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Newer insecticide molecules for the management of *Spodoptera litura* Fabricius in soybean

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Abstract
A field experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2017 to evaluate the efficacy of different bio-pesticides and newer molecules against *Spodoptera litura* in soybean. The experiment was laid out in randomized block design with nine treatments and replicated thrice. Among the different treatments significantly lower population of *S. litura* was recorded in flubendiamide 480 SC applied @ 0.2 ml/l which was on par with spinetoram 12 SC @0.2 ml/l. The next best treatments were spinosad 45 SC @ 0.2 ml/l, chlorantraniliprole 18.5 SC @ 0.2 ml/l and buprofezin 25 SC @ 1ml/l.

Keywords: *Spodoptera litura*, soybean, newer molecules and bio-pesticides

1. Introduction

Soybean (*Glycine max* (L) Merrill) is one of the miracle 'Golden beans' of the 20th century. It is a unique crop with high nutritional value, providing 40 per cent protein, 20 per cent edible oil, Vitamin A, B, C, D, E and K. Soybean protein provides all the nine essential amino acids. It also supports many industries; soybean oil is used as raw material in manufacturing antibiotics, paints, varnishes, adhesives, lubricants etc. Soybean meal is used as the protein supplement in the human diet, cattle and poultry feed [1].

In India, the crop is grown over an area of 11.18 million hectares with a production of 13.15 million tonnes and productivity of 1176 kg per hectare which is much below the average productivity of world *i.e.*, 2,233 kg per hectare. In Karnataka, soybean is grown over an area of 3.18 lakh hectares with a production of 2.37 lakh tonnes and a productivity of 745 kg per hectare [2]. The low productivity of soybean both at national and state level is attributed to abiotic stresses as well as biotic stresses like drought, weeds, insect pests and diseases. Among these, insect pests often pose a serious threat to soybean production by increasing cost of cultivation and impairing quality of produce in many ways [3]. Soybean crop is reported to be attacked by about 350 species of insects in many parts of the world [4]. Among the insect pests attacking soybean, defoliators and pod borers are economically important causing considerable yield losses [5]. The defoliators *S. litura*, *T. orichalcea*, *S. obliqua* and *Helicoverpa armigera* (Hub) feed on foliage, flower and pods causing significant yield loss [6].

2. Materials and methods

A field experiment was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2017 to evaluate the efficacy of different bio-pesticides and newer molecules against *Spodoptera litura* soybean. The experiment was laid out in randomized block design with nine treatments and replicated thrice (Table 1). Soybean variety, DSb 21 was raised as per the package of practices except the plant protection measures against defoliators. Seed treatment with thiram + carboxin was done @ 2 g per kg seed. A blanket spray with rynaxypyr was given at 75-80 days of sowing to control pod borers. The treatments given in the Table 1 were imposed at 30 and 45 days after sowing.

Observations on larval population of *Spodoptera litura* were made at three randomly selected spots of one meter row length in each treatment leaving border rows. Pre-treatment counts were taken one day before the application of insecticide. Subsequently, the larval population was observed on third, seventh and tenth day after each spray.

3. Results and discussion

3.1 First spray: The initial larval population at one day before spraying ranged from 3.42 to 3.45 larvae/mrl without any significant difference among different treatments.

At three days after spraying however, flubendiamide 480 SC recorded significantly lower number of larvae (0.84 larvae/mrl) which was on par with spinetoram 12SC (1.06 larvae/mrl), spinosad 45SC (1.38 larvae/mrl), chlorantraniliprole 18.5 SC (1.65 larvae/mrl) and buprofezin 25 SC (1.94 larvae/mrl). All these treatments proved their superiority over untreated check (3.47 larvae/mrl). Tetraniliprole 200 SC, nimbecidine 3000 ppm and *N. rileyi* 2×10^8 CFU/g harboured 2.57, 2.67 and 2.74 larvae per meter row length, respectively which were found on par with the untreated check (Table 1).

Further, the observations made at 7 DAS revealed that the larval population in flubendiamide 480 SC, chlorantraniliprole 18.5 SC, spinetoram 12 SC, spinosad 45 SC and buprofezin 25 SC treatments were found on par with each other (0.55, 0.66, 0.74, 1.37 and 1.46 larvae/mrl, respectively). Significantly higher incidence (3.61 larvae/mrl) was recorded in untreated check which was on par with the treatments *viz.*, nimbecidine 3000 ppm (2.03 larvae/mrl), *N. rileyi* 2×10^8 CFU/g (2.26 larvae/mrl) and tetraniliprole 200 SC (2.34 larvae/mrl).

At 10 days after the spray, significantly lower population was observed in flubendiamide 480 SC (0.40 larvae/mrl) which was found on par with spinetoram 12 SC (0.41 larvae/mrl). On the contrary, the treatments *viz.*, nimbecidine 3000 ppm and *N. rileyi* 2×10^8 CFU/g stood on par with the untreated control up to 7 days after spraying but however, both these treatments were found to be superior over the untreated check at 10 days after the spray. The remaining treatments were also superior over the untreated check (Table 1).

3.2 Second spray: A day before spraying, the initial larval count ranged from 1.27 to 4.10 larvae per meter row length. Significantly lower larval population was observed in flubendiamide 480 SC (1.27 larvae/mrl) which stood on par with all the other treatments except the untreated check. With highest number of larvae per meter row length (4.10), the untreated check was found on par with *N. rileyi* 2×10^8 CFU/g and nimbecidine 3000 ppm treatments (Table 2). At three days after spraying, the larval count varied from 0.24 to 4.34 larvae per meter row length with the lowest population recorded in spinetoram 12 SC (0.24 larvae/mrl) which was on par with flubendiamide 480 SC (0.34 larvae/mrl) and spinosad 45 SC (0.56 larvae/mrl). The next best treatments were chlorantraniliprole 18.5 SC (1.57 larvae/mrl), *N. rileyi* 2×10^8 CFU/g (1.66 larvae/mrl), buprofezin 25 SC (1.68 larvae/mrl), tetraniliprole 200 SC (1.79 larvae/mrl) and nimbecidine 3000 ppm (2.17 larvae/mrl). All these treatments showed their superiority over the untreated check (4.34 larvae/mrl).

Table 1: Efficacy of bio-pesticides and newer molecules against *Spodoptera litura* in soybean (I Spray)

Tr. No.	Treatment	Dosage	No. of larvae/mrl			
			1 DBS	3 DAS	7 DAS	10 DAS
T_1	*Nomuraea rileyi* 2×10^8 CFU/g	2 g/l	3.43 (1.97)^a	2.74 (1.80)^{ab}	2.26 (1.66)^{ab}	2.39 (1.70)^b
T_2	Nimbecidine 3000 ppm	3 ml/l	3.42 (1.98)^a	2.67 (1.78)^{ab}	2.03 (1.59)^{ab}	2.31 (1.68)^b
T_3	Flubendiamide 480 SC	0.2 ml/l	3.44 (1.98)^a	0.84 (1.16)^c	0.55 (1.02)^c	0.40 (0.95)^c
T_4	Buprofezin 25 SC	1 ml/l	3.46 (1.99)^a	1.94 (1.56)^{ac}	1.46 (1.40)^{bc}	1.50 (1.42)^b
T_5	Tetraniliprole 200 SC	1 ml/l	3.43 (1.98)^a	2.57 (1.75)^{ab}	2.34 (1.69)^{ab}	2.14 (1.60)^b
T_6	Spinetoram 12 SC	0.2 ml/l	3.44 (1.98)^a	1.06 (1.24)^c	0.74 (1.10)^c	0.41 (0.96)^c
T_7	Chlorantraniliprole 18.5 SC	0.2 ml/l	3.45 (1.99)^a	1.65 (1.46)^{bc}	0.66 (1.07)^c	1.34 (1.36)^b
T_8	Spinosad 45 SC (Standard check)	0.2 ml/l	3.44 (1.98)^a	1.38 (1.35)^{bc}	1.37 (1.37)^{bc}	1.44 (1.39)^b
T_9	Untreated check	_	3.43 (1.98)^a	3.47 (1.99)^a	3.61 (2.03)^a	4.25 (2.18)^a
S. Em±			0.07	0.06	0.06	0.07
C.V. (%)			6.12	6.93	7.45	9.13

DBS- Days before spraying, DAS- Days after spraying, mrl- meter row length

Figures in parentheses are $\sqrt{X+0.5}$ transformed values

Means in the columns followed by the same alphabet do not differ significantly by DMRT (P = 0.05)

The observations made at seven days after spraying revealed that spinetoram 12 SC registered significantly lower larval count (0.21 larvae/mrl) which failed to differ significantly from flubendiamide 480 SC (0.24 larvae/mrl), spinosad 45 SC (0.24 larvae/mrl), chlorantraniliprole 18.5 SC (0.92 larvae/mrl), buprofezin 25 SC (0.98 larvae/mrl), tetraniliprole (1.03 larvae/mrl) and *N. rileyi* 2×10^8 CFU/g (1.08 larvae/mrl). In contrast, significantly higher larval incidence (5.00 larvae/mrl) was recorded in untreated check which was on par with nimbecidine 3000 ppm (1.67 larvae/mrl).

Similar trend was observed at 10 DAS with significantly lower larval incidence recorded in spinetoram 12 SC (0.33 larvae/mrl) followed by flubendiamide 480 SC (0.45 larvae/mrl), spinosad 45SC (0.86 larvae/mrl), buprofezin 25 SC (1.11 larvae/mrl) chlorantraniliprole 18.5 SC (1.20 larvae/mrl), tetraniliprole (1.23 larvae/mrl) and *N. rileyi* 2×10^8 CFU/g (1.48 larvae/mrl) which were on par with each other. Whereas, the untreated check with a significantly higher larval incidence (5.33 larvae/mrl) was found inferior to all other treatments (Table 2). Nayaka [7] got similar results with flubendiamide 480 SC in managing *S. litura* in soybean. Indoxacarb 14.5 SC and spinosad 45 SC were found to be the next treatments.

3.3 Reduction of *Spodoptera litura* population after insecticidal application : Flubendiamide 480 SC recorded highest larval reduction over untreated check (89.15%), followed by spinetoram 12 SC (88.50%), spinosad 45 SC (77.50%), chlorantraniliprole 18.5 SC (71.77%) and buprofezin 25 SC (66.65%). The least per cent reduction was noticed in nimbecidine 3000 ppm (49.92%) (Table 3). Flubendiamide 480 SC recorded maximum reduction of *S. litura* in (84.03%) followed by indoxacarb 15.8 EC (79.95%) [8] which are comparable with the present findings.

Table 2: Efficacy of bio-pesticides and newer molecules against *S. litura* in soybean (II Spray)

Tr. No.	Treatment	Dosage	No. of larvae/mrl			
			1DBS	3DAS	7DAS	10DAS
T_1	*N. rileyi* 2×10^8 CFU/g	2 g/l	2.52 (1.74)^{ab}	1.66 (1.47)^{bc}	1.08 (1.26)^{bc}	1.48 (1.41)^{bc}
T_2	Nimbecidine 3000 ppm	3 ml/l	2.81 (1.82)^{ab}	2.17 (1.63)^{b}	1.67 (1.47)^{ab}	2.17 (1.63)^{b}
T_3	Flubendiamide 480 SC	0.2 ml/l	1.27 (1.33)^{b}	0.34 (0.92)^{d}	0.24 (0.86)^{c}	0.45 (0.98)^{c}
T_4	Buprofezin 25 SC	1 ml/l	2.10 (1.61)^{b}	1.68 (1.48)^{bc}	0.98 (1.22)^{bc}	1.11 (1.27)^{bc}
T_5	Tetraniliprole 200 SC	1 ml/l	2.00 (1.58)^{b}	1.79 (1.51)^{bc}	1.03 (1.24)^{bc}	1.23 (1.32)^{bc}
T_6	Spinetoram 12 SC	0.2 ml/l	1.30 (1.34)^{b}	0.24 (0.86)^{d}	0.21 (0.84)^{c}	0.33 (0.91)^{c}
T_7	Chlorantraniliprole 18.5 SC	0.2 ml/l	1.92 (1.56)^{b}	1.57 (1.44)^{bc}	0.92 (1.19)^{bc}	1.20 (1.30)^{bc}
T_8	Spinosad 45 SC (Standard check)	0.2 ml/l	1.76 (1.50)^{b}	0.56 (1.03)^{cd}	0.24 (0.86)^{c}	0.86 (1.17)^{bc}
T_9	Untreated check	-	4.10 (2.12)^{a}	4.34 (2.18)^{a}	5.00 (2.34)^{a}	5.33 (2.39)^{a}
S. Em. ±			0.07	0.07	0.06	0.08
C.V. (%)			7.76	9.12	8.61	9.78

DBS- Days before spraying, DAS- Days after spraying, mrl- meter row length
Figures in parentheses are √ X+0.5 transformed values
Means in the columns followed by the same alphabet do not differ significantly by DMRT (P = 0.05)

Table 3: Reduction of *Spodoptera litura* population after insecticidal application

Tr. No.	Treatment	Dosage	Mean of post treatment counts (No. of larvae/mrl)			Population reduction over control (%)
			Spray I	Spray II	Average	
T_1	*N. rileyi* 2×10^8 CFU/g	2 g/l	2.46	1.41	1.94	55.35
T_2	Nimbecidine 3000 ppm	3 ml/l	2.34	2.00	2.17	49.92
T_3	Flubendiamide 480 SC	0.2 ml/l	0.60	0.34	0.47	89.15
T_4	Buprofezin 25 SC	1 ml/l	1.63	1.26	1.45	66.65
T_5	Tetraniliprole 200 SC	1 ml/l	2.35	1.35	1.85	57.30
T_6	Spinetoram 12 SC	0.2 ml/l	0.74	0.26	0.50	88.50
T_7	Chlorantraniliprole 18.5 SC	0.2 ml/l	1.22	1.23	1.22	71.77
T_8	Spinosad 45 SC (Standard check)	0.2 ml/l	1.40	0.55	0.98	77.50
T_9	Untreated check	-	3.78	4.89	4.33	-

DBS- Days before spraying, DAS- Days after spraying, mrl- meter row length
Figures in parentheses are √ X+0.5 transformed values
Means in the columns followed by the same alphabet do not differ significantly by DMRT (P = 0.05)

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