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Evaluation of ecofriendly insecticides for the management of spotted pod borer, *Maruca vitrata* (Geyer) in pigeonpea (*Cajanus cajan* L.)

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Abstract
Two field experiments were conducted during *Kharif*, 2018 and 2019 to evaluate the efficacy of eco-friendly insecticides against spotted podborer, *Maruca vitrata* (Geyer) in pigeonpea along with the recommended sequential application of chemical insecticides. Among the eco-friendly insecticides tested, *Bacillus thuringiensis* var. *kurstaki* @ 1 g/ litre was found to be effective in minimizing the webcounts of spotted podborer after three applications during both the seasons tested. This resulted in the lowest mean per cent pod damage (23.33) with 52.6 per cent reduction and the highest grain yield of 910.8 kg per ha with a yield increase of 39.1 per cent over untreated check. However, sequential application of insecticides *viz*., Chlorantraniliprole 18.5 SC 30 g a.i/ha followed by Flubendiamide 480 SC @ 30 g a.i/ha and Deltamethrin 2.8 EC@ 12.5 g a.i/ha recorded the highest reduction of web-counts which resulted in the lowest mean pod damage per cent with increased grain yield of 1145.7 kg per ha.

Keywords: Bio-insecticides, pigeonpea, spotted podborer, webcounts

1. Introduction

Pigeonpea (*Cajanus cajan* L.), also known as redgram or tur or arhar ia a tropical grain legume mainly grown in India and ranks second in area and production and contributes 90% of world's pulse production. In India, pigeonpea is grown in 4.42 million ha with an annual production of 2.89 million tonnes with 655 kg ha^{-1} of productivity. In Tamil Nadu, it accounts for 1.88% area (0.73 lakh ha) and 3.24% production (0.91lakh tonnes) with a productivity of 1256 kg/ha. It is a predominant pulse crop in Vellore district next to groundnut, paddy and sugarcane. It is grown in an area of 13,584 ha, which accounts for about 20% of the Tamil Nadu state. Being attacked by than 250 species of insects of which webforming or spotted podborer (SPB), *Maruca vitrata* (Geyer) gains importance and yield loss estimated to be about 84 per cent. *M.vitrata* is basically a hidden pest and completes its larval development inside the webs by rolling and tying together leaves, flowers, buds and pods. This typical concealed feeding protects the larvae from adverse situations and leads to escape from management options including insecticides [1]. At the same time, many insecticides were tested and few of them found to be effective [2] and also reported with various levels of insecticide resistance. This resulted in renewed interest in the research for exploring the opportunities of using eco-friendly insecticides such as *Bacillus thuringiensis* (Berliner), *Beauveria bassiana* and NSKE 5% can provide alternative, eco-friendly options to control this insect pest [3]. Keeping this in view, the present study was undertaken to evaluate the bioefficacy of bioinsecticides against *M. vitrata*.

2. Materials and Methods

Two field experiments were conducted at Agricultural Research station, Virinjipuram during Kharif 2018 and 2019. The experiment was laid out in a randomized block design (RBD) using pigeonpea var. CO Rg7 with the following seven treatments and three replications in a plot size of 5.0 m x5.0m with a spacing of 90x30 cm. The crop was raised with recommended agronomic practices. Totally, three sprays were given at 15 days interval commenced from 50% flowering stage using hand operated knapsack sprayer with a spray volume of 500L/ha. Twenty five inflorescence of 30 cm length were selected at random in each plot from three randomly selected plants. Observation on the number of web counts caused due to *M. vitrata* were taken at precount, 3, 7 and 10 days after treatment (DAT).

At maturity, the number of pods showing the damage caused by *M. vitrata* were recorded and expressed as per cent pod damaged. All the pods from each treatment were then threshed and grain yield per plot was recorded and arrived for hectare. The data, thus obtained were subjected to RBD analysis using AGRES package [4]. Per cent poddamage was calculated by using the following formula [5]

$$\text{Percent pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

Treatment details

S. No	Treatments	Dose (per litre)
1.	*Bt Kurstaki*	1.0 g
2.	*Beauveria bassiana*	5.0 g
3.	*Metarhizium anisopliae*	5.0 g
4.	*Lecanicilium lecanii*	5.0 g
5.	*Azadirachtin 1500 ppm*	5.0ml
6.	Chlorantraniliprole 18.5 SC 30 g a.i/ha >Flubendiamide 480 SC @ 30 g a.i/ha> dimethoate	-
7.	Untreated check	-

3. Results and Discussion

The data on the number of web counts caused by *M. vitrata* in pigeonpea raised during kharif 2018 is presented in Table 1. The data showed that the webcounts taken before initiating the spray was non-significant in all the treatments indicating the uniform distribution. The precount webcounts of *M. vitrata* ranged from 9.11 -10.44 webs per plant. Among all the treatments tested, Chlorantaraniliprole 18.5SC @ 30 g a.i. ha^{-1} followed by Flubendiamide 480 SC @ 30 g a.i. ha^{-1} followed by Deltamethrin 2.8 EC @ 12.5 g a.i. ha^{-1} treated plots was found to be effective and superior which recorded 2.56, 2.89 and 2.67 webs per plant at 3, 7 and 10 DAT, respectively. Among the bio-insecticides tested, *Bt* var *Kurstaki* @ 1.0 g /l was found effective in reducing the web counts recording 6.67, 5.89 and 5.78 webs per plant at 3, 7 and 10 DAT, respectively. This was followed by Azadirachtin 1500 ppm @5.0 ml/l and recorded with 6.00, 5.78 and 6.11 webs per plant at 3, 7 and 10 DAT, respectively. The same trend of effectiveness in different treatments found to be similar with second and third application taken at above intervals. All the treatments tested, were found to be effective in reducing the web counts when compared with untreated check which reported with 11.22-12.00 webs per plant throughout the observation period.

The data on the number of web counts caused by *M. vitrata* in pigeonpea raised during kharif 2019 is presented in Table 2. The precount webcounts of *M. vitrata* ranged from 9.66 - 10.53 webs per plant. When compared with first year experiment, the larval population in bio-insecticides treated plots, *Bt* var *Kurstaki* @ 1.0 g /l varied with less web counts and recorded 2.55, 2.44 and 1.89 webs per plant at 3, 7 and 10 DAT, respectively after third application and found to be effective. This was followed by Azadirachtin 1500 ppm @5.0 ml/l and recorded with 3.78, 3.11 and 2.44 webs per plant at 3, 7 and 10 DAT, respectively. However, the efficacy when compared with sequential application of insecticides, Chlorantaraniliprole 18.5SC @ 30 g a.i. ha^{-1} followed by Flubendiamide 480 SC @ 30 g a.i. ha^{-1} followed by Deltamethrin 2.8 EC @ 12.5 g a.i. ha^{-1} treated plots was found to be effective and superior which recorded 0.63, 0.11 and 0.33 webs per plant at 3, 7 and 10 DAT, respectively. All the bioinsecticides tested were found to be effective in reducing the web counts when compared with untreated check which reported with 11.09-11.88 webs per plant till third round of application of treatments.The data on the per cent pod damage at the end of the experiment mean of two seasons is presented in Table 3. The results on the number of webcounts recorded in different treatments were worked out as a mean of two seasons. The results showed that the webcounts ranged from 1.54 – 11.24 Nos in all the treatments, the lowest in the sequential application of insecticides and the highest in the untreated check. The various bioinsecticide treated plots recorded 4.10-5.25 Nos with the lowest in the *Btk* treated plots. The results also revealed that there was a reduction in the mean per cent pod damage caused due to *M. vitrata* in all the bioinsecticide treated plots. Among them, the lowest mean per cent pod damage (23.33) with 52.6 per cent reduction and the highest grain yield of 910.8 kg per ha with a yield increase of 39.1 per cent over untreated check was recorded in Btk @1 g/l. The bioinsecticides treated plots were effective in reducing the pod damage and varied from 23.33 -30.66 per cent over untreated check. However, when the bio-insecticides were compared with chemical insecticides, sequential application of insecticides *viz*., Chlorantraniliprole 18.5 SC 30 g a.i/ha followed by Flubendiamide 480 SC @ 30 g a.i/ha and Deltamethrin 2.8 EC@ 12.5 g a.i/ha recorded the highest reduction of webcounts which resulted in the lowest mean pod damage per cent with increased grain yield of 1145.7 kg per ha. High efficacy of microbial formulations of bacteria and fungi over chemical insecticides in the present studies was not observed to a greater extent probably due to lack of high humidity conditions in field required for the growth of the microbes. The relative low efficacy of the biopesticides over synthetic insecticides in the present findings was also reported by [6] who reported that cent per cent mortality of *M. vitrata* larvae at 7 DAT, whereas *B. thuringiensis* and NSKE showed only 70 per cent mortality. Likewise, [7] observed that lower pod damage due to *H. armigera* was recorded in endosulfan than *B.thuringiensis* var.*kurstaki* in pigeonpea. [8, 9, 10, 11] also found that per cent pod and grain damage due to *H. armigera* at harvest was the lowest in spinosad and reported that all the chemical insecticides were superior over the biopesticides with high yield and benefit:cost ratio. The two biopesticides *viz*., *B.thuringiensis* and *Metarihizium anisopliae* were moderately effective while botanical pesticide, neem fruit extract was ineffective. In contrast to the above, [12] reported that neem extract and *B. thuringiensis* were not as effective as the synthetic insecticides [13]. also reported that *Btk*, *Btk* alternated with endosulfan alone was the most effective in the reduction of larval population of *H. armigera*. [14] reported that *B.t* var. *Kurstaki* based product (Spic-Bio) @2.5 l /ha was the best treatment recording the lesser *H. armigera* larval population (0.7/plant).

Table 1: Evaluation of Eco-friendly insecticides for the management of spotted podborer, *M.vitrata* in Pigeonpea (*Kharif* 2018)

Treatments	Dose (per litre)	Web counts (No. /plant)									
			I spray			II spray			III spray		
		Precount	3 DAT	7 DAT	10 DAT	3 DAT	7 DAT	10 DAT	3 DAT	7 DAT	10 DAT
T1: *Bt Kurstaki*	1.0 g	10.00	6.67 (2.58)	5.89 (2.42)	5.78 (2.39)	4.56 (2.13)	4.11 (2.02)	3.89 (1.97)	2.78 (1.66)	2.56 (1.58)	2.11 (1.43)
T2: *Beauveria bassiana*	5.0 g	9.56	7.67 (2.77)	7.33 (2.71)	6.44 (2.53)	5.44 (2.32)	5.33 (2.30)	5.09 (2.26)	4.11 (2.02)	3.00 (1.72)	2.67 (1.62)
T3: *Metarhizium anisopliae*	5.0 g	9.78	7.11 (2.66)	6.67 (2.58)	7.00 (2.64)	6.22 (2.49)	5.89 (2.42)	5.70 (2.39)	4.11 (2.03)	3.11 (1.76)	2.33 (1.52)
T4: *Lecanicilium lecanii*	5.0 g	9.78	5.33 (2.30)	5.11 (2.25)	6.11 (2.47)	6.00 (2.45)	5.56 (2.36)	5.55 (2.36)	4.33 (2.08)	3.00 (1.73)	2.56 (1.59)
T5: *Azadirachtin 1500 ppm*	5.0ml	9.11	6.00 (2.45)	5.78 (2.40)	6.11 (2.47)	5.33 (2.31)	5.22 (2.28)	5.20 (2.28)	4.11 (2.01)	3.67 (1.91)	3.11 (1.76)
T6: Chlorantraniliprole 18.5 SC 30 g a.i/ha >Flubendiamide 480 SC @ 30 g a.i/ha> dimethoate	-	10.00	2.56 (1.60)	2.89 (1.70)	2.67 (1.63)	1.89 (1.37)	1.56 (1.25)	1.62 (1.27)	0.56 (0.74)	0.33 (0.50)	0.22 (0.42)
T7:Untreated check	-	10.44	11.22 (3.35)	11.22 (3.35)	10.89 (3.30)	11.00 (3.32)	11.22 (3.35)	10.99 (3.31)	10.89 (3.30)	11.44 (3.38)	12.00 (3.46)
SED		NS	0.42	0.42	0.71	0.40	0.41	0.05	0.45	0.28	0.28
CD<0.5%			0.91	0.92	0.52	0.87	0.88	0.11	0.96	0.61	0.60

Values in parentheses are square root transformed values

Table 2: Evaluation of Eco-friendly insecticides for the management of spotted podborer, *M.vitrata* in pigeonpea (*Kharif* 2019)

Treatments	Dose (per litre)	Web counts (No. /plant)									
			I spray			II spray			III spray		
		Precount	3 DAT	7 DAT	10 DAT	3 DAT	7 DAT	10 DAT	3 DAT	7 DAT	10 DAT
T1: *Bt Kurstaki*	1.0 g	9.66	5.64 (2.57)	5.44 (2.33)	5.44 (2.32)	4.22 (2.05)	4.32 (2.07)	3.43 (1.85)	2.55 (1.59)	2.44 (1.55)	1.89 (1.33)
T2: *Beauveria bassiana*	5.0 g	10.18	6.33 (2.52)	5.55 (2.36)	6.20 (2.49)	4.78 (2.16)	4.66 (2.16)	3.52 (1.87)	3.67 (1.91)	3.09 (1.75)	2.42 (1.55)
T3: *Metarhizium anisopliae*	5.0 g	10.09	7.11 (2.60)	6.33 (2.52)	6.66 (2.58)	6.22 (2.49)	5.56 (2.36)	4.82 (2.19)	3.86 (1.96)	3.22 (1.78)	2.76 (1.65)
T4:*Lecanicilium lecanii*	5.0 g	10.09	7.33 (2.71)	7.00 (2.64)	6.33 (2.52)	6.00 (2.45)	5.53 (2.35)	4.82 (2.19)	4.29 (2.06)	3.20 (1.78)	2.78 (1.67)
T5:*Azadirachtin 1500 ppm*	5.0ml	9.98	6.33 (2.52)	6.11 (2.47)	6.20 (2.49)	5.09 (2.25)	5.00 (2.23)	4.07 (2.02)	3.78 (1.94)	3.11 (1.76)	2.44 (1.56)
T6: Chlorantraniliprole 18.5 SC 30 g a.i/ha >Flubendiamide 480 SC @ 30 g a.i/ha> dimethoate	-	10.31	2.22 (1.48)	2.56 (1.59)	2.88 (1.69)	2.10 (1.45)	1.44 (1.20)	1.39 (1.18)	0.63 (0.78)	0.11 (0.26)	0.33 (0.50)
T7:Untreated check	-	10.53	11.09 (3.35)	11.33 (3.37)	10.89 (3.32)	10.88 (3.30)	11.32 (3.36)	11.48 (3.39)	11.09 (3.33)	11.56 (3.10)	11.88 (3.45)
SED		NS	0.48	0.59	0.73	0.52	0.47	0.26	0.42	0.38	0.41
CD<0.5%			1.06	1.29	1.60	1.14	1.03	0.58	0.93	0.82	0.90

Values in parentheses are square root transformed values

Table 3: Effect of eco-friendly insecticides on the spotted pod borer damage and yield

Treatments	Dose (per litre)	Mean Web counts *	Per cent pod damage			Per cent reduction over control	Yield (Kg/ha)			Percent Yield increase over check
			2018	2019	Mean		2018	2019	Mean	
T1: *Bt Kurstaki*	1 g	4.10	33.33 (35.25)	13.33 (25.50)	23.33	52.59	858.3	963.3	910.8	39.08
T2: *Beauveria bassiana*	5.0 g	4.84	38.89 (38.57)	16.00 (24.43)	27.44	44.12	820.0	976.0	898.0	37.09
T3: *Metarhizium anisopliae*	5.0 g	5.25	37.78 (37.92)	28.67 (30.12)	33.21	32.37	798.3	843.3	820.8	25.31
T4:*Lecanicilium lecanii*	5.0 g	5.04	37.78 (37.90)	28.67 (30.12)	33.21	32.37	780.0	878.0	829.0	26.56
T5:*Azadirachtin 1500 ppm*	5.0ml	4.81	40.00 (39.22)	21.33 (26.37)	30.66	37.56	826.0	870.0	848.0	29.46
T6: Chlorantraniliprole 18.5 SC 30 g a.i/ha >Flubendiamide 480 SC @ 30 g a.i/ha> dimethoate	-	1.54	20.00 (26.43)	6.67 (18.81)	13.33	72.85	1098.2	1193.3	1145.7	74.90
T7:Untreated check	-	11.24	68.89 (56.14)	29.33 (29.12)	49.11	-	610.0	700.0	655	-

Values in parentheses are arc sine transformed values * Mean of two seasons

4. Conclusion

From the present study, it may be concluded among the bio-insecticides tested, the application of *Bt* var *Kurstaki* @ 1.0 g /l was found effective for the suppression of *Maruca* webcounts for obtaining higher grain yield and can be included as one of the eco-friendly approach to find place in IPM concept of pod borer management and also to avoid the insecticide resistance. At the same time, for immediate reduction of webcounts of *M. vitrata* three sequential application of Chlorantraniliprole 18.5 SC 30 g a.i/ha followed by Flubendiamide 480 SC @ 30 g a.i/ha and Deltamethrin 2.8 EC@ 12.5 g a.i/ha may be given for obtaining the highest grain yield.

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