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Efficacy of biopesticides and chemical insecticides against tobacco leaf eating caterpillar *Spodoptera litura* (Fab.) of soybean

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Abstract
Field experiment on Efficacy of biopesticides and chemical insecticides against tobacco leaf eating caterpillar *Spodoptera litura* (Fab.) of soybean was conducted during *kharif* season of 2019 on soybean crop at College of Agriculture, Dhule. The present investigation was carried out with an object to study bioefficacy of biopesticides and chemical insecticides against tobacco leaf eating caterpillar *Spodoptera litura* (Fab.) of soybean. Mean larval population of tobacco leaf eating caterpillar after three, seven and fourteen days after sprays revealed that all the treatments were significantly superior over untreated control. The average number of leaf eating caterpillar larvae/mrl ranged from 4.34 to 7.89, 2.06 to 6.34 and 2.17 to 5.61 among the chemical insecticidal and bio pesticidal treatments as against 9.78, 9.78 and 10.67 in untreated control at 3, 7 and 14 days after spray, respectively. At three days after spray, flubendamide 39.35 SC @ 100 ml/ha was found significantly most effective against tobacco leaf eating caterpillar population (4.34/mrl) and was at par with chlorantraniliprole 18.5 SC @ 150 ml/ha (4.61/mrl) and spinosad 45 SC @ 250 ml/ha (4.72/mrl) and emamectin benzoate 5 SG @ 200 g/ha (5.23/mrl) and *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha (5.61/mrl). At seven days after spray, spinosad 45 SC @ 250 ml/ha was found most effective treatment against tobacco caterpillar and recorded minimum number of average tobacco caterpillar population (2.06/mrl) and was at par with chlorantraniliprole 18.5 SC @ 150 ml/ha (2.11/mrl) and flubendamide 39.35 SC @ 100 ml/ha (2.39/mrl), and *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha (3.50/mrl). At fourteen days after spray, chlorantraniliprole 18.5% SC @150 ml/ha and Spinosad 45 SC @ 250 ml/ha were found most effective treatment against tobacco caterpillar and minimize tobacco caterpillar population (2.17/mrl) and was at par with flubendiamide 39.35% SC @100ml/ha (3.11/mrl) and emamectin benzoate 5 SG @ 200 g/ha (3.11/mrl). Among the treatments of biopesticides, the treatment with *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @ 500 ml/ha effectively controlled the population of tobacco leaf eating caterpillar recorded significantly minimum of 5.61, 3.50 and 4.28 number of larvae/mrl at 3, 7 and 14 days after spray. The insecticidal and bio pesticidal treatments gave significantly higher soybean grain yield over untreated control. Significantly maximum grain yield of 26.73 q/ha was recorded in plot treated with insecticidal spray of chlorantraniliprole 18.5 SC @ 150 ml /ha over untreated control (11.67 q/ha). However, it was at par with flubendamide 39.35 SC @ 100 ml/ha (26.01 q/ha), spinosad 45 SC @ 250 ml/ha (25.89 q/ha) and emamectin benzoate 5 SG @ 200 g/ha (22.27 q/ha) followed by quinalphos 25 EC 1000 ml/ha (21.27 q/ha), *Bt – Bacillus thuringiensis var. kurstaki 0.5%*WP @ 500 g/ha (18.00 q/ha), *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha (17.51 q/ha) and NSE (Neem seed extract) 5% (16.05 q/ha).

Keywords: Soybean insect pests, *Spodoptera litura*, insecticides, biopesticides

Introduction
Soybean [*Glycine max* (L.) Merrill] belongs to the family Leguminoceae, sub family Papilionaceae. Soybean is the major oilseed crop around the world. Almost every parts of soybean plants are used for various purposes especially in livestock and poultry feeds [16]. The low productivity of soybean both at national and state level is attributed to abiotic and 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 the produce in many ways [18]. Soybean has luxuriant crop growth, soft and succulent foliage, unlimited source of food, space and shelter there by it invites many insect-pests. Immature stages (larva or caterpillar) of tobacco caterpillar damages the crop at vegetative stage and in severe case, it completely defoliate the crop and dramatic yield loss. Leaf eating caterpillar, *Spodoptera litura* larvae even damages to soybean pods also [2, 10, 14]. The tobacco caterpillar, *S. litura* is a serious pest and its incidence is being observed in all the soybean growing areas of Maharashtra during *Kharif* season. After feeding the leaves, it also feed on tender pods, consequently damaging 30 to 50 per cent of pods.

The indiscriminate use of insecticides has led to problems like health hazards, insecticide resistance, pest resurgence and environmental pollution besides upsetting the natural ecosystem [7]. The researchers later recognized the harmful effects of pesticides and tried to bring eco-friendly approaches to reduce pesticide load in environment by using botanicals and bio-pesticides [6]. However, botanicals and bio-pesticides are quickly degradable, less hazardous to human health and not so harmful for the environment [17]. Moreover, reports are available on integrated pest management practices of soybean insect pests using plant extracts in India [8]. Taking in consideration the seriousness of the pest infestation and damage to soybean crop, the present study was undertaken to manage the pest with the help of biopesticides and chemical insecticides and to know the suitable control measure for the management of foliage feeders on soybean.

Materials and Methods

The field experiment was conducted during *kharif* season of 2019, at the experimental farm of Entomology Section, College of Agriculture, Dhule-424004, (Maharashtra). In the experiment, the variety Phule Sangam was grown for this study. Later the seeds were sown in main field with a spacing of 45 × 10-15 cm^2 and all the agronomical practices *viz*. fertilizer application and intercultural operations were followed as recommended for soybean crop in this area to raise the crop. The treatments were *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @ 500 ml/ha, *Bt – Bacillus thuringiensis var. kurstaki* 0.5%WP @ 500 g/ha, NSE (Neem seed extract) 5%, chlorantraniliprole 18.5 SC @ 150 ml /ha, quinalphos 25 EC @1000 ml/ha, spinosad 45 SC @ 250 ml/ha, emamectin benzoate 5 SG @ 200 g/ha, flubendiamide 39.35 SC @100ml/ha and untreated control. The insecticides were applied as high volume sprays @ 500 litters of spray fluid/ha. Sprayings was given by using a hand compression knapsack high volume sprayer during morning hours. The plot in each treatment was sprayed with respective insecticides ensuring uniform coverage of insecticide. The treatments imposed when the pest reached ETL. The population of tobacco leaf eating caterpillar was recorded. The average larval population per meter row length was recorded early in the morning from randomly selected three locations of one meter row length of each plot before application of spray as a pre count and 3, 7 and 14 days after spray as a post count. Second spray was given after 15 days of first spray and observations on larval population before spray application at 15 days will be recorded as a pre count and post count will be recorded at 3, 7 and 14 days after second spray. Finally the grain yield was recorded on plot basis and expressed in quintal/ha. The data obtained for field experiments were subjected to statistical analysis.

Results and Discussion

The data pertaining to effect of different biopesticides and chemical insecticides on the average population of tobacco caterpillar infesting soybean after average of two sprays are presented in Table 1 and depicted in Figure 1. The data revealed that all the treatments were significantly superior to the untreated control in checking the tobacco leaf eating caterpillar population at 3, 7 and 14 days after spray. The result in respect of the trend of the efficacy of various biopesticides and chemical insecticides against tobacco leaf eating caterpillar are more or less the same at 3, 7 and 14 days after spray. The data recorded on third day after treatment application revealed that all the treatments were significantly superior over untreated control. The average number of larvae/mrl ranged from 4.34 to 7.89 in the insecticidal and bio pesticidal treatments as against 9.78 in untreated control. The treatment with flubendamide 39.35 SC @ 100 ml/ha was found significantly most effective against tobacco leaf eating caterpillar population (4.34/mrl) and was at par with chlorantraniliprole 18.5 SC @ 150 ml/ha (4.61/mrl) and spinosad 45 SC @ 250 ml/ha (4.72/mrl) and emamectin benzoate 5 SG @ 200 g/ha (5.23/mrl) and *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha (5.61/mrl) and followed by quinalphos 25 EC @1000 ml/ha(6.34/mrl), *Bt – Bacillus thuringiensis var. kurstaki 0.5%* WP @ 500 g/ha (6.67 number of larvae/mrl) and followed by NSE (Neem seed extract) 5% (7.89/mrl). Among the treatments of biopesticides, the treatment with *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha effectively controlled the population of tobacco leaf eating caterpillar recorded significantly minimum of 5.61 number of larvae/mrl. It was at par with *Bt – Bacillus thuringiensis var. kurstaki 0.5%*WP @ 500 g/ha (6.67 number of larvae/mrl) and followed by NSE (Neem seed extract) 5% (7.89/mrl). On seventh day after spray all the treatments significantly reduced the tobacco leaf eating caterpillar population as compared to untreated control. The average number of larvae/mrl ranged from 2.06 to 6.34 in the insecticidal and bio pesticidal treatments as against 9.78 in untreated control. Spinosad 45 SC @ 250 ml/ha was found most effective treatment against tobacco leaf eating caterpillar and recorded minimum number of average tobacco leaf eating caterpillar population (2.06/mrl) and it was at par with chlorantraniliprole 18.5 SC @ 150 ml/ha (2.11/mrl) and flubendamide 39.35 SC @ 100 ml/ha (2.39/mrl), and *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha (3.50/mrl) and followed by emamectin benzoate 5 SG @ 200 g/ha (3.84/mrl), *Bt – Bacillus thuringiensis var. kurstaki 0.5%*WP @ 500 g/ha (4.73 number of larvae/mrl), quinalphos 25 EC @1000 ml/ha (4.95/mrl) and NSE (Neem seed extract) 5% (6.34/mrl). Among the treatments of biopesticides, the treatment with *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha effectively controlled the population of tobacco leaf eating caterpillar recorded significantly minimum of 3.50 number of larvae/mrl. It was at par with *Bt – Bacillus thuringiensis var. kurstaki 0.5%*WP @ 500 g/ha (4.73 number of larvae/mrl) and followed by NSE (Neem seed extract) 5% (6.34/mrl). At fourteenth day after spray all treatments significantly reduced population of the tobacco leaf eating caterpillar as compared to untreated control. The average number of larvae/mrl were ranged from 2.17 to 5.61 in the insecticidal and bio pesticidal treatments as against 10.67 in untreated control. Chlorantraniliprole 18.5 SC @150 ml/ha and Spinosad 45 SC @ 250 ml/ha were found most effective treatment against tobacco leaf eating caterpillar and minimize tobacco leaf eating caterpillar population (2.17/mrl) and was at par with flubendiamide 39.35 SC@100ml/ha (3.11/mrl) and emamectin benzoate 5 SG @ 200 g/ha (3.11/mrl). Among the treatments of biopesticides, the treatment with *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha effectively controlled the population of tobacco leaf eating caterpillar recorded significantly minimum of 4.28 number of larvae/mrl. It was at par with *Bt – Bacillus thuringiensis var. kurstaki 0.5%*WP @ 500 g/ha (4.61 number of larvae/mrl) and NSE (Neem seed extract) 5% (5.61/mrl).

In the present findings insecticides Chlorantraniliprole 18.5 SC @150 ml/ha, Spinosad 45 SC @ 250 ml/ha, flubendiamide 39.35% SC @ 100ml/ha and emamectin benzoate 5 SG @ 200 g/ha were found most effective in minimizing the tobacco leaf eating caterpillar population and showed their superiority over the bio pesticides. The present finding that chlorantraniliprole 18.5 SC, flubendamide 39.35 SC were most effective in minimizing the *Spodoptera litura* larval population [13]. Similar results are also reported [9, 11, 15, 19]. In results of present findings among the treatments of biopesticides *viz*., *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha, *Bt – Bacillus thuringiensis var. kurstaki 0.5%*WP @ 500 g/ha and NSE (Neem seed extract) 5% were found effective for controlling the tobacco leaf eating caterpillar population. The results of present findings are corroborated with findings of earlier researchers [1, 3, 12].

The grain yield obtained from different treatments are presented in Table 2 and depicted in Fig 2. The insecticidal and bio pesticidal treatments gave significantly higher soybean grain yield over untreated control. The average soybean grain yield 16.05 q/ha to 26.73 q/ha in the treatments as against untreated control reading 11.67 q/ha. Significantly maximum grain yield of 26.73 q/ha was recorded in plot treated with insecticidal spray of chlorantraniliprole 18.5 SC @ 150 ml /ha over untreated control (11.67 q/ha). However, it was at par with flubendamide 39.35 SC @ 100 ml/ha (26.01 q/ha), spinosad 45 SC @ 250 ml/ha (25.89 q/ha) and emamectin benzoate 5 SG @ 200 g/ha (22.27 q/ha) followed by quinalphos 25 EC 1000 ml/ha (21.27 q/ha), *Bt – Bacillus thuringiensis var. kurstaki 0.5%*WP @ 500 g/ha (18.00 q/ha), *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha (17.51 q/ha) and NSE (Neem seed extract) 5% (16.05 q/ha). Among the treatments of biopesticides of the treatment with *Bt – Bacillus thuringiensis var. kurstaki 0.5%*WP @ 500 g/ha recorded significantly highest (18.00 q/ha) grain yield of soybean and it was at par with *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha (17.51 q/ha) and NSE (Neem seed extract) 5% (16.05 q/ha). The results regarding per cent increase in yield are presented in Table 2 and depicted in Fig. 2. The highest (129.04) per cent increase in yield over untreated control was recorded in treatment chlorantraniliprole 18.5 SC @ 150 ml /ha. The trend of per cent increase in yield in descending order was observed in treatments as flubendamide 39.35 SC @ 100 ml/ha (122.88), spinosad 45 SC @ 250 ml/ha (121.85) and emamectin benzoate 5 SG @ 200 g/ha (90.83), quinalphos 25 EC 1000 ml/ha (81.83), *Bt – Bacillus thuringiensis var. kurstaki* 0.5% WP @ 500 g/ha (54.24), *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @5 00 ml/ha (50.04) and NSE (Neem seed extract) 5% (37.53). Among biopesticides treatment with *Bt – Bacillus thuringiensis var. kurstaki 0.5%*WP @ 500 g/ha registered highest of 54.24 per cent increase in yield over untreated control and it was followed by *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha (50.04) and NSE (Neem seed extract) 5% (37.53).

In the present findings insecticides Chlorantraniliprole 18.5 SC @150 ml/ha, Spinosad 45 SC @ 250 ml/ha, flubendiamide 39.35% SC @ 100ml/ha and emamectin benzoate 5 SG @ 200 g/ha were found most effective in minimizing the tobacco leaf eating caterpillar and green semilooper population and recorded the better yield over untreated control. These findings that highest grain yield in treatment with emamectin benzoate 5 SG (2276.69 kg/ha) and spinosad 45 SC (2274.67 kg/ha) [4]. The highest grain yield of soybean recorded with treatment of flubendiamide 39.35% SC [5].

Table 1: Effect of different bio pesticide and chemical insecticides on survival population of tobacco leaf eating caterpillar (*S. litura*) of soybean

SN	Treatment details	Dose formulated product g-ml/ha	Survival population of leaf eating caterpillar per meter row length at				Mean
			Pre count	3 DAS	7 DAS	14 DAS	
T_1	*Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml	500 ml	7.39 (2.90)	5.61 (2.57)	3.50 (2.12)	4.28 (2.30)	4.46(2.34)
T_2	*Bt – Bacillus thuringiensis var. kurstaki 0.5%*WP	500 g	7.82 (2.97)	6.67 (2.77)	4.73 (2.39)	4.61 (2.37)	5.34(2.52)
T_3	NSE (Neem Seed Extract) 5%	5 kg in 100 litter of water	8.61 (3.10)	7.89 (2.98)	6.34 (2.71)	5.61 (2.57)	6.61(2.76)
T_4	Clorantraniliprole 18.5 SC	150 ml	6.50 (2.74)	4.61 (2.37)	2.11 (1.76)	2.17 (1.78)	2.96(1.99)
T_5	Quinalphos 25 EC	1000 ml	7.72 (2.95)	6.34 (2.71)	4.95 (2.44)	4.84 (2.42)	5.38(2.53)
T_6	Spinosad 45 SC	250 ml	6.22 (2.69)	4.72 (2.39)	2.06 (1.75)	2.17 (1.78)	2.98(1.99)
T_7	Emamectin benzoate 5 SG	200 g	6.89 (2.81)	5.23 (2.50)	3.84 (2.20)	3.11 (2.03)	4.06(2.25)
T_8	Flubendiamide 39.35 SC	100 ml	7.66 (2.94)	4.34 (2.31)	2.39 (1.84)	3.11 (2.03)	3.28(2.07)
T_9	Untreated/ control	--	10.50 (3.39)	9.78 (3.28)	9.78 (3.28)	10.67 (3.42)	10.08(3.33)
	SE +		0.17	0.13	0.14	0.13	--
	CD at 5%		NS	0.39	0.42	0.39	--
	CV		8.66	8.24	10.48	10.88	--

- DAS- Days after spray
- Figures in parentheses indicate V_{n+1} transformed value,
- Date(s) of Insecticidal application: i) 02/09/2019 ii) 17/09/2019
- Date of Harvest: 31/10/2019

Table 2: Effect of different bio pesticide and chemical insecticides on grain yield

SN	Treatment details	Dose formulated product g-ml/ha	Grain yield		% increased in yield over control
			Kg/plot	q/ha	
T_1	*Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml	500 ml	1.58	17.51	50.04
T_2	*Bt – Bacillus thuringiensis var. kurstaki 0.5%*WP	500 g	1.62	18.00	54.24
T_3	NSE (Neem Seed Extract) 5%	5 kg in 100 litter of water	1.44	16.05	37.53
T_4	Clorantraniliprole 18.5 SC	150 ml	2.41	26.73	129.04
T_5	Quinalphos 25 EC	1000 ml	2.00	21.22	81.83
T_6	Spinosad 45 SC	250 ml	2.31	25.89	121.85
T_7	Emamectin benzoate 5 SG	200 g	2.00	22.27	90.83
T_8	Flubendiamide 39.35 SC	100 ml	2.36	26.01	122.88

T_9	Untreated/ control	--	1.05	11.67	--
	SE +		0.16	1.79	--
	CD at 5%		0.49	5.40	--
	CV		14.96	14.93	--

- DAS- Days after spray
- Figures in parentheses indicate V_{n+1} transformed value,
- Date(s) of Insecticidal application: i) 02/09/2019 ii) 17/09/2019
- Date of Harvest: 31/10/2019

Conclusion
The treatments with chlorantraniliprole 18.5 SC @ 150 ml /ha, flubendamide 39.35 SC @ 100 ml/ha, spinosad 45 SC @ 250 ml/ha and emamectin benzoate 5 SG @ 200 g/ha were found significantly superior for the control of tobacco leaf eating caterpillar and green semilooper with recording the highest grain yield of 26.73 q/ha, 26.01 q/ha, 22.77 q/ha and 25.89 q/ha, respectively. Among the biopesticides the treatment with *Spodoptera litura* Nuclear Polyhydral Virus (S*l*NPV) 1 x 10^9 POB/ml @500 ml/ha was found most effective for the control of tobacco leaf eating caterpillar.

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