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Management of legume pod borers on Yardlong bean (*Vigna unguiculata* subsp. *sesquipedalis* L.)

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ABSTRACT: Field experiments were carried out at Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India, during *kharif* 2020 and 2021 on management of legume pod borers on Yardlong bean (*Vigna unguiculata* subsp. *sesquipedalis* L.). Results revealed that chlorantraniliprole 18.5 SC @ 0.4 ml/L was effective in reducing pod borers (89.11 %) and was on par with the spinetoram 11.7 SC @ 0.4 ml/L (88.17 %), followed by other chemicals evaluated. However, the pod borers populations were reduced in all the treatments compared to the control. The highest marketable pod yield was recorded in the chlorantraniliprole 18.5 SC @ 0.4 ml/L (24.23 t/ha) and it was closely on par with the spinetoram 11.7 SC @ 0.4 ml/L (24.06 t/ha). The efficacy and pod yield was superior in chlorantraniliprole 18.5 SC but, after analyzing the C: B ratio, spinetoram 11.7 SC recorded the highest C: B ratio of 1: 4.71) as compared to the chlorantraniliprole 18.5 SC (1: 4.49). Hence, spinetoram 11.7 SC @ 0.4 ml per L was superior in pod borers reduction, increase in yield and C: B ratio.

Keywords: Chlorantraniliprole, *Helicoverpa armigera, Lampides boeticus, Maruca vitrata,* spinetoram, yardlong bean

INTRODUCTION

Yardlong bean (*Vigna unguiculata* subsp. *sesquipedalis* L.) is an important leguminous vegetable crop grown all over the country. It is also known as asparagus bean, string bean, snake bean and vegetable cowpea (Purseglove, 1977). In India, Kerala state contributes a major share accounting for nearly 90 percent in both area and production, followed by Karnataka and Tamil Nadu. The area of yard long beans in India is about 18,560–20,160 ha (Saurabh *et al.,* 2018). It is a highly nutritive vegetable containing a good amount of digestible protein (23.5-26.3 %) both in pods and in leaves (Ano and Ubochi, 2008). It can be used as fodder, vegetable, and green manure crop. The cultivation of this crop encounters various problems, including pest management (Rashid, 1993). About 150 species of insect pests are known to attack beans in India, of which about 25 species are reported to be serious (Srivastava, 1987). In Karnataka, a total of four species of insects (*Spodoptera litura, Maruca vitrata, Liriomyza trifolii* and *Aphis fabae*) and one mite pest (*Tetranychus urticae*) is causing a major serious problem (Manjesh *et al.,* 2017). Flower and pod-feeding lepidopterans cause severe yield losses to edible legumes, particularly in tropical and sub-tropical zones (Rouf and Sardar, 2011). Lepidopteran borers *viz.,* spotted pod borer, *Maruca vitrata* (Fabricius), gram pod borer, *Helicoverpa armigera* (Hubner) and blue butterfly, *Lampides boeticus* (Linnaeus) cause severe loss in yardlong bean (Didgur, 2022).

To overcome the loss, minimize the pest's attack and increase the ultimate production of the yardlong bean, the farmers are using the insecticides indiscriminately. In India, the scientific information on the management of pod borers in yardlong beans is limited. Hence, the present study was initiated to find out the effective insecticide fit into integrated pest management modules for the effective management of pod borers and increase in the yield of yardlong beans.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2020 and 2021 at Zonal Agricultural and Horticultural Research Station (ZAHRS), Bavikere, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences (KSNUAHS), Shivamogga (13° 42′ N and 75° 51′ E), Karnataka, India. Yardlong bean variety 'Arka Mangala' was used for the experiment. The crop was sown by dibbling with a spacing of 120 x 30 cm. Gap filling and thinning were done to maintain the optimum plant density. The crop was raised by following a package of practices released by KSNUAHS, Shivamogga, except plant protection measures for pod borers.

Seven insecticides *viz*., lambdacyhalothrin 5 EC, flubendiamide 39.35 SC, chlorantraniliprole 18.5 SC, indoxacarb 15.8 EC, spinetoram 11.7 SC, malathion 50 EC and azadirachtin 5 EC were evaluated. The experiment included eight treatments and three replications, including an absolute control. The treatments were imposed at 45

Table 1. Bio-efficacy of different insecticides against legume pod borers infesting yardlong bean during 2020

Treatment	Dosage (ml/L)	Number of larvae per five plants										Mean	Per cent reduction
		First Spraying					Second Spraying						
		DBS	3 DAS	7 DAS	10 DAS	14 DAS	DBS	3 DAS	7 DAS	10 DAS	14 DAS		
T1-Lambdacyhalothrin 5EC	1.0	11.53 (3.47)	5.20 (2.39)^{bc}	3.41 (1.98)^{cd}	1.78 (1.51)^{bcd}	3.22 (1.93)^{cd}	7.22 (2.78)^{c}	5.14 (2.38)^{cd}	3.69 (2.05)^{cd}	1.24 (1.32)^{c}	2.94 (1.85)^{c}	3.33	75.39
T2-Flubendiamide 39.35 SC	0.20	10.58 (3.33)	2.95 (1.86)^{d}	1.32 (1.35)^{f}	0.64 (1.07)^{e}	1.53 (1.42)^{ef}	6.30 (2.61)^{c}	3.88 (2.09)^{de}	2.36 (1.69)^{d}	0.70 (1.10)^{c}	2.02 (1.59)^{cd}	1.93	85.76
T3-Chlorantraniliprole 18.5SC	0.40	11.15 (3.41)	3.29 (1.95)^{d}	1.08 (1.26)^{f}	0.57 (1.04)^{e}	1.12 (1.27)^{f}	4.49 (2.23)^{e}	2.65 (1.77)^{e}	0.21 (0.84)^{e}	0.00 (0.71)^{d}	0.55 (1.03)^{e}	1.18	91.24
T4-Indoxacarb 15.8 EC	0.60	11.38 (3.45)	4.09 (2.14)^{cd}	2.48 (1.73)^{de}	1.37 (1.37)^{cde}	2.27 (1.67)^{de}	6.24 (2.60)^{cd}	4.87 (2.32)^{cd}	2.97 (1.86)^{d}	0.96 (1.21)^{c}	1.97 (1.57)^{d}	2.62	80.61
T5-Spinetoram 11.7 SC	0.40	12.06 (3.54)	3.11 (1.90)^{d}	1.57 (1.44)^{ef}	0.98 (1.22)^{de}	1.37 (1.37)^{f}	4.85 (2.31)^{de}	2.98 (1.87)^{e}	0.67 (1.08)^{e}	0.54 (1.02)^{cd}	0.95 (1.20)^{e}	1.52	88.75
T6-Malathion 50 EC	2.00	10.06 (3.25)	6.51 (2.65)^{b}	4.18 (2.16)^{bc}	2.48 (1.73)^{bc}	4.05 (2.13)^{bc}	9.04 (3.09)^{b}	6.56 (2.66)^{bc}	4.82 (2.31)^{bc}	3.64 (2.03)^{b}	4.42 (2.22)^{b}	4.58	66.10
T7-Azadirachtin 5 EC	0.50	11.30 (3.44)	6.95 (2.73)^{b}	5.24 (2.40)^{b}	3.05 (1.89)^{b}	4.79 (2.30)^{b}	9.75 (3.20)^{b}	7.78 (2.88)^{b}	5.46 (2.44)^{b}	3.69 (2.05)^{b}	5.01 (2.35)^{b}	5.25	61.19
T8-Control	0.0	11.32 (3.44)	12.20 (3.56)^{a}	12.62 (3.62)^{a}	13.13 (3.69)^{a}	13.42 (3.73)^{a}	13.35 (3.72)^{a}	14.15 (3.83)^{a}	14.64 (3.89)^{a}	14.27 (3.84)^{a}	13.71 (3.77)^{a}	13.52	75.39
CD (p=0.05)		NS	0.43	0.33	0.40	0.27	0.28	0.41	0.36	0.32	0.28	-	-
CV (%)		7.58	10.27	9.75	13.83	7.91	5.79	9.70	10.45	11.12	8.34	-	-

NS-Non significant; Figures within the parentheses indicates $\sqrt{x+0.5}$ transformed values; Mean followed by the same letter do not differ significantly by DMRT (P=0.05); DBS= Day before spray; DAS= Day after spray and 60 days after sowing the crop using a knapsack sprayer fitted with a hollow cone nozzle. The observations were recorded on five randomly selected plants on a day before spraying and 3, 7, 10 and 14 days after spraying by counting the number of larvae per plant and the data were expressed as the number of larvae per five plants. Totally three species of pod borers were observed *viz.,* spotted pod borer, *Maruca vitrata* (Fabricius), gram pod borer, *Helicoverpa armigera* (Hubner) and blue butterfly, *Lampides boeticus* (Linnaeus). All the three species data was averaged, subjected to square root transformation, and analyzed statistically. The results were interpreted at a five percent significance level using ICAR WASP (Web Agri Stats Package) 2.0 software. Percent reduction over untreated control was calculated, and the data for two years was pooled for a better interpretation of a valid conclusion.

RESULTS AND DISCUSSION

During 2020, the mean data of first and second spray indicated that, the lowest mean larval population of 1.18 larvae per five plants was recorded in chlorantraniliprole 18.5 SC @ 0.4 ml/L followed by spinetoram 11.7 SC @ 0.4 ml/L (1.52 larvae/5 plants) and flubendiamide 39.35 SC @ 0.2 ml/L (1.93 larvae/5 plants). The highest larval population of 13.52 larvae per plant was recorded in the control plot. However, in all the treatments larval population was reduced when compared to the control. Chlorantraniliprole 18.5 SC recorded 91.24 per cent reduction followed by spinetoram 11.7 SC (88.75 %) and flubendiamide 39.35 SC (85.76 %). The lowest percent reduction (61.19 %) was recorded in Azadirachtin 5 EC, followed by Malathion 50 EC (66.10 %).

In 2021, the same trend was recorded as in the case of 2020. The mean data of first and second spray showed that, the lowest mean larval population of 1.33 larvae per five plants was recorded in chlorantraniliprole 18.5 SC @ 0.4 ml/L followed by spinetoram 11.7 SC @ 0.4 ml/L (1.63 larvae/5 plants) and flubendiamide 39.35 SC @ 0.2 ml/L (2.2 larvae/5 plants). The highest larval population of 12.40 larvae per 5 plants was recorded in the control plot. However, in all the treatments larval population was reduced when compared to the control. Chlorantraniliprole 18.5 SC recorded 88.11 per cent reduction followed by spinetoram 11.7 SC (85.35 %) and flubendiamide 39.35 SC (80.30 %). The lowest percent reduction (52.79 %) was recorded in Azadirachtin 5 EC, followed by Malathion 50 EC (60.25 %).

The pooled mean data (Table 3) of pod borers in yardlong beans didn't vary significantly one day before spraying (DBS) (10.08 to 11.58 pod borers/5 plants), indicating the uniform distribution of pod borers throughout the experimental plot. All the molecules tested proved their superiority in significantly suppressing the pod borers population compared to untreated control up to 14 days of the first and second application of insecticides. The lowest number of the pod was recorded in chlorantraniliprole 18.5 SC @ 0.4 ml/L, which was found to be far with spinetoram 11.7 SC @ 0.4 ml/L. The next best chemical in reducing pod borers population was flubendiamide 39.35 SC @ 0.2 ml/L; it was found to be on par with the indoxacarb15.8 EC @ 0.6 ml/L, followed by lambda-cyhalothrin 5 EC @ 1.0 ml/L. The least reduction in pod borers during all the observations was recorded in azadirachtin 5 EC @ 0.5 ml/L, followed by Malathion 50 EC @ 2.0 ml/L. However, the highest number of pod borers per five plants was observed in the untreated control (Table 3).

The mean population of first and second sprays indicated that lowest number of pod borers per five plants was recorded in the chlorantraniliprole 18.5 SC @ 0.4 ml/L (1.34) and it was found to be on par with the spinetoram 11.7 SC @ 0.4 ml/L (1.46). The next best chemical was flubendiamide 39.35 SC @ 0.2 ml/L (2.06), Indoxacarb 15.8 EC @ 0.6 ml/L (2.66), lambdacyhalothrin 5 EC @ 1.0 ml/L (3.48), Malathion 50 EC @ 2.0 ml/L (4.51) and azadirachtin 5 EC @ 0.5 ml/L (5.25). The highest mean number of pod borers was recorded in the untreated control (12.33 pod borers/5 plants) (Table 3). The chemical, chlorantraniliprole 18.5 SC @ 0.4 ml/L and spinetoram 11.7 SC @ 0.4 ml/L recorded 89.11 and 88.17 per cent reduction, respectively over untreated control. Next best treatment was flubendiamide 39.35 SC @ 0.2 ml/L (83.29 %) followed by Indoxacarb 15.8 EC @ 0.6 ml/L (78.45%) and lambdacyhalothrin 5 EC @ 1.0 ml/L (71.76%). The lowest per cent reduction of pod borers over untreated control was observed in the treatment of azadirachtin 5 EC @ 0.5 ml/L (57.40 %) followed by malathion 50 EC @ 2.0 ml/L (63.46 %) (Table 3).

The marketable pod yield of yardlong beans recorded in all the chemicals treated plots varied between 17.38 to 24.23 tonnes/ha. The highest yield (24.23 t/ha) was recorded in the chlorantraniliprole 18.5 SC @ 0.4 ml/L, which was found to be on par with the spinetoram 11.7 SC @ 0.4 ml/L (24.06 t/ha). The lowest green pod yield (12.11 t/ha) was recorded in the untreated control (Table 3). The efficacy and yield were superior in chlorantraniliprole 18.5 SC treatment, but the B:C ratio of spinetoram 11.7 SC was highest (4.71) compared to the chlorantraniliprole 18.5 SC (1: 4.49) because of the high cost of the chemical. Hence, spinetoram 11.7 SC @ 0.4 ml per L was found to be superior in pod borer management in yardlong bean with respect to the high

Table 2. Bio-efficacy of different insecticides against legume pod borers infesting yardlong bean during 2021

Treatment	Dosage (ml/L)	Number of larvae per five plants										Mean	Per cent reduction
		First spraying					Second spraying						
		DBS	3 DAS	7 DAS	10 DAS	14 DAS	DBS	3 DAS	7 DAS	10 DAS	14 DAS		
T1-Lambdacyhalothrin 5EC	1.0	10.06 (3.25)	5.82 (2.51)^{c}	4.15 (2.16)^{c}	2.96 (1.86)^{c}	3.27 (1.94)^{c}	7.95 (2.91)^{abcd}	5.08 (2.36)^{cd}	3.24 (1.93)^{c}	2.23 (1.65)^{d}	2.35 (1.69)^{d}	3.64	67.36
T2-Flubendiamide 39.35 SC	0.20	9.74 (3.20)	3.69 (2.05)^{de}	2.19 (1.64)^{de}	1.58 (1.44)^{de}	1.76 (1.50)^{de}	7.27 (2.79)^{bcd}	3.53 (2.01)^{e}	1.77 (1.51)^{d}	1.47 (1.40)^{e}	1.56 (1.44)^{e}	2.20	80.30
T3-Chlorantraniliprole 18.5SC	0.40	9.91 (3.23)	2.62 (1.77)^{f}	1.35 (1.36)^{f}	0.92 (1.19)^{e}	1.19 (1.30)^{e}	5.92 (2.53)^{cd}	2.54 (1.74)^{f}	0.92 (1.19)^{e}	0.50 (1.00)^{g}	0.56 (1.03)^{g}	1.33	88.11
T4-Indoxacarb 15.8 EC	0.60	9.81 (3.21)	4.02 (2.13)^{d}	2.43 (1.71)^{d}	1.76 (1.50)^{d}	1.94 (1.56)^{d}	6.74 (2.69)^{bcd}	4.73 (2.29)^{d}	2.72 (1.79)^{c}	1.83 (1.53)^{de}	2.12 (1.62)^{de}	2.69	75.83
T5-Spinetoram 11.7 SC	0.40	9.73 (3.20)	2.88 (1.84)^{ef}	1.52 (1.42)^{ef}	1.10 (1.27)^{de}	1.31 (1.34)^{de}	5.59 (2.47)^{d}	2.91 (1.85)^{ef}	1.44 (1.39)^{de}	0.92 (1.19)^{f}	0.97 (1.21)^{f}	1.63	85.35
T6-Malathion 50 EC	2.00	10.09 (3.25)	6.80 (2.70)^{bc}	4.90 (2.32)^{bc}	3.65 (2.04)^{bc}	3.76 (2.06)^{bc}	8.42 (2.99)^{abc}	5.95 (2.54)^{bc}	4.11 (2.15)^{b}	3.01 (1.87)^{c}	3.24 (1.93)^{c}	4.43	60.25
T7-Azadirachtin 5 EC	0.50	10.17 (3.27)	8.00 (2.92)^{b}	5.78 (2.51)^{b}	4.57 (2.25)^{b}	4.70 (2.28)^{b}	8.67 (3.03)^{ab}	6.37 (2.62)^{b}	4.43 (2.22)^{b}	4.06 (2.13)^{b}	4.17 (2.16)^{b}	5.26	52.79
T8-Control	-	11.83 (3.51)	12.26 (3.57)^{a}	12.55 (3.61)^{a}	12.76 (3.64)^{a}	12.99 (3.67)^{a}	10.99 (3.39)^{a}	10.46 (3.31)^{a}	12.32 (3.58)^{a}	12.68 (3.63)^{a}	13.21 (3.70)^{a}	12.40	0.0
CD (p=0.05)		NS	0.27	0.21	0.25	0.23	0.48	0.24	0.19	0.17	0.18	-	-
CV (%)		6.31	6.45	5.99	7.83	6.83	9.78	6.08	5.89	5.70	5.78	-	-

NS-Non significant; Figures within the parentheses indicates $\sqrt{x+0.5}$ transformed values; Mean followed by the same letter do not differ significantly by DMRT (P=0.05); DBS= Day before spray; DAS= Day after spray

Table 3. Bio-efficacy of different insecticides against legume pod borers infesting yardlong bean (Pooled data of two seasons)

Treatment	Dosage (ml/L)	Number of larvae per five plants										Per cent reduction	B:C ratio
		First Spraying					Second spraying						
		DBS	3 DAS	7 DAS	10 DAS	14 DAS	DBS	3 DAS	7 DAS	10 DAS	14 DAS		
T1-Lambdacyhalothrin 5EC	1.00	10.80 (3.36)	5.51 (2.45)^{c}	3.78 (2.07)^{c}	2.37 (1.69)^{cd}	3.25 (1.94)$_{bcd}$	7.75 (2.87)^{bc}	5.11 (2.37)$_{c}$	3.47 (1.99)^{cd}	1.74 (1.50)^{c}	2.64 (1.77)^{d}	71.76	4.10
T2-Flubendiamide 39.35 %SC	0.20	10.16 (3.26)	3.32 (1.95)$_{de}$	1.76 (1.50)^{e}	1.11 (1.27)^{ef}	1.65 (1.46)^{de}	7.28 (2.79)^{cd}	3.71 (2.05)$_{d}$	2.07 (1.60)^{e}	1.09 (1.26)^{d}	1.79 (1.51)^{e}	83.29	4.55
T3-Chlorantraniliprole 18.5SC	0.40	10.44 (3.31)	2.87 (1.83)^{e}	1.30 (1.34)^{e}	0.84 (1.16)^{f}	1.21 (1.31)e	6.32 (2.61)^{d}	2.76 (1.81)$_{e}$	0.80 (1.14)^{f}	0.46 (0.98)^{e}	0.70 (1.12)^{f}	89.11	4.49
T4-Indoxacarb 15.8 EC	0.60	10.60 (3.33)	4.05 (2.13)^{d}	2.46 (1.72)^{d}	1.57 (1.44)^{de}	2.11 (1.61)$_{cde}$	7.16 (2.77)^{cd}	4.80 (2.30)$_{c}$	2.84 (1.83)^{de}	1.39 (1.38)^{cd}	2.04 (1.59)^{e}	78.45	4.40
T5-Spinetoram 11.7 SC	0.40	10.99 (3.39)	3.09 (1.89)^{e}	1.46 (1.40)^{e}	0.95 (1.21)^{ef}	1.28 (1.33)^{e}	6.39 (2.62)^{d}	2.78 (1.81)$_{e}$	0.83 (1.15)^{f}	0.52 (1.01)^{e}	0.76 (1.12)^{f}	88.17	4.71
T6-Malathion 50 EC	2.00	10.08 (3.25)	6.66 (2.67)$_{bc}$	4.54 (2.24)^{c}	3.07 (1.89)^{bc}	3.90 (2.10)^{bc}	8.73 (3.04)^{b}	6.26 (2.60)$_{b}$	4.47 (2.23)^{bc}	3.33 (1.96)^{b}	3.83 (2.08)^{c}	63.46	3.89
T7-Azadirachtin 5 EC	0.50	10.74 (3.35)	7.48 (2.82)^{b}	5.51 (2.45)^{b}	3.81 (2.08)^{b}	4.75 (2.29)^{b}	9.21 (3.12)^{b}	7.07 (2.75)$_{b}$	4.95 (2.33)^{b}	3.87 (2.09)^{b}	4.59 (2.26)^{b}	57.40	3.72
T8-Control	0.0	11.58 (3.48)	12.23 (3.57)^{a}	12.59 (3.62)^{a}	12.94 (3.67)^{a}	13.21 (3.70)^{a}	11.34 (3.44)^{a}	11.81 (3.51)$_{a}$	12.13 (3.55)^{a}	11.98 (3.53)^{a}	11.74 (3.50)^{a}	0.0	2.69
CD (p=0.05)		-	0.24	0.19	0.27	0.52	0.25	0.21	0.25	0.17	0.25		-
CV (%)		6.39	5.83	5.41	8.79	15.42	5.08	5.11	7.39	5.79	5.88		-

NS-Non significant; Figures within the parentheses indicates √x+0.5 transformed values; Mean followed by the same letter do not differ significantly by DMRT (P=0.05); DBS= Day before spray; DAS= Day after spray

B:C ratio. These results are also in conformity with the findings of Sontakke and Amrita (2022), who reported that chlorantraniliprole 18.5SC @ 30 g a.i. per hectare was superior in reducing the *Lampides boeticus* in yard long beans. Similarly, the highest grain yield of redgram was obtained using chlorantraniliprole 18.5 SC (Sreekanth *et al.,* 2015). The same results were also obtained by Mohanraj *et al.,* (2012) and Sapkal *et al.,* (2018). Didgur (2022) reported that spinetoram 11.7 SC was the best chemical in reducing *Maruca vitrata*, *Lampides boeticus* and increase in green pod yield in yardlong beans, but chlorantraniliprole 18.5 SC was found to be superior in reducing *Helicoverpa armigera.* In our study, chlorantraniliprole 18.5 SC was proved to be the best insecticide in reducing the pod borers. But, because of the high cost of this chemical, the B:C ratio was low; hence spinetoram 11.7 SC was found to be superior concerning profit. The results of the present investigation indicated that spinetoram 11.7 SC @ 0.4 ml per L was found to be best in pod borer management.

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