecticide in minimizing population of *S. litura* infesting soybean (0.81 larva per mrl) followed by emamectin benzoate 0.001 per cent (1.07 larvae per mrl), indoxacarb 0.010 per cent (3.27 larvae per mrl), quinalphos 0.050 per cent (3.33 larvae per mrl), profenophos 0.100 per cent (3.81 larvae per mrl), triazophos 0.050 per cent (4.11 larvae per mrl) and ethion 0.100 per cent (4.22 larvae per mrl) after application of insecticides. The maximum grain yield was obtained by the treatment with chlorantraniliprole 0.004 per cent (34.87 q per ha) while quinalphos 0.050 per cent (1:19.72) registered highest incremental cost benefit ratio. The results on residual toxicity of different insecticides against *S. litura* infesting soybean indicated that chlorantraniliprole 0.004 per cent and emamectin benzoate 0.001 per cent had highest persistent toxicity index (PT) (913.01 and 860.89, respectively) and LT_{50} values (7.59 and 6.69, respectively) against early instar larvae of *S. litura* after spray as compared to the other insecticides.

Keywords: Soybean, leaf eating caterpillar, *Spodoptera litura* (Fab.), bio-efficacy, residual toxicity, persistence, LT_{50}

Introduction
Soybean [*Glycine max* (L.) Merrill], a most happening crop of twenty first century is occupying premier position among the oilseed crops cultivated worldwide (IISR, 2018) [11]. Rightly known as Golden Bean, soybean is rich source of 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 (Bhamare *et al*. 2020) [4]. The food derived from soybean is generally considered to offer both specific and general health benefits. It is the most vital oil bearing leguminous crop of the world supplies quality proteins for alleviating protein calorie malnutrition prevalent in poor sections of the society (DSR, 2015) [7]. The presence of bioactive compounds in soybean has been also associated with antihypercholesterolemic, antihypertensive, regulation of diabetes, alleviation of antioxidant defence mechanism, immunomodulatory activities, and chemopreventive effects (Naresh *et al*. 2019) [14].

Climate change resulting in increased temperature could impact insect-pest populations in several complex ways. The changes in climate created challenging situation for soybean growers. In recent years many insect-pests and diseases pose serious threat to soybean requiring effective remedial interventions (DSR, 2015) [7]. Soybean is reported to be attacked by 13 species of insects-pest in Marathwada region of Maharashtra (Bhamare *et al*. 2018) [3]. Amongst defoliators, *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) is emerged as one of the serious and devastating insect-pests attacking soybean (Bapatla *et al*. 2018) [2]. Larvae of *S. litura* feeds on the foliage results in complete defoliation and in case of severe infestation, complete devastation of soybean crop occurs. Larvae even damages to soybean flowers and pods and cause significant yield losses (Singh and Singh 1990) [23]. The outbreaks of *S. litura* on soybean in Marathwada and Vidarbha region of Maharashtra have been reported to cause monetary losses to the tune of USD 22.5 crores (CROPSAP, 2012) [5]. Moreover, with a changing climate, there is the potential for this insect to become an increasingly severe pest in certain regions due to increased habitat suitability (Fand *et al*. 2015) [8].

In India insecticides are the first option that farmers choose and hence several chemical insecticides have been recommended for the control of *S. litura* by CIB and RC. However, these label claimed insecticides need to be revalidated from time to time for the effective management of *S. litura* 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 LT_{50} values (Sarup *et al*. 1970) [22]. Thus these values can serve as ready recknor for quick selection of persistent pesticides. In the view of these facts, the present investigation was planned to study the bio-efficacy, persistence and residual toxicity of different insecticides against *S. litura* infesting soybean.

Materials and Methods

Bio-efficacy of different label recommended insecticides against *S. litura* infesting soybean

The field experiment on bio-efficacy of different label recommended insecticides against *S. litura* 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 total number of *S. litura* 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 *S. litura* 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) [10].

Persistence and residual toxicity of different label recommended insecticides against *S. litura* infesting soybean

The toxicity of different insecticides was studied against third instar larvae of *S. litura* 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 *S. litura* 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) [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) [9].

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) [21] and elaborated further by Pradhan (1967) [18], Sarup *et al.* (1970) [22] and; Bhamare *et al*. (2020) [4] was utilized.

Results and Discussion

Effect of different insecticides on population of *S. litura* infesting soybean

Data pertaining to effect of different insecticides on population of *S. litura* infesting soybean after application of insecticides 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 *S. litura* at 1, 3, 7 and 14 days after application of insecticides.

At one day after spray, significantly minimum larval population of *S. litura* was registered from the plots treated with chlorantraniliprole 0.004 per cent (0.62 per mrl) and emamectin benzoate 0.001 per cent (0.88 per mrl). Both these treatments were found statistically at bar with each other. Subsequently effective treatments in reducing larval population were indoxacarb 0.010 per cent (2.67 per mrl), quinalphos 0.050 per cent (2.78 per mrl), profenophos 0.100 per cent (2.89 per mrl), triazophos 0.050 per cent (3.00 per mrl) and ethion 0.100 per cent (3.78 per mrl).

At three days after spray, chlorantraniliprole 0.004 per cent (0.64 per mrl) and emamectin benzoate 0.001 per cent (0.97 per mrl) evidenced significantly lowest larval population of *S. litura* and found statistically at par with each other. However, the next effective treatments were indoxacarb 0.010 per cent, quinalphos 0.050 per cent, profenophos 0.100 per cent, triazophos 0.050 per cent and ethion 0.100 per cent recorded 3.20, 3.20, 3.22, 3.44 and 4.11 larvae per mrl, respectively.

Analogously, at seven days after spraying, significantly minimum larval population of *S. litura* was recorded from the plots treated with chlorantraniliprole 0.004 per cent (0.77 per mrl) and emamectin benzoate 0.001 per cent (1.00 per mrl). Both these treatments were found equally effective. The subsequent order of effectiveness was indoxacarb 0.010 per cent (3.22 larvae per mrl), quinalphos 0.050 per cent (3.29 larvae per mrl), profenophos 0.100 per cent (3.78 larvae per mrl), triazophos 0.050 per cent (4.04 larvae per mrl) and ethion 0.100 per cent (4.15 larvae per mrl).

At 14 days after spraying, chlorantraniliprole 0.004 per cent (0.81 per mrl) and emamectin benzoate 0.001 per cent (1.07 per mrl) exhibited equally effective treatments in diminishing larval population of *S. litura*. However, indoxacarb 0.010 per cent (3.27 larvae per mrl), quinalphos 0.050 per cent (3.33 larvae per mrl), profenophos 0.100 per cent (3. 81 larvae per mrl), triazophos 0.050 per cent (4.11 larvae per mrl) and ethion 0.100 per cent (4.22 larvae per mrl) were found to be subsequently effective treatments.

The findings of present investigation are in confirmation with the results of Raut *et al*. (2015) [20] who revealed that chlorantraniliprole 18.5 SC at the rate of 0.006 per cent proved to be the most effective treatment in minimizing the *Spodoptera* larval population followed by chlorantraniliprole 18.5 SC at the rate of 0.0019, emamectin benzoate 5 SG at the rate of 0.002 per cent and triazophos 40 EC at the rate of 0.04 per cent. Wagh *et al*. (2015) [24] indicated that minimum number of *Spodoptera* larvae were recorded in profenophos 50 EC at the rate of 0.185 per cent followed by profenophos 50 EC at the rate of 0.125 per cent, quinalphos 25 EC at the rate of 0.075 per cent, quinalphos 25 EC at the rate of 0.05 per cent, triazophos 40 EC at the rate of 0.06 per cent and triazophos 40 EC at the rate of 0.04 per cent. According to Patil and Mohite (2015) [17] emamectin benzoate 1.9 EC at the rate of 200 ml per ha and indoxacarb 14.5 SC at the rate of 200 ml per ha offered excellent protection against *S. litura* infesting soybean. Kothalkar *et al*. (2015) [12] 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 *Spodoptera* infestation. Patil *et al.* (2014) [16] documented that chlorantraniliprole (30 g a.i. per ha) was found to be effective in protecting the soybean crop from the infestation of *S. litura*.

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 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 concurrence with the findings of Patil *et al*. (2014) [16] 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) [12] 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 revealed 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 parallel to the findings of Wagh *et al*. (2015) [24] 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. Raghuvanshi *et al*. (2014) [19] observed highest ICBR (1:9.6) in triazophos; however, indoxacarb and emamectin benzoate noticed ICBR of 1: 4.5 and 1: 4.1, respectively.

Table 1: Effect of different insecticides on larval population *S. litura*, grain yield and ICBR of soybean

Treatments	Mean larval population of *S. litura* per mrl					Main grain yield q/ha	ICBR
	One day before spray	Days after spraying					
		1	3	7	14		
Profenophos 0.100 per cent	5.33 (2.29)*	2.89 (1.69)	3.22 (1.78)	3.78 (1.93)	3.81 (1.94)	20.46	1:6.77
Triazophos 0.050 per cent	8.44 (2.32)	3.00 (1.72)	3.44 (1.85)	4.04 (2.00)	4.11 (2.03)	20.96	1:11.69
Quinalphos 0.050 per cent	5.67 (2.37)	2.78 (1.62)	3.20 (1.78)	3.29 (1.75)	3.33 (1.82)	29.63	1:19.72
Indoxacarb 0.010 per cent	5.67 (2.35)	2.67 (1.66)	3.20 (1.73)	3.22 (1.79)	3.27 (1.80)	31.25	1:11.24
Ethion0.100 per cent	6.22 (2.49)	3.78 (1.94)	4.11 (2.05)	4.15 (2.01)	4.22 (2.01)	16.43	1:3.51

Chlorantraniliprole 0.004 per cent	5.55 (2.30)	0.62 (0.77)	0.64 (0.97)	0.77 (0.87)	0.81 (0.89)	34.87	1:7.95
Emamectin benzoate 0.001 per cent	5.33 (2.26)	0.88 (0.92)	0.97 (0.98)	1.00 (1.00)	1.07 (1.03)	31.55	1:9.87
Untreated Control	5.00 (2.19)	5.00 (2.20)	5.33 (2.30)	5.66 (2.37)	6.00 (2.44)	12.09	-
S.E ±	-	0.06	0.06	0.09	0.11	0.02	-
C.D. at 5 per cent	NS	0.18	0.20	0.29	0.34	0.08	-
C.V.	-	8.88	6.50	9.94	11.22	0.61	-

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

Residual toxicity of different insecticides against *S. litura*
The data on the average percentage mortality of third instar larvae *S. litura* on soybean leaves against spray recorded at 1, 3, and 7 and 14 days intervals are presented in Table 2.
The result of first spray evident that chlorantraniliprole 0.004 per cent and emamectin benzoate 0.001 per cent concentrations showed comparatively high percentage mortality of third instar larvae of *S. litura* to the tune of 60.78 and 57.17 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 (913.01) > emamectin benzoate 0.001 per cent (860.89) > indoxacarb 0.010 per cent (852.70) > quinalphos 0.050 per cent (778.64) > triazophos 0.050 per cent (719.60) > profenophos 0.100 per cent (692.96) > and ethion 0.100 per cent (656.49). The data on LT_{50} values of insecticides against third instar larvae *S. litura* on soybean leaves receiving spray are presented in Table 3. The data revealed that chlorantraniliprole 0.004 per cent registered highest LT_{50} value (7.59) against third instar larvae of *S. litura* on soybean leaves receiving application of groundnut. insecticides. The descending relative order of efficacy of insecticides in days was found to be chlorantraniliprole 0.004 per cent (7.59) > emamectin benzoate 0.001 per cent (6.69) > indoxacarb 0.010 per cent (5.84) > quinalphos 0.050 per cent (5.28) >triazophos 0.050 per cent (4.53) > profenophos 0.100 per cent (4.03) > ethion 0.100 per cent (3.43).
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 *S. litura* as compare to other insecticides. These findings are identical with the results of Dake (2015) [6] who reported that emamectin benzoate 0.002 per cent and chlorantraniliprole 0.005 per cent noticed highest PT (963.34 and 878.46) and LT_{50} values (8.18 and 6.96 days) against *S. litura* on sunflower. Murthy *et al.* (2015) [13] found that emamectin benzoate 0.0005 per cent recorded 100 per cent kill in 6 hrs of exposure of 2nd instars larvae of *S. litura*. Patel *et al.* (2014) [15] documented that chlorantraniliprole 0.006 per cent caused maximum mortality of *S. litura* (93 per cent) followed by emamectin benzoate 0.0025 per cent (87 per cent) on

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

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	79.31	62.04	42.79	13.85	49.49	14	692.96	1.05	6
Triazophos 0.050 per cent	82.73	62.56	46.46	13.85	51.40	14	719.60	1.09	5
Quinalphos 0.050 per cent	86.24	68.97	50.00	17.26	55.61	14	778.64	1.19	4
Indoxacarb 0.010 per cent	89.65	72.38	64.34	17.26	60.90	14	852.70	1.30	3
Ethion 0.100 per cent	75.90	62.04	39.29	10.34	46.89	14	656.49	1.00	7
Chlorantraniliprole 0.004 per cent	96.58	79.31	60.78	24.19	65.21	14	913.01	1.39	1
Emamectin benzoate 0.001 per cent	93.07	75.05	57.17	20.68	61.49	14	860.89	1.31	2

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

Insecticides	Heterogeneity		Regression Equation (y=……)	Log $LT_{50} \pm$ S.Em	LT_{50} (days)	Fiducial Limit (days)	R.E.	O.R.E.
	d.f.	χ^2						
Profenophos 0.100 per cent	2	0.715	$y = 0.0258 - 1.5478x$	0.6056±0.1467	4.03	1.01 10.34	1.17	6
Triazophos 0.050 per cent	2	0.871	$y = 0.0824 - 1.6506x$	0.6570±0.1391	4.53	1.05 11.44	1.32	5
Quinalphos 0.050 per cent	2	0.697	$y = 0.1253 - 1.6957x$	0.7226±0.1379	5.28	1.15 14.26	1.53	4
Indoxacarb 0.010 per cent	2	0.808	$y = 0.1661 - 1.8482x$	0.7667±0.1303	5.84	1.17 14.92	1.70	3
Ethion 0.100 per cent	2	0.889	$y = -0.0198 - 1.5482x$	0.5358±0.1485	3.43	0.90 8.05	1.00	7
Chlorantraniliprole 0.004 per cent	2	0.418	$y = 0.2044 - 2.1610x$	0.8802±0.1211	7.59	1.29 19.61	2.21	1
Emamectin benzoate 0.001 per cent	2	0.612	$y = 0.1937 - 1.9641x$	0.8257±0.1272	6.69	1.24 17.49	1.95	2

Conclusion
Amongst insecticides evaluated, chlorantraniliprole 0.004 per cent was proved to be the most efficacious insecticide against *S. litura* infesting soybean followed by emamectin benzoate 0.001 per cent and indoxacarb 0.010 per cent. Similarly, the higher residual toxicity was evidenced by these insecticides against third instar larvae of *S. litura* on soybean.

References

1. Abbott WS. A method of computing the effectiveness of insecticide. J Econ. Entmol 1925;18(4):265-267.
2. Bapatla KG, Patil RH, Yeddula S. Impact of leaf damage by defoliators on yield of soybean as a sole crop and as a main crop in intercropping systems. International Journal of Pest Management 2018;64(1):51-58.
3. Bhamare VK, Phatak SV, Kumbhar SC, Bade AS. Influence of ambient weather on the incidence of major insect-pests of sole soybean and soybean intercropped with pigeonpea. J Entomol. Zool. Stud 2018;6(5):437-443.
4. Bhamare VK, Wahekar GR, Bankar DR, Thakre BA, Hajare PB, Mahajan RS. Bio-efficacy, persistence and

residual toxicity of different insecticides against soybean pod borer *Helicoverpa armigera* (Hubner) infesting soybean. J Entomol. Zool. Stud 2020;8(6):1764-1769.
5. CROPSAP. Crop Pest Surveillance and Advisory Project in Maharashtra, Sponsored by Commissionerate of Agriculture, Government of Maharashtra under Rashtriya Krishi Vikas Yojana. Available 2012. http://www.ncipm.org.in/cropsap2013/CROPSAP.PDF/Project.Background.pdf. Accessed 24 August 2014.
6. Dake RB. Bio-efficacy and residual toxicity of different insecticides against major insect-pests of sunflower. M.Sc. (Agri.) Thesis submitted to Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (MS) 2015.
7. DSR. Vision. Directorate of Soybean Research (Indian Council of Agricultural Research) Khandwa Road, Indore 2050;452(001), 2015, 1-33.
8. Fand BB, Sul NT, Bal SK, Minhas PS. Temperature impacts the development and survival of common cutworm (*Spodoptera litura*): Simulation and visualization of potential population growth in India under warmer temperatures through life cycle modelling and spatial mapping. PLoS ONE 2015;10(4):1-25. (e0124682. doi:10.1371/journal.pone.0124682)
9. Finney DJ. Probit Analysis, Cambridge University Press, Cambridge 1971, 333.
10. Gomez KA, Gomez AA. Statistical procedures for agricultural and research (2 edn.). A John Wiley and Sons Intersciences Publications. An International Res. Institute, Philippines 1984, 680.
11. IISR. Soybean: Package of practices for crop management. Extension Bulletin-13. ICAR-Indian Institute of Soybean Research, Indore, India 2018.
12. Kothalkar RR, Thakare AY, Salunke PB. Effect of newer insecticides in combination with Triazophos against insect pest of soybean. Agric. Sci. Digest 2015;35(1):46-50.
13. Murthy KSRK, Sashibhushan V, Reddy AR. Studies on the toxicity of certain botanicals on tobacco caterpillar, *Spodoptera litura* (Fab.) under laboratory conditions. Pestology 2015;39(1):11-13.
14. Naresh S, Ong MK, Thiagarajah K, Muttiah NBS. Kunasundari B, Lye HS. Engineered soybean-based beverages and their impact on human health. In Non-Alcoholic Beverages, Editor(s): Alexandru Mihai Grumezescu, Alina Maria Holban, Woodhead Publishing 2019, 329-361 (https://doi.org /10.1016/B978-0-12-815270-6.00011-6).
15. Patel PK, Damasia DM, Patel HP, Bhaliya CM. Effect of various insecticides against *Spodoptera litura* (Fab.) in groundnut. Pestology 2014;38(4):69-71.
16. Patil MU, Kulkarni AVGavkare O. Evaluating the efficacy of novel molecules against soybean defoliators. The Bioscan 2014;9(1):577-580.
17. Patil PP, Mohite BP. Bio-efficacy of new molecules of insecticides against leaf eating caterpillar, *Spodoptera litura* (Fab.) infesting soybean. Indian J Res. Sci 2015;17(2):322-324.
18. Pradhan S. Strategy of integrated pest control. Indian J Entomol 1967;29(1):105-122.
19. Raghuvanshi S, Bhadauria NS, Singh P. Efficacy of Insecticides against Major Insect Pests of Soybean. Indian. J Com 2014;7(3):191-193.
20. Raut AS, Barkhade UP, Bhalkare SK, Borkar UH. Efficacy of Newer Insecticides against major pests of soybean. Indian J Entomol 2015;7(20):3133-3138.
21. Saini ML. Bioassay of persistence of spray residues on leaf surface of maize using just hatched larvae of *Chilo zonellus* (Swinhoe) as test insect. Assoc. I.A.R.I. Thesis, Indian Agricultural Research Institute, New Delhi (Unpublished) 1959.
22. Sarup P, Singh DS, Amarpuri S, Rattan Lal. Persistent and relative residual toxicity to some important pesticides to the adults of sugarcane leaf-hopper, *Pyrilla perpusilla* Walker (Lophopidae: Homoptera). Indian J Entomol 1970;32(3):256-267.
23. Singh OP, Singh KJ. Insect pest of soybean and their management. Indian farming 1990;39(10):9-14.
24. Wagh GV, Deotale RO, Lavhe NV, Jiotode DJ, Patil KA. Validation of different insecticides against defoliator on soybean. Pestology 2015;39(5):35-40.