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Evaluation of newer insecticide molecules and poison baits against *Spodoptera litura* in soybean ecosystem

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Abstract
The field experiment was conducted at Agricultural Research Station, Bailhongal, Karnataka, during 2010-11 and 2011-12 to study on the evaluation of novel insecticides for the management of *Spodoptera litura* (Fab.) infesting soybean. Results of the field experiments revealed that among the treatments flubendiamide 480 SC recorded the least larval population (0.42 larvae per meter row length) and it was significantly superior over other treatments. Indoxacarb 14.5 SC and spinosad 45 SC were found to be the next best treatments, which recorded 0.64 and 0.68 larvae per meter row length, respectively and were on par with each other, followed by rynaxypyr 20 SC, emamectin benzoate 5 SG which recorded 0.94 and 0.93 larvae per meter row length, respectively. Flubendiamide 480 SC provided consistent protection from defoliation to a soybean crop from *S. litura*.

Keywords: *Spodoptera litura*, insecticides, poison baits, newer molecules, soybean

1. Introduction

Soybean (*Glycine max* [L.] Merrill) is a unique crop with high nutritional value, providing 40 per cent protein and 20 per cent edible oil besides minerals and vitamins. It ranks first among the oilseeds in the world as well as in India. In India it is grown in 10.27 m ha with production of 11.0 m t and an average yield of 1,071 kg per ha [4]. Soybean accounts more than 0.22 m ha area with production of 0.23 MT in Karnataka. The leaf eating caterpillars *Spodoptera litura* (Fab), *Thysanoplusia orichalcea* (Fab) and *Spilarctia obliqua* (Walk.) are major defoliators damaging the foliage, flower and tender pods causing significant yield loss (Singh and Singh, 1990). In case of a heavy attack, the caterpillars are also found to feed on flowers and pods (Anonymous, 2007). *Thysanoplusia orichalcea* damages the crop from August to September during *kharif* and March to May during *Rabi* season. The infestation can result into 30 per cent undeveloped pods and about 50 per cent yield loss [6]. The tobacco caterpillar, *S. litura* is a serious pest and its incidence was observed in all the soybean growing areas of northern Karnataka, which feeds on leaves and tender pods, consequently damaging 30 to 50 per cent of the pods [3]. The Bihar hairy caterpillar, *S. obliqua* is a voracious feeder, which feeds gregariously on soybean leaves and causing 40 per cent defoliation of leaf area. To overcome these losses caused by insect pests various control measures have been recommended, of which chemical control measures are reported to be more effective. The investigations on synthetic organic insecticides developed during 20th century initially provided spectacular results in suppressing the insect pests which led to the abandonment of traditional pest control practices [5]. However, indiscriminate use of insecticides has led to problems like insecticide resistance, pest resurgence and environmental pollution besides upsetting the natural ecosystem [7].

Though seasonal abundance studies on seedling borers and defoliators have been carried out extensively, practical application of these findings on the field incidence and quantitative estimation of loss on the basis of concrete field experiments is lacking. The unilateral approach of managing the crop pests by synthetic insecticides has dictated the necessity for developing need based, cost effective, eco-friendly and safe management strategies. At the same time basic information on the seasonal incidence of leaf eating caterpillars on soybean is considered most essential to manage the pest.

2. Materials and Methods

Field experiments were conducted to estimate the crop loss due to stem fly under two different dates of sowing, *i.e.*, first week of June and July 15th during *kharif* seasons of 2010-11 and 2011-12 at the Agricultural Research Station, Bailhongal, Karnataka, India using the soybean cultivar JS -335 in factorial randomized block design with 16 treatments (Table 1) including untreated check (UTC) replicated thrice. The crop was sown with a spacing of 30 cm between rows and 10 cm between plants in a plot size of 5 x 3.6 m. The seeds of treatment one to four were treated with thiamethoxam or imidacloprid @ 3 g/kg seeds, respectively in a plastic bowl uniformly and shade dried. The treatment 15 *viz.*, phorate 10 G was applied to soil at the time of sowing. The foliar applications were taken up with thiamethoxam 25 WG @ 0.5 g/l or imidacloprid 17.8 SL @ 0.25 ml/l as treatments in treatments T_1 to $T_{14.}$ A blanket spray of Lambda cyhalothrin @ 0.5 ml/l was taken to manage other pests of soybean, at 30 days after sowing (DAS) in all the treatments.

Observations on the seedling mortality were recorded at 15, 21, 30 and 35 DAS and per cent mortality was worked out. Ten plants in each treatment were selected randomly for observations on per cent stem fly incidence and per cent stem tunnelling at 30, 45, 60 DAS and at harvesting period, number of pods per 10 plants at harvest, plant height at maturity stage (50 DAS). At harvest the pods from the plants were harvested from individual plots were recorded and the yield was recorded in the plot area of 18 m^2 and yield data was computed to quintals per hectare (q/ha) and B:C ratio was worked out. The 1000 seed weight was also recorded. The stem tunneling was transformed to arcsine values for reliable analysis and the yield data were analyzed using ANOVA technique and subjected to DMRT (Duncan's Multiple Range Test).

3. Results and Discussion

The pooled results of first and second spray revealed that of larval population of *S. litura* on one day before imposing the treatment ranged from 0.95 to 3.37 larvae per mrl
(Table 1) which were on par with each other. At one day after spray T_6 (flubendiamide 480 SC) recorded the least larval population (0.42 larvae/mrl) was significantly superior over other treatments, T_2 (indoxacarb 14.5 SC) and T_4 (spinosad 45 SC) which were found to be the next best treatments (0.64 and 0.68 larvae/mrl, respectively) and were on par with each other, followed by T_3 (rynaxypyr 20 SC), T_5 (emamectin benzoate 5 SG) which recorded 0.94 and 0.93 larvae per mrl, respectively. However, all the insecticide treatments were significantly superior over untreated check, whereas methomyl poison bait recorded highest larval population of 1.69 larvae per mrl. At two and three days after spraying similar trend was noticed. At seven days after spraying T_6 (flubendiamide 480 SC) (0.13 larvae/mrl) was found to be superior over other treatments. The treatments T_2 (indoxacarb 14.5 SC) and T_4 (spinosad 45 SC) recorded significantly lowest larval population 0.29 and 0.30 larvae per mrl, respectively and were on par with each other. Untreated check recorded significantly higher population *S. litura* (3.52 larvae/mrl). All the poison baits were found to be inferior to foliar sprays in managing the leaf eating caterpillars. The result identified effectiveness of flubendiamide 480 SC @ 0.2 ml/l with two sprays against leaf eating caterpillar. This could be recommended for the management of this pest in soybean. The reviews pertaining to efficacy of flubendiamide 480 SC 0.2 ml/l in soybean are lacking as it is new molecule. However, its superiority in managing the pests in various other crops has been well documented. The newer molecule flubendiamide 20 WG @ 50 g a.i./ha was found superior in reducing the incidence of fruit borers in chilli with highest yield [10]. Flubendiamide 20 WG @ 35 g a.i./ha was the most effective in reducing the incidence of rice stem borer, *Scirpophaga incertulas* (Walker) and leaf folder *Cnaphalocrosis medinalis* (Guen.) and recorded the higher yield [9]. Similarly, flubendiamide 20 WG was found highly effective against, *H. armigera* on cotton [8].

Flubendiamide application showed better performance in reducing 80.63 per cent fruit infestation by *Leucinodes orbonalis* (Guenee) and produced the higher fruit yield in brinjal [1]. Flubendiamide 480 SC @ 50 ml/ha caused significantly higher reduction of diamond back moth damage in cabbage [2, 11] reported the strong activity of flubendiamide 480 SC against lepidopteran insect pests and its severity towards non-target organisms.

Over the two years maximum seed yield was recorded in treatments flubendiamide 480 SC (24.30 q/ha) with 37.11 per cent avoidable loss (Table 2) as compared to other treatments, followed by indoxacarb 14.5 SC (23.18 q/ha) with 34.08 per cent avoidable loss. Spinosad 45 SC and emamectin benzoate 5 SG were next best in recording the higher yield of 22.30 and 22.22 q per ha, respectively. The economic analysis on the feasibility during 2010 and 2011, revealed that the higher analysis on the incremental returns of Rs. 40152 was obtained by indoxacarb 14.5 SC. The highest B: C ratio of 3.59 was observed in indoxacarb 14.5 SC (Table 3).

Table 1: Efficacy of insecticides in the management of *Spodoptera litura* during *kharif* 2010 and 2011 after II Spray

Treatments	Dosage	Larvae/mrl														
		1DBS			1 DAS			2 DAS			3 DAS			7 DAS		
		2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
T-$_1$Thiodicarb 75 WP	0.75 g/l	1.48 (1.41)	1.26 (1.32)	1.37 (1.37)	0.96 (1.21)de	0.82 (1.15)d-f	0.89 (1.18)	0.85 (1.16)e	0.57 (1.04)fg	0.71 (1.1)	0.70 (1.09)g	0.39 (0.94)cd	0.56 (1.03)	0.67 (1.08)g	0.43 (0.96)e	0.53 (1.02)
T-$_2$Indoxacarb 14.5 SC	0.5 ml/l	1.29 (1.34)	1.00 (1.22)	1.15 (1.28)	0.70 (1.10)ef	0.58 (1.04)f	0.64 (1.07)	0.59 (1.05)f	0.34 (0.92)gh	0.47 (0.98)	0.44 (0.97)h	0.19 (0.83)de	0.33 (0.91)	0.40 h (0.95)	0.22 (0.85)f	0.29 (0.89)
T-$_3$Rynaxypyr 20 SC	0.2 ml/l	1.44 (1.39)	1.22 (1.31)	1.33 (1.35)	0.96 (1.21)de	0.91 (1.19)cd	0.94 (1.2)	0.89 (1.18)de	0.64 (1.07)d-f	0.76 (1.12)	0.74 (1.10)fg	0.51 (1.01)bc	0.65 (1.07)	0.70 (1.10)fg	0.55 (1.02)de	0.61 (1.05)
T-$_4$Spinosad 45 SC	0.2 ml/l	1.26 (1.32)	1.00 (1.22)	1.13 (1.28)	0.74 (1.11)ef	0.61 (1.05)ef	0.68 (1.09)	0.59 (1.05)f	0.34 (0.92)gh	0.47 (0.98)	0.44 (0.97)h	0.19 (0.83)de	0.33 (0.91)	0.40 (0.95)h	0.22 (0.85)f	0.30 (0.89)
T-$_5$Emamectin benzoate 5 SG	0.2 g/l	1.53 (1.42)	1.28 (1.33)	1.4 (1.37)	1.00 (1.22)de	0.86 (1.17)c-e	0.93 (1.2)	0.89 (1.18)de	0.61 (1.06)ef	0.75 (1.12)	0.70 (1.10)g	0.39 (0.94)cd	0.56 (1.03)	0.67 (1.08)g	0.42 (0.96)e	0.53 (1.01)
T-$_6$Flubendiamide 480 SC	0.2 g/l	1.11 (1.27)	0.79 (1.13)	0.95 (1.2)	0.52 (1.01)f	0.32 (0.90)g	0.42 (0.96)	0.33 (0.91)g	0.21 (0.84)h	0.27 (0.88)	0.26 (0.87)i	0.04 (0.73)e	0.17 (0.82)	0.22 (0.85)i	0.07 (0.75)g	0.13 (0.79)
T-$_7$Chlorpyriphos 20 EC	2 ml/l	1.67 (1.47)	1.39 (1.37)	1.53 (1.42)	1.15 (1.28)d	1.01 (1.23)cd	1.08 (1.26)	1.04 (1.24)c-e	0.77 (1.13)c-f	0.91 (1.19)	0.85 (1.16)ef	0.55 (1.02)bc	0.73 (1.11)	0.81 (1.15)d-g	0.61 (1.05)de	0.68 (1.09)
T-$_8$Fipronil 5 SL	1 ml/l	1.82 (1.52)	1.52 (1.42)	1.67 (1.47)	1.22 (1.31)d	1.08 (1.26)cd	1.15 (1.29)	1.11 (1.27)c-e	0.93 (1.19)b-e	1.02 (1.23)	1.01 (1.23)d	0.79 (1.13)b	0.93 (1.2)	1.00 (1.23)c-e	0.85 (1.16)c	0.90 (1.18)
T-$_9$Imidacloprid 17.8 SL	0.25 ml/l	1.78 (1.51)	1.56 (1.43)	1.67 (1.47)	1.29 (1.34)cd	1.15 (1.29)c	1.22 (1.31)	1.18 (1.29)cd	1.01 (1.23)bc	1.10 (1.26)	1.18 (1.29)c	0.85 (1.16)b	1.05 (1.25)	1.11 (1.27)bc	0.93 (1.19)bc	0.98 (1.22)
T-$_{10}$Cartap hydrochloride 50 SP	2 g/l	1.71 (1.48)	1.41 (1.38)	1.56 (1.43)	1.11 (1.27)d	0.96 (1.21)cd	1.04 (1.24)	0.96 (1.21)c-e	0.67 (1.08)d-f	0.82 (1.15)	0.81 (1.14)fg	0.53 (1.01)bc	0.69 (1.09)	0.78 (1.13)e-g	0.58 (1.04)de	0.66 (1.07)
T-$_{11}$Thiamethoxam 25% WG	0.5 g/l	1.87 (1.53)	1.59 (1.44)	1.73 (1.49)	1.26 (1.33)cd	1.08 (1.25)cd	1.17 (1.29)	1.11 (1.27)c-e	0.86 (1.17)b-f	0.99 (1.22)	1.00 (1.22)d	0.72 (1.10)bc	0.88 (1.17)	0.96 (1.20)c-f	0.75 (1.12)cd	0.84 (1.16)
T-$_{12}$Acetamaprid 20% SL	0.25 g/l	1.93 (1.56)	1.63 (1.46)	1.78 (1.51)	1.33 (1.35)cd	1.20 (1.30)c	1.27 (1.33)	1.22 (1.31)c	0.83 (1.15)c-f	1.03 (1.24)	1.07 (1.25)cd	0.79 (1.13)b	0.96 (1.21)	1.00 (1.23)c-e	0.84 (1.16)c	0.90 (1.18)
T-$_{13}$Methomyl (PB)	*	2.33 (1.68)	2.12 (1.62)	2.22 (1.65)	1.78 (1.51)b	1.60 (1.45)b	1.69 (1.48)	1.52 (1.42)b	1.23 (1.31)b	1.38 (1.37)	1.37 (1.37)b	0.76 (1.10)b	1.25 (1.32)	1.29 (1.34)b	1.14 (1.28)c	1.03 (1.23)
T-$_{14}$Chlorpyriphos (PB)	*	2.22 (1.65)	1.90 (1.55)	2.06 (1.6)	1.63 (1.46)bc	1.53 (1.43)b	1.58 (1.44)	1.63 (1.45)b	1.01 (1.21)b-d	1.32 (1.35)	1.15 (1.29)c	0.79 (1.13)b	1.00 (1.22)	1.07 (1.25)b-d	0.84 (1.15)c	0.93 (1.19)
T-$_{15}$Monocrotophos (PB)	*	1.96 (1.57)	1.56 (1.42)	1.76 (1.5)	1.29 (1.34)cd	1.15 (1.28)cd	1.22 (1.31)	1.18 (1.29)cd	0.86 (1.16)c-f	1.02 (1.23)	0.96 (1.21)de	0.70 (1.09)bc	0.86 (1.16)	0.92 (1.18)c-g	0.76 (1.12)cd	0.81 (1.14)
T-$_{16}$Untreated check	-	3.78 (2.07)	2.96 (1.86)	3.37 (1.97)	3.89 (2.08)a	3.00 (1.87)a	3.45 (1.98)	3.89 (2.08)a	3.11 (1.90)a	3.50 (2.00)	3.96 (2.11)a	3.11 (1.90)a	3.61 (2.03)	3.92 (2.10)a	3.26 (1.94)a	3.52 (2.00)
S. Em. ±		0.05	0.05	0.05	0.04	0.03	0.04	0.03	0.04	0.03	0.02	0.05	0.02	0.03	0.03	0.03
C. D. at 5%		NS	NS	NS	0.13	0.12	0.11	0.11	0.14	0.08	0.06	0.16	0.06	0.10	0.10	0.10

Figures in the parentheses are √ x+0.5 transformed values, DBS = Days before spray, DAS=Days after spray, mrl = meter row length, Means followed by same letters in the column are not statistically different by DMRT (P=0.05), NS = Non-significant, PB: Poison bait

*Poison Bait (PB) = Rice bran 50 kg + jaggery 4 kg + chemical + 8 litres of water

Table 2: Influence of insecticides on yield

Treatments	Dosage	Yield (q/ha)			Avoidable loss (%)
		2010	2011	Pooled	
T_1 - Thiodicarb 75 WP	0.75ml/l	21.25	20.01	20.63	25.93
T_2 - Indoxacarb 14.5 SC	0.5 ml/l	22.99	23.37	23.18	34.08
T_3 - Rynaxypyr 20 SC	0.2 ml/l	22.87	21.97	22.42	31.84
T_4 - Spinosad 45 SC	0.2 ml/l	22.19	22.42	22.30	31.48
T_5 - Emamectin benzoate 5 SG	0.2 g/l	22.03	22.41	22.22	31.23
T_6 - Flubendiamide 480 SC	0.2 ml/l	23.95	24.65	24.30	37.11
T_7 - Chlorpyriphos 20 EC	2ml/l	21.87	19.97	20.92	26.96
T_8 - Fipronil 5 SL	1ml/l	18.07	17.60	17.83	14.30
T_9 - Imidacloprid 17.8 SL	0.25 ml/l	18.46	17.52	17.99	15.06
T_{10} - Cartap hydrochloride 50 SP	2g/l	19.08	18.26	18.67	18.15
T_{11} - Thiamethoxam 25 WG	0.5 g/l	19.20	17.48	18.34	16.68
T_{12} - Acetamiprid 20 SL	0.25g/l	19.32	17.37	18.34	16.68
T_{13} - Methomyl (PB)	*	18.22	16.75	17.48	12.58
T_{14} - Chlorpyriphos (PB)	*	18.17	17.22	17.69	13.62
T_{15} - Monocrotophos (PB)	*	17.82	16.18	17.00	10.11
T_{16} - Untreated check	-	15.16	15.41	15.28	-
S.Em.±		2.96	2.75	2.88	-
C.D. at 5%		8.59	7.93	8.31	-

* Poison Bait (PB) = Rice bran 50 kg + jaggery 4 kg + chemical + 8 litres of water

Table 3: Cost economics as influenced by different treatments

Treatments	Cost of production (Rs./ha)	Insecticide cost (Rs./ha)	Total cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
T_1 - Thiodicarb 75 WP	14000	1890.00	15890.00	49512.00	33622.00	3.12
T_2 - Indoxacarb 14.5 SC	14000	1480.00	15480.00	55632.00	40152.00	3.59
T_3 - Rynaxypyr 20 SC	14000	1800.00	15800.00	53808.00	38008.00	3.41
T_4 - Spinosad 45 SC	14000	3096.00	17096.00	53520.00	36424.00	3.13
T_5 - Emamectin benzoate 5 SG	14000	1800.00	15800.00	53328.00	37528.00	3.38
T_6 - Flubendiamide 480 SC	14000	23000.00	37000.00	58320.00	21320.00	1.58
T_7 - Chlorpyriphos 20 EC	14000	1000.00	15000.00	50208.00	35208.00	3.35
T_8 - Fipronil 5 SL	14000	1360.00	15360.00	42792.00	27432.00	2.79
T_9 - Imidacloprid 17.8 SL	14000	880.00	14880.00	43176.00	28296.00	2.90
T_{10} - Cartap hydrochloride 50 SP	14000	624.00	14624.00	44808.00	30184.00	3.06
T_{11} - Thiamethoxam 25 WG	14000	1640.00	15640.00	44016.00	28376.00	2.81
T_{12} - Acetamiprid 20 SL	14000	840.00	14840.00	44016.00	29176.00	2.97
T_{13} - Methomyl (PB)	14000	950.00	14950.00	41952.00	27002.00	2.81
T_{14} - Chlorpyriphos (PB)	14000	726.00	14726.00	42456.00	27730.00	2.88
T_{15} - Monocrotophos (PB)	14000	800.00	14800.00	40800.00	26000.00	2.76
T_{16} - Untreated check	14000	0.00	14000.00	36672.00	22672.00	2.62

4. Conclusion

The results on the efficacy of insecticides in the management of soybean defoliator pest S. litura, flubendiamide 480 SC recorded the minimum larval population with first spray having only 0.42, second spray 0.27, third spray 0.17, and seventh spray 0.13 larva/mrl followed by Indoxacarb 14.5 SC @ 0.5 ml/l with 0.58, 0.47,0.33 and 0.29 after first, second, third and seventh spray respectively. Flubendiamide 480 SC proved significantly effective in managing the major insect pests of soybean and obtained comparatively higher yield and net monetary return.

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