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Bio-efficacy of different insecticides against tobacco leaf eating caterpillar, *Spodoptera litura* (Fab.) infesting soybean under field condition

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Abstract
With a view to find out the relative bio-efficacy of different insecticides against tobacco leaf eating caterpillar, *Spodoptera litura* (Fab.) infesting soybean under field condition, field trial was carried out at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh during *Kharif* season of 2017. The result of two applications of different insecticidal treatments against tobacco leaf eating caterpillar, *S. litura* (Fab.) revealed that the treatment with chlorantraniliprole 0.006 per cent, indoxacarb 0.008 per cent and quinalphos 0.05 per cent were found most effective against *S. litura* (Fab.). Among the combination of different insecticidal treatments there order of effectiveness were found as *B. bassiana* 0.0035 per cent + chlorantraniliprole 0.003 per cent >*B. bassiana* 0.0035 per cent + indoxacarb 0.004 per cent >*M. anisopliae* 0.0035 per cent + chlorantraniliprole 0.003 per cent >*M. anisopliae* 0.0035 per cent + indoxacarb 0.004 per cent. However *M. anisopliae* 0.007 per cent and *B. bassiana* 0.007 per cent were found less effective in controlling the pest.

Keywords: Soybean, bio-efficacy, insecticides, tobacco leaf eating caterpillar, *S. litura,* field condition and Junagadh

1. Introduction

Soybean [*Glycine max* (L.) Merrill.] is an important leguminous crop. Native of soybean is in Asia and the first known records, indicate that soybean emerged as a domesticated crop around the eleventh century B. C. in China (Hymowitz, 1970) [9]. They named it as a "yellow jewel" which feeds China's entire population. Soybean was introduced in India in 1870-80 (Andole, 1984) [4]. The soybean crop is one of the remarkable success stories in Indian agriculture.

It is one of the most important oilseed cash crops of India. It is a fascinating crop with innumerable possibilities of not only improving agriculture, but also supporting industries. It is a unique crop with high nutritional value, providing 40 per cent protein and 20 per cent edible oil besides minerals and vitamins. Soybean oil is used as a raw material in manufacturing antibiotics, paints, varnishes, lubricants etc. Soybean meal is used as protein supplement in human diet, cattle and poultry feeds (Alexander, 1974) [3]. Soybean is a major oil seed crop of the world grown in an area of 113.01m ha with production of 283.79 mt and productivity of 2.51 t/ha (Anonymous, 2013) [5]. India contributes more than 90 per cent of the world's acreage.

In India, soybean occupies an area of 109.714 lakh ha with production potential of 114.907 lakh tons. Major production comes from Madhya Pradesh (57.168 lakh t) followed by Maharashtra (39.456 lakh t). Other soybean producing states are Andhra Pradesh, Karnataka, Chhattisgarh and Gujarat (SOPA, 2016) [12]. In India in the year 2012-13, soybean cultivation reached to 12.03 mha recording production of 12.98 mt with an average of 1079 kg/ha. In Gujarat, the area under soybean was 14,000 hectares and the yield was 714 kg per ha with total production of 10,000 tones (Anon., 2003) [6].

Soybean is mainly rich in amino acids like leucine, methionine and threonine that the human body requires. For vegetarians, it is known as "poor man's meat". It also contains good amount of potassium, sulphur and vitamin E. Due to absence of sugar content, it is considered to be very suitable diet for diabetic patients.

Soybean crop having luxuriant growth with succulent leaves attracts the number of insect pests for feeding, oviposition and shelter. About 150 insect pests cause damage to soybean in various parts of Madhya Pradesh, out of which about a dozen of insect pests cause serious damage to the crop from sowing to the harvest (Singh and Singh, 1992) [11]. Among them green semilooper, *Chrysodeixis acuta* (Walker), tobacco caterpillar, *Spodoptera litura* (Fabricius) and pod borer, *Helicoverpa armigera* are major foliage feeder insects which voraciously feeds on foliage, flower and pods causing significant yield loss.

The damage caused by this pest depends on population of damaging stage of insect, crop growth stage, cropping pattern in the area and prevailing environmental conditions. Perusal of literature reveals that insecticidal recommendations are available for protecting the crop from soybean defoliators attack. They are highly toxic to natural enemies and cause environmental pollution.

2. Materials and Methods

2.1 Treatments imposed

Ten treatments viz., chlorantraniliprole 18.5 SC, indoxacarb 14.5 SC, *B. bassiana* 1.15 WP, *M. anisopliae* 1.15 WP, *B. bassiana* 1.15 WP + chlorantraniliprole 18.5 SC, *B. bassiana* 1.15 WP + indoxacarb 14.5 SC, *M. anisopliae* 1.15 WP + chlorantraniliprole 18.5 SC, *M. anisopliae* 1.15 WP + indoxacarb 14.5 SC, quinalphos 25 EC and untreated control were imposed in all three replications randomly. Total 30 plots of 5 m × 2.7 m size were sown with variety Jawahar Soybean 335 and spacing of 45 cm X 15 cm between rows and plants were maintained respectively. The experiment was laid out in randomized block design (RBD) with ten treatments that were replicated thrice. The crop was raised under rainfed conditions. All the recommended agronomic practices *i.e.*, fertilizer application, thinning, inter cultivation and weeding operations were practiced.

2.2 Method of recording observations

When the population of insect pests was sufficient, the first application was given on 28th August, 2017. Similarly, the second application was given on fifteen days interval, *i.e.* on 13th September, 2017. To evaluate the efficacy of different insecticides, observations of larval population were recorded from randomly selected five plants from each treatment before 24 hours and 3, 5, 7 and 10 days after spraying. The grain yield received from each treatment along with control, were weighed and recorded, and data were converted on hectare basis. The data of larval population was converted into per cent mortality by using the following formula given by Henderson and Tilton (1955) [8] and the data obtained was transformed to arc sine transformation before statistical analysis.

3. Results and Discussion

3.1 First spray

3.1.1 Three days after spraying

The data on mortality of tobacco leaf eating caterpillar recorded three days after spraying (Table- 1 and Fig.-1) indicated that chlorantraniliprole 0.006 per cent recorded highest mortality i.e 80.65 per cent which was at par with indoxacarb 0.008 per cent and quinalphos 0.05 per cent which registered 76.17 and 73.30 per cent mortality, respectively. They were followed by *B. bassiana* 0.0035 per cent + chlorantraniliprole 0.003 per cent, *B. bassiana* 0.0035 per cent + indoxacarb 0.004 per cent, *M. anisopliae* 0.0035 per cent + chlorantraniliprole 0.003 per cent and *M. anisopliae* 0.0035 per cent + indoxacarb 0.004 per cent which recorded 68.41, 65.02, 64.02 and 62.36 per cent mortality, respectively. The treatment with *B. bassiana* 0.007 per cent and *M. anisopliae* 0.007 per cent were found comparatively less effective against the pest as they recorded 61.59 and 58.47 per cent mortality, respectively.

3.1.2 Five days after spraying

The data presented in Table-1 and Fig.-1 showed that among different insecticide tested chlorantraniliprole 0.006 per cent found to be the superior as it caused highest mortality 85.75 per cent. It found at par with indoxacarb 0.008 per cent and quinalphos 0.05 per cent which showed 81.36 and 79.54 per cent mortality, respectively. However the treatments next in order were *B. bassiana* 0.0035 per cent + chlorantraniliprole 0.003 per cent, *B. bassiana* 0.0035 per cent + indoxacarb 0.004 per cent, *M. anisopliae* 0.0035 per cent + =chlorantraniliprole 0.003 per cent and *M. anisopliae* 0.0035 per cent + indoxacarb 0.004 per cent with 71.37, 68.46, 67.27, and 65.64 per cent mortality, respectively. *M. anisopliae* 0.007 per cent was recorded lowest mortality among tested insecticides and *B. bassiana* 0.007 per cent was second last with 64.02 per cent mortality.

3.1.3 Seven days after spraying

The data (Table-1 and Fig.-1) clearly indicated that the treatment chlorantraniliprole 0.006 per cent was found superior over the all tested insecticides as it recorded highest mortality 90.65 per cent. It was at par with the indoxacarb 0.008, quinalphos 0.05 and *B. bassiana* 0.0035 per cent + chlorantraniliprole 0.003 per cent which showed 85.41, 82.50 and 80.64 per cent mortality, respectively. The treatments of *B. bassiana* 0.0035 per cent + indoxacarb 0.004 per cent, *M. anisopliae* 0.0035 per cent + chlorantraniliprole 0.003 per cent and *M. anisopliae* 0.0035 per cent + indoxacarb 0.004 per cent were next in order with 76.93, 72.74 and 70.80 per cent mortality, respectively. Among all tested insecticides *M. anisopliae* 0.007 and *B. bassiana* 0.007 per cent were found less effective with 62.90 and 67.26 per cent mortality, respectively.

3.1.4 Ten days after spraying

The data in Table-1 and Fig.-1 indicated that chlorantraniliprole 0.006 per cent recorded highest larval mortality 83.03 per cent of tobacco leaf eating caterpillar on ten days after spraying which was at par with indoxacarb 0.008 per cent, quinalphos 0.05 per cent, *B. bassiana* 0.0035 per cent + chlorantraniliprole 0.003 per cent and *B. bassiana* 0.0035 per cent + indoxacarb 0.004 per cent as they were recorded 77.91, 77.79, 76.97, and 73.20 per cent mortality, respectively. *M. anisopliae* 0.0035 per cent + chlorantraniliprole 0.003 per cent and *M. anisopliae* 0.0035 per cent + indoxacarb 0.004 per cent were found as next effective treatment with 69.58 and 68.18 per cent mortality, respectively. *M. anisopliae* 0.007 per cent and *B. bassiana* 0.007 per cent remained significantly inferior among all other insecticides evaluated with 60.33 and 63.29 per cent mortality, respectively.

3.2 Second spray

3.2.1 Three days after spraying

The pragmatic data of different insecticidal treatments at three days after spraying were presented in Table-1 and Fig.-2. The treatment of chlorantraniliprole 0.006 per cent proved to be the most effective against the pest as it recorded the highest mortality (78.70 per cent) among all tested insecticides. This treatment was statistically at par with indoxacarb 0.008 per cent, quinalphos 0.05 per cent, *B. bassiana* 0.0035 per cent + chlorantraniliprole 0.003 per cent and *B. bassiana* 0.0035 per cent + indoxacarb 0.004 per cent which showed 75.40, 72.93, 71.85 and 68.90 per cent mortality, respectively. The treatments of *M. anisopliae* 0.0035 per cent + chlorantraniliprole 0.003 per cent, *M. anisopliae* 0.0035 per cent + indoxacarb 0.004 per cent were found next in order with 66.53 and 64.06 per cent mortality, respectively. However *M. anisopliae* 0.007 per cent and *B. bassiana* 0.007 per cent alone were less effective in controlling the pest and registered lowest mortality 50.93 and 62.79 per cent, respectively.

3.2.2 Five days after spraying
The data (Table-1 and Fig.-2) clearly indicated that the treatment chlorantraniliprole 0.006 per cent was found superior over the all tested insecticides as it recorded highest mortality 83.34 per cent. This treatment was statistically at par with indoxacarb 0.008 per cent, quinalphos 0.05 per cent and *B. bassiana* 0.0035 per cent + chlorantraniliprole 0.003 per cent which showed 79.47, 77.53 and 74.86 per cent mortality, respectively. The treatments of *B. bassiana* 0.0035 per cent + indoxacarb 0.004 per cent, *M. anisopliae* 0.0035 per cent + chlorantraniliprole 0.003 per cent and *M. anisopliae* 0.0035 per cent + indoxacarb 0.004 per cent were found next in order with 72.39, 70.45 and 68.02 per cent mortality, respectively. *M. anisopliae* 0.007 per cent was recorded lowest mortality (54.28 per cent) among tested insecticides and *B. bassiana* 0.007 per cent was second last in order of effectiveness with 66.18 per cent mortality.

3.2.3 Seven days after spraying
The data presented in Table-1 and depicted in Fig.-2 revealed that the chlorantraniliprole 0.006 per cent proved most effective insecticide in controlling pest as it recorded highest mortality (87.65 per cent) among evaluated insecticides. This treatment was statistically at par with indoxacarb 0.008 per cent, quinalphos 0.05 per cent and *B. bassiana* 0.0035 per cent + chlorantraniliprole 0.003 per cent which showed 83.81, 82.80 and 78.51 per cent mortality, respectively. *B. bassiana* 0.0035 per cent + indoxacarb 0.004 per cent, *M. anisopliae* 0.0035 per cent + chlorantraniliprole 0.003 per cent and *M. anisopliae* 0.0035 per cent + indoxacarb 0.004 per cent were found next effective against pest as which recorded 72.40, 71.97 and 67.38 per cent mortality, respectively. *M. anisopliae* 0.007 per cent was recorded lowest mortality among tested insecticides 62.16 per cent and *B. bassiana* 0.007 per cent was second last in order of effectiveness with 65.48 per cent mortality.

3.3.3 Ten days after spraying
The data (Table-1 and Fig.-2) regarding the mortality of different insecticides at ten days after spraying revealed that chlorantraniliprole 0.006 per cent proved most effective as it recorded the highest mortality 82.53 per cent as compare to other evaluated insecticides. This treatment was statistically at par with quinalphos 0.05 per cent, indoxacarb 0.008 per cent, *B. bassiana* 0.0035 per cent + chlorantraniliprole 0.003 per cent and *B. bassiana* 0.0035 per cent + indoxacarb 0.004 per cent which showed 78.28,77.97, 71.03 and 68.44 per cent mortality, respectively. Among all tested insecticides *M. anisopliae* 0.007 and *B. bassiana* 0.007 per cent were found less effective and registered 58.68 and 59.43 per cent mortality, respectively.

Greg *et al*. (2009) [7] revealed that chlorantraniliprole is among the fastest acting insecticides available for control of lepidopteran pests and is faster than indoxacarb and is effective against insect populations that have developed resistance to other insecticide groups representing an attractive tool for integrated pest management programs. Ahirwar *et al*. (2013) [2] conducted field trial during *kharif* season with microbial insecticide against foliage feeders of soybean crop. Among these treatments *B. bassiana* (5.06 larvae/mrl) was found to be most effective followed by *M. anisopliae* (6.06 larvae/mrl). Vinaykumar *et al.* (2013) [13] evaluated the newer insecticides against *S. litura* in soybean field experiment at Instructional Farm, College of Agriculture, Junagadh during *kharif*, 2009 and reported that among different insecticides tested, chlorantraniliprole @ 0.006 per cent and indoxacarb @ 0.0029 per cent were found to be most effective against *S. litura* and remaining treatments were moderately effective in managing *S. litura*. Patil *et al*. (2014) [10] reported that chlorantraniliprole 18.5 per cent SC @ 30 g a.i./ha provide consistent protection from defoliation to soybean crop from *S. litura* with highest cost benefit ratio among the tested insecticides. Acharya *et al.* (2015) [1] revealed that chlorantraniliprole 0.006 per cent were found to be the most effective against *S. litura* on groundnut.

Thus, the present findings are more or less in confirmation with the reports of earlier workers.

Table 1: Bio-efficacy of different insecticides against *S. litura* infesting soybean under field condition

Sr. no.	Treatment	Corrected per cent mortality							
		First spray				Second spray			
		3 DAS	5 DAS	7 DAS	10 DAS	3 DAS	5 DAS	7 DAS	10 DAS
1.	Chlorantraniliprole 0.006%	63.90* (80.65)	67.82 (85.75)	72.19 (90.65)	65.68 (83.03)	62.51 (78.70)	65.91 (83.34)	69.42 (87.65)	65.30 (82.53)
2.	Indoxacarb 0.008%	60.78 (76.17)	64.42 (81.36)	67.54 (85.41)	61.97 (77.91)	60.27 (75.40)	63.06 (79.47)	66.28 (83.81)	62.01 (77.97)
3.	*B. bassiana* 0.007%	51.70 (61.59)	53.14 (64.02)	55.10 (67.26)	52.71 (63.29)	52.41 (62.79)	54.44 (66.18)	54.02 (65.48)	50.44 (59.43)
4.	*M. anisopliae* 0.007%	49.88 (58.47)	51.12 (60.60)	52.48 (62.90)	50.96 (60.33)	45.53 (50.93)	47.46 (54.28)	52.04 (62.16)	50.00 (58.68)
5.	*B. bassiana* 0.0035% + Chlorantraniliprole 0.003%	55.80 (68.41)	57.65 (71.37)	63.90 (80.64)	61.32 (76.97)	57.95 (71.85)	59.91 (74.86)	62.38 (78.51)	57.43 (71.03)
6.	*B. bassiana* 0.0035% + Indoxacarb 0.004%	53.74 (65.02)	55.83 (68.46)	61.29 (76.93)	58.82 (73.20)	56.11 (68.90)	58.30 (72.39)	58.31 (72.40)	55.82 (68.44)
7.	*M. anisopliae* 0.0035% + Chlorantraniliprole 0.003%	53.14 (64.02)	55.10 (67.27)	58.53 (72.74)	56.52 (69.58)	54.65 (66.53)	57.07 (70.45)	58.03 (71.97)	52.64 (63.17)
8.	*M. anisopliae* 0.0035% + Indoxacarb 0.004%	52.15	54.11	57.29	55.66	53.17	55.56	55.17	51.84

		(62.36)	(65.64)	(70.80)	(68.18)	(64.06)	(68.02)	(67.38)	(61.82)
9.	Quinalphos 0.05%	58.89 (73.30)	63.11 (79.54)	65.27 (82.50)	61.88 (77.79)	58.65 (72.93)	61.70 (77.53)	65.50 (82.80)	62.23 (78.28)
	S. Em. ±	3.98	4.11	4.20	4.23	3.77	3.55	4.27	4.93
	C. D. at 5%	11.93	12.32	12.58	12.70	11.31	10.65	12.79	14.78
	C. V. %	10.20	9.97	9.53	10.19	9.64	8.6	9.93	12.50

*Arcsine transformed value Figures in parentheses are retransformed value

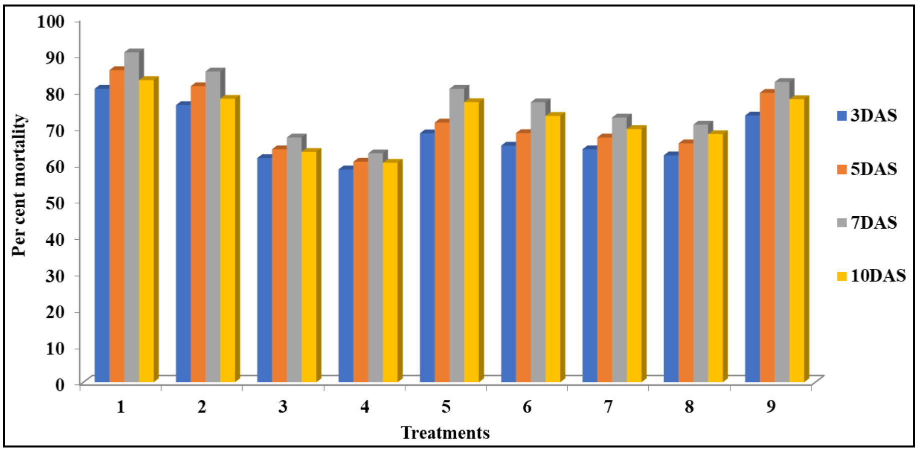

Fig 1: Bio-efficacy of different insecticides against *S. litura* infesting soybean after first spray under field condition

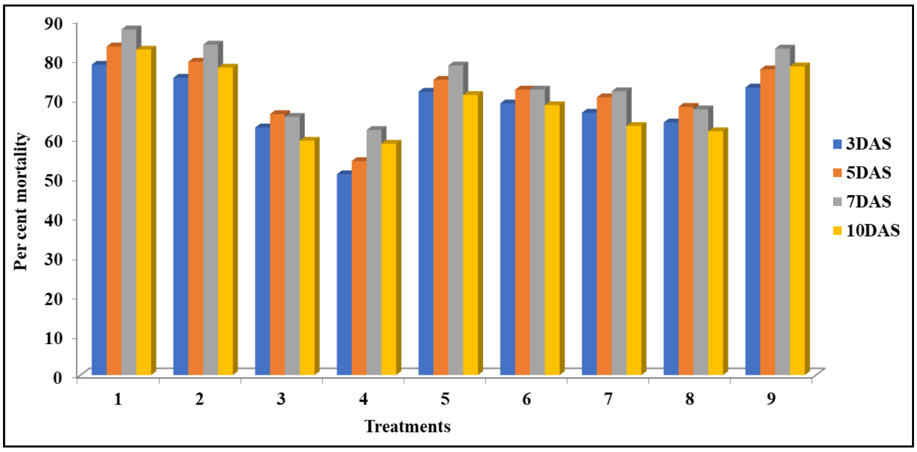

Fig 2: Bio-efficacy of different insecticides against *S. litura* infesting soybean after second spray under field condition

4. Conclusion

The nine insecticides were evaluated against pest revealed that the of chlorantraniliprole 0.006 per cent proved to be the most effective against the pest as it recorded the highest mortality among all tested insecticides. This treatment was followed by indoxacarb 0.008 per cent, quinalphos 0.05 per cent, *B. bassiana* 0.0035 per cent + chlorantraniliprole 0.003 per cent and *B. bassiana* 0.0035 per cent + indoxacarb 0.004 per cent, respectively. The treatments of *M. anisopliae* 0.0035 per cent + chlorantraniliprole 0.003 per cent, *M. anisopliae* 0.0035 per cent + indoxacarb 0.004 per cent were found next in order, respectively. However *M. anisopliae* 0.007 per cent and *B. bassiana* 0.007 per cent were less effective in controlling the pest and registered lowest mortality, among all evaluated insecticides.

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