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Efficacy of chemical insecticides against spotted pod borer, *Maruca vitrata* (Geyer) on pigeonpea

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Abstract

The different eight chemical insecticides were evaluated against *Maruca vitrata* (Geyer) in pigeonpea field during *Kharif*, 2021-22 and 2022-23. The pooled results showed that the plots treated with flubendiamide 39.35 SC @ 0.008% found significantly most effective which showed lowest population of 0.44 larva per plant followed by chlorantraniliprole 18.5 SC @ 0.006% (0.67 larva/plant). Among the investigated insecticides, plots treated with novaluron 10 EC @ 0.005% was found significantly least (1.46 larvae/plant) effective but superior to the untreated control. The significantly higher (1480 kg/ha) seed yield was obtained in plots treated with chlorantraniliprole 18.5 SC @ 0.006% and it remained at par with flubendiamide 39.35 SC @ 0.008% (1367 kg/ha). However, the treatment of novaluron 10 EC @ 0.005% recorded minimum (1046 kg/ha) yield.

Keywords: *Maruca vitrata*, insecticides, pigeonpea, population, larva, plant

Introduction

Pigeonpea [*Cajanus cajan* (Linnaeus) Millspaugh] is an important grain legume crop of the tropics and sub-tropics. It is also known as tur, arhar and redgram. Pigeonpea is a rich source of protein (22.3%) which supplies a major share of the protein requirement of the vegetarian population of the country, making it a valuable component for improving food security and nutrition for many poor families (Tiwari and Shivhare, 2016) [10]. It has better quality fiber, 7g/100g of seeds (Kandhare, 2014) [5]. Besides its nutritional value, it also possesses various medicinal properties due to the presence of several polyphenols and flavonoids. Pigeonpea is a multi-purpose crop used as dal (split grains), vegetable (green seeds and pods), fodder (green and dry leaves), feed (dry crushed grains) and fuel. It helps in natural nitrogen fixation and can be grown for green manuring. Globally, pigeonpea is grown in an area of 6.03 million hectares with a production of 5.33 million tonnes and productivity of 883.40 kg/ha (FAO, 2022) [3]. In India, it is grown on 5.05 million hectares with an annual production and productivity of 4.34 million tonnes and 859 kg/ha, respectively. Maximum economic damage is caused by the insect pests feeding on buds, flowers and pods. Among several insect pests infesting pigeonpea, the lepidopteran pests viz., pod borer, *Helicoverpa armigera* (Hubner); spotted pod borer, *Maruca vitrata* (Geyer); pod fly, *Melanagromyza obtusa* (Malloch); plume moth, *Exelastis atomosa* (Walshingham) and blue butterfly, *Lampides boeticus* (Linnaeus) are most serious. Damage inflicted by *H. armigera* larvae is confined to flowers, seeds and pods and a single larvae can destroy 30-40 pods. Whereas *M. vitrata* larvae causes substantial damage to flowers by webbing and boring into the pods (Sreekanth *et al.*, 2015) [9]. In India, the pod damage caused by *M. obtusa*, *C. gibbosa*, *H. armigera* and *M. vitrata* has been reported to be 34.4 to 49.9, 23.1 to 47.3, 9.4 to 18.1 and 5.7 to 12.4%, respectively (Keval *et al.*, 2017) [6]. Considering the above facts, the present investigations are carried out.

2. Materials and methods

2.1 Experimental details

Table 1: Experimental Details of the Field Trial Conducted on Pigeonpea

Location	:	Agronomy Instructional Farm C. P. College of Agriculture S. D. Agricultural University Sardarkrushinagar
Year & Season	:	<i>Kharif</i> , 2021-22 and 2022-23
Crop and Variety	:	Pigeonpea, GT 101
Design	:	Randomized Block Design (RBD)
Replications	:	3
No. of treatments	:	9
Plot size i) Gross	:	4.80 m x 4.00 m
ii) Net	:	3.60 m x 3.00 m
Spacing	:	60 cm x 20 cm
Fertilizer	:	25:50:00 - N:P:K (kg/ha)

2.2 Treatment details

The details of insecticides and their doses used in the present investigation were given as below.

Table 2: Details of Treatments Applied in the Field Experiment

Tr. No.	Treatments	Concentration (%)	Dose (g or ml / 10 lit. of water)
T ₁	Chlorantraniliprole 18.5 SC	0.006	3
T ₂	Spinosad 45 SC	0.015	3
T ₃	Flubendiamide 39.35 SC	0.008	2
T ₄	Indoxacarb 14.5 SC	0.01	7
T ₅	Chlorantraniliprole 9.30 + Lambda cyhalothrin 4.60 ZC	0.006	4
T ₆	Novaluron 10 EC	0.005	5
T ₇	Profenofos 40 + Cypermethrin 4 EC	0.088	20
T ₈	Emamectin benzoate 5 SG	0.002	4
T ₉	Untreated control	-	-

2.3 Application of insecticides

The first spray was applied at 50% flowering and second spray at 15 days after first spray. The spray volume for treatment was calibrated by spraying water in control plot. Spraying was done by using knapsack sprayer in early morning hours.

2.4 Observations recorded

The number of *M. vitrata* larvae was counted on five randomly selected plants from each treatment one day before and three, seven and fifteen days after application of treatment.

3. Results

A field experiment was conducted at the Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, during *Kharif*, 2021-22 and 2022-23 to investigate the efficacy of different chemical insecticides against management of *M. vitrata* in pigeonpea.

3.1 First year (2021-22)

The efficacy of different newer insecticides was evaluated by counting the larvae of spotted pod borer, *M. vitrata* on pigeonpea after two sprayings. The observations were taken one day before, 3, 7 and 15 days after spraying. The efficacy of different chemical insecticides against *M. vitrata* populations are presented in Table 3.1. The results showed that the population of *M. vitrata* before spray was homogeneously distributed in all plots, ranging between

2.32 and 2.55 larvae per plant, which was statistically non-significant.

3.1.1 First spray

The results showed that significantly lowest (0.77 larva/plant) population was recorded from plots treated with flubendiamide 39.35 SC @ 0.008% which was at par with chlorantraniliprole 18.5 SC @ 0.006% (0.99 larva/plant) at three days after first spray. The next effective group of treatments were spinosad 45 SC @ 0.015% (1.34 larvae/plant), emamectin benzoate 5 SG @ 0.002% (1.39 larvae/plant), chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (1.44 larvae/plant), indoxacarb 14.5 SC @ 0.010% (1.49 larvae/plant), profenofos 40 + cypermethrin 4 EC @ 0.088% (1.54 larvae/plant) and novaluron 10 EC @ 0.005% (1.59 larvae/plant) which were at par with each other. Among the studied insecticides, the plots treated with novaluron 10 EC @ 0.005% was least effective (1.59 larva/plant) but which was superior over the untreated control (2.47 larvae/plant).

The data on larval population of *M. vitrata* recorded at seven days after first spray of insecticides revealed that flubendiamide 39.35 SC @ 0.008% was significantly the most effective treatment which recorded the lowest (0.69 larva/plant) population which remained at par with chlorantraniliprole 18.5 SC @ 0.006% (0.86 larva/plant). The treatments spinosad 45 SC @ 0.015%, emamectin benzoate 5 SG @ 0.002%, chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% were found to be the next best group of treatments which were statistically at par with each other as they recorded 1.22, 1.28 and 1.33 larvae per plant, respectively. However, rest of the insecticide treatments were significantly superior over untreated

control. Among the studied insecticides, plots treated with novaluron 10 EC @ 0.005% was significantly least (1.49 larvae/plant) effective. The untreated control recorded the highest population of 2.54 larvae per plant.

Fifteen days after first spray the significantly lowest population (0.75 larva/plant) was recorded from plots treated with flubendiamide 39.35 SC @ 0.008% which was at par with chlorantraniliprole 18.5 SC @ 0.006% (0.94 larvae/plant). The next effective group of treatments were spinosad 45 SC @ 0.015% (1.31 larvae/plant), emamectin benzoate 5 SG @ 0.002% (1.36 larvae/plant), chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (1.41 larvae/plant), indoxacarb 14.5 SC @ 0.010% (1.47 larvae/plant), profenofos 40 + cypermethrin 4 EC @ 0.088% (1.50 larvae/plant) and novaluron 10 EC @ 0.005% (1.54 larvae/plant) which were at par with each other. The untreated control recorded significantly highest (2.67 larvae/plant) population of *M. vitrata*.

The results of pooled over period data after first spray presented in Table 3.1 reported that the plots treated with flubendiamide 39.35 SC @ 0.008% was significantly most effective which showed lowest population of 0.73 larva per plant, which was followed by chlorantraniliprole 18.5 SC @ 0.006% (0.94 larvae/plant), spinosad 45 SC @ 0.015% (1.30 larvae/plant), emamectin benzoate 5 SG @ 0.002% (1.36 larvae/plant), chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (1.41 larvae/plant), indoxacarb 14.5 SC @ 0.010% (1.47 larvae/plant), profenofos 40 + cypermethrin 4 EC @ 0.088% (1.49 larvae/plant) and novaluron 10 EC @ 0.005% (1.54 larvae/plant). Among the studied insecticides, plots treated with novaluron 10 EC @ 0.005% was significantly the least (1.54 larvae/plant) effective but was superior over the untreated control (2.56 larvae/plant).

Table 3.1: Efficacy of different chemical insecticides against *M. vitrata* on pigeonpea during 2021-22

Tr. No.	Treatments	Conc. (%)	DBS	No. of larvae/plant								Pooled over period over spray
				1 st spray				2 nd spray				
				3 DAS	7 DAS	15 DAS	Pooled over period	3 DAS	7 DAS	15 DAS	Pooled over period	
T ₁	Chlorantraniliprole 18.5 SC	0.006	1.71 (2.44)	1.22 ^{ab} (0.99)	1.17 ^{ab} (0.86)	1.20 ^{ab} (0.94)	1.20 ^b (0.94)	1.07 ^{ab} (0.64)	0.96 ^{ab} (0.42)	1.00 ^{ab} (0.51)	1.01 ^b (0.52)	1.10 ^b (0.72)
T ₂	Spinosad 45 SC	0.015	1.73 (2.49)	1.36 ^b (1.34)	1.31 ^{bc} (1.22)	1.35 ^b (1.31)	1.34 ^c (1.30)	1.15 ^{bc} (0.83)	1.10 ^{bc} (0.72)	1.13 ^{bc} (0.78)	1.13 ^c (0.78)	1.23 ^c (1.01)
T ₃	Flubendiamide 39.35 SC	0.008	1.72 (2.45)	1.13 ^a (0.77)	1.09 ^a (0.69)	1.12 ^a (0.75)	1.11 ^a (0.73)	0.92 ^a (0.34)	0.84 ^a (0.21)	0.88 ^a (0.27)	0.88 ^a (0.27)	1.00 ^a (0.50)
T ₄	Indoxacarb 14.5 SC	0.010	1.73 (2.51)	1.41 ^b (1.49)	1.37 ^c (1.38)	1.40 ^b (1.47)	1.40 ^c (1.47)	1.34 ^{cd} (1.30)	1.30 ^{de} (1.19)	1.32 ^{cd} (1.24)	1.32 ^d (1.24)	1.36 ^d (1.35)
T ₅	Chlorantraniliprole 9.30 + Lambda cyhalothrin 4.60 ZC	0.006	1.72 (2.47)	1.39 ^b (1.44)	1.35 ^{bc} (1.33)	1.38 ^b (1.41)	1.38 ^c (1.41)	1.31 ^{cd} (1.22)	1.26 ^{cde} (1.10)	1.29 ^{cd} (1.16)	1.29 ^d (1.16)	1.33 ^d (1.27)
T ₆	Novaluron 10 EC	0.005	1.75 (2.55)	1.45 ^b (1.59)	1.41 ^c (1.49)	1.43 ^b (1.54)	1.43 ^c (1.54)	1.39 ^d (1.43)	1.37 ^e (1.37)	1.38 ^d (1.40)	1.38 ^d (1.40)	1.40 ^d (1.46)
T ₇	Profenofos 40 + Cypermethrin 4 EC	0.088	1.74 (2.53)	1.43 ^b (1.54)	1.39 ^c (1.44)	1.42 ^b (1.50)	1.41 ^c (1.49)	1.38 ^{cd} (1.41)	1.34 ^e (1.30)	1.36 ^d (1.34)	1.36 ^d (1.34)	1.39 ^d (1.43)
T ₈	Emamectin benzoate 5 SG	0.002	1.73 (2.50)	1.37 ^b (1.39)	1.33 ^{bc} (1.28)	1.36 ^b (1.36)	1.36 ^c (1.36)	1.19 ^{bcd} (0.91)	1.14 ^{bcd} (0.79)	1.16 ^{bc} (0.85)	1.16 ^c (0.85)	1.26 ^{cd} (1.09)
T ₉	Untreated control	-	1.68 (2.32)	1.72 ^c (2.47)	1.74 ^d (2.54)	1.78 ^c (2.67)	1.75 ^d (2.56)	1.82 ^e (2.79)	1.85 ^f (2.93)	1.87 ^e (3.00)	1.85 ^e (2.93)	1.80 ^e (2.74)
S. Em. ±		T	0.09	0.07	0.06	0.07	0.03	0.07	0.06	0.06	0.03	0.03
		P	-	-	-	-	0.02	-	-	-	0.02	0.01
		S	-	-	-	-	-	-	-	-	-	0.01
		T×P	-	-	-	-	0.07	-	-	-	0.06	0.04
		T×S	-	-	-	-	-	-	-	-	-	0.04
		P×S	-	-	-	-	-	-	-	-	-	0.02
		T×P×S	-	-	-	-	-	-	-	-	-	0.06
C. D. at 5%		T	N.S.	0.20	0.19	0.20	0.09	0.20	0.18	0.19	0.09	0.07
C. V. (%)			8.62	8.24	8.20	8.35	8.27	8.80	8.45	8.74	8.67	8.06

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

Treatment means with the letter(s) in common are not significantly different by DNMRT at 5% level of significance

3.1.2 Second spray

The results indicated that significantly lower population (0.34 larva/plant) was recorded from plots treated with flubendiamide 39.35 SC @ 0.008% which remained at par with chlorantraniliprole 18.5 SC @ 0.006% (0.64 larvae/plant) at three days after second spray (Table 3.1). Spinosad 45 SC @ 0.015% (0.83 larvae/plant) and emamectin benzoate 5 SG @ 0.002% (0.91 larvae/plant) were at par with each other followed next in the group. All the remaining insecticidal treatments were significantly superior over untreated control. Among the studied insecticides, plots treated with novaluron 10 EC @ 0.005%

was least effective (1.43 larvae/plant) but was superior over the untreated control (2.79 larvae/plant).

The data on larval population of *M. vitrata* recorded at seven days after second spray of insecticides revealed that flubendiamide 39.35 SC @ 0.008% was significantly the most effective treatment with 0.21 larva per plant which was at par with chlorantraniliprole 18.5 SC @ 0.006% (0.42 larvae/plant). The treatments spinosad 45 SC @ 0.015% and emamectin benzoate 5 SG @ 0.002% were found to be the next best group of treatments which were statistically at par with each other as they recorded 0.72 and 0.79 larva per

plant, respectively. Rest of insecticidal treatments performed much better than the untreated control (2.93 larvae/plant).

Fifteen days after second spray, significantly lowest (0.27 larva/plant) population was recorded from plots treated with flubendiamide 39.35 SC @ 0.008% and remained at par with chlorantraniliprole 18.5 SC @ 0.006% (0.51 larva/plant). The next effective group of treatments were spinosad 45 SC @ 0.015% (0.78 larva/plant) and emamectin benzoate 5 SG @ 0.002% (0.85 larva/plant) which found at par with each other. All the remaining treatments were significantly better than the untreated control (3.00 larvae/plant).

The results of pooled data after second spray presented in Table 3.1 revealed that the plots treated with flubendiamide 39.35 SC @ 0.008% was significantly more effective with lowest population of 0.27 larva per plant which was followed by chlorantraniliprole 18.5 SC @ 0.006% (0.52 larva/plant), spinosad 45 SC @ 0.015% (0.78 larva/plant), emamectin benzoate 5 SG @ 0.002% (0.85 larva/plant), chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (1.16 larvae/plant), indoxacarb 14.5 SC @ 0.010% (1.24 larvae/plant), profenofos 40 + cypermethrin 4 EC @ 0.088% (1.34 larvae/plant) and novaluron 10 EC @ 0.005% (1.40 larvae/plant). Among the studied insecticides, plots sprayed with novaluron 10 EC @ 0.005% was significantly least (1.40 larvae/plant) effective but superior over the untreated control (2.93 larvae/plant).

3.2 Second year (2022-23)

The efficacy of different chemical insecticides against management of *M. vitrata* populations are presented in Table 3.2. The results showed that the population of *M. vitrata* before spray was homogeneously distributed in all plots, ranging between 2.06 and 2.25 larvae per plant, which was statistically non-significant.

3.2.1 First spray

The results showed that significantly lowest (0.68 larva/plant) population was recorded from plots treated with flubendiamide 39.35 SC @ 0.008% which remained at par with chlorantraniliprole 18.5 SC @ 0.006% (0.96 larva/plant) at three days after first spray. The next effective group of treatments were spinosad 45 SC @ 0.015% (1.24 larvae/plant), emamectin benzoate 5 SG @ 0.002% (1.29 larvae/plant), chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (1.39 larvae/plant) and indoxacarb 14.5

SC @ 0.010% (1.45 larvae/plant) which were at par with each other. Among the studied insecticides, plots treated with novaluron 10 EC @ 0.005% was significantly least (1.63 larvae/plant) effective but was superior over the untreated control (2.22 larvae/plant).

Seven days after first spray of insecticides, the untreated control recorded significantly highest (2.29 larvae /plant) population of *M. vitrata*. The treatment flubendiamide 39.35 SC @ 0.008% was found significantly most (0.57 larva/plant) effective and remained at par with chlorantraniliprole 18.5 SC @ 0.006% (0.85 larva/plant). The treatments spinosad 45 SC @ 0.015%, emamectin benzoate 5 SG @ 0.002%, chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% and indoxacarb 14.5 SC @ 0.010% were found to be the next best group of treatments which were at par with each other with

Values of 1.12, 1.20, 1.28 and 1.32 larvae per plant, respectively. Plot treated with novaluron 10 EC @ 0.005% was significantly least effective (1.52 larvae/plant) but was superior over the untreated control.

The lowest population (0.63 larva/plant) was recorded from the plots treated with flubendiamide 39.35 SC @ 0.008% which remained at par with chlorantraniliprole 18.5 SC @ 0.006% (0.90 larva/plant) fifteen days after first spray. The next effective group of treatments were spinosad 45 SC @ 0.015% (1.18 larvae/plant), emamectin benzoate 5 SG @ 0.002% (1.25 larvae/plant), chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (1.33 larvae/plant) and indoxacarb 14.5 SC @ 0.010% (1.38 larvae/plant) which were at par with each other. However, the remaining treatments performed much better than the untreated control (2.34 larvae per plant).

The mean results of pooled data after first spray presented in Table 3.2 revealed that the plots treated with flubendiamide 39.35 SC @ 0.008% was significantly most effective with lowest (0.63 larva/plant) population which was followed by chlorantraniliprole 18.5 SC @ 0.006% (0.90 larva/plant), spinosad 45 SC @ 0.015% (1.18 larvae/plant), emamectin benzoate 5 SG @ 0.002% (1.25 larvae/plant), chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (1.33 larvae/plant) and indoxacarb 14.5 SC @ 0.010% (1.38 larvae/plant). However, the remaining insecticides treatment performed much better than the untreated control (2.29 larvae/plant). Plots treated with novaluron 10 EC @ 0.005% was significantly the least effective (1.58 larvae/plant).

Table 3.2: Efficacy of different chemical insecticides against *M. vitrata* on pigeonpea during 2022-23

Tr. No.	Treatments	Conc. (%)	DBS	No. of larvae/plant								Pooled over period over spray
				1 st spray				2 nd spray				
				3 DAS	7 DAS	15 DAS	Pooled over period	3 DAS	7 DAS	15 DAS	Pooled over period	
T ₁	Chlorantraniliprole 18.5 SC	0.006	1.63 (2.15)	1.21 ^{ab} (0.96)	1.16 ^{ab} (0.85)	1.18 ^{ab} (0.90)	1.18 ^b (0.90)	0.98 ^{ab} (0.46)	0.92 ^{ab} (0.34)	0.94 ^{ab} (0.39)	0.95 ^b (0.39)	1.07 ^b (0.64)
T ₂	Spinosad 45 SC	0.015	1.64 (2.19)	1.32 ^{bc} (1.24)	1.27 ^{bc} (1.12)	1.30 ^{bc} (1.18)	1.30 ^c (1.18)	1.13 ^{bc} (0.78)	1.08 ^{bc} (0.67)	1.11 ^{bc} (0.73)	1.11 ^c (0.73)	1.20 ^c (0.95)
T ₃	Flubendiamide 39.35 SC	0.008	1.62 (2.12)	1.09 ^a (0.68)	1.04 ^a (0.57)	1.06 ^a (0.63)	1.06 ^a (0.63)	0.87 ^a (0.25)	0.80 ^a (0.14)	0.83 ^a (0.19)	0.83 ^a (0.19)	0.95 ^a (0.40)
T ₄	Indoxacarb 14.5 SC	0.010	1.65 (2.21)	1.40 ^{bc} (1.45)	1.35 ^{bc} (1.32)	1.37 ^{bc} (1.38)	1.37 ^{cd} (1.38)	1.25 ^{cde} (1.06)	1.20 ^{cde} (0.95)	1.22 ^{cde} (1.00)	1.23 ^{de} (1.01)	1.30 ^d (1.19)
T ₅	Chlorantraniliprole 9.30 + Lambda cyhalothrin 4.60 ZC	0.006	1.63 (2.17)	1.37 ^{bc} (1.39)	1.33 ^{bc} (1.28)	1.35 ^{bc} (1.33)	1.35 ^{cd} (1.33)	1.20 ^{cde} (0.95)	1.16 ^{cde} (0.84)	1.18 ^{cde} (0.89)	1.18 ^{cd} (0.89)	1.27 ^{cd} (1.11)
T ₆	Novaluron 10 EC	0.005	1.66 (2.25)	1.46 ^c (1.63)	1.42 ^c (1.52)	1.44 ^c (1.58)	1.44 ^d (1.58)	1.36 ^e (1.35)	1.32 ^e (1.24)	1.34 ^e (1.29)	1.34 ^f (1.29)	1.39 ^e (1.43)
T ₇	Profenofos 40 + Cypermethrin	0.088	1.65	1.44 ^c	1.40 ^c	1.42 ^c	1.42 ^d	1.33 ^{de}	1.29 ^{de}	1.31 ^{de}	1.31 ^{ef}	1.36 ^{de}

	4 EC		(2.23)	(1.57)	(1.46)	(1.51)	(1.51)	(1.27)	(1.16)	(1.21)	(1.21)	(1.35)
T ₈	Emamectin benzoate 5 SG	0.002	1.64 (2.20)	1.34 ^{bc} (1.29)	1.30 ^{bc} (1.20)	1.32 ^{bc} (1.25)	1.32 ^c (1.25)	1.16 ^{bcd} (0.84)	1.11 ^{cd} (0.73)	1.14 ^{cd} (0.79)	1.13 ^c (0.78)	1.23 ^{cd} (1.01)
T ₉	Untreated control	-	1.60 (2.06)	1.65 ^d (2.22)	1.67 ^d (2.29)	1.69 ^d (2.34)	1.67 ^e (2.29)	1.72 ^f (2.47)	1.75 ^f (2.55)	1.77 ^f (2.62)	1.75 ^g (2.55)	1.71 ^f (2.42)
	S. Em. ±	T	0.08	0.07	0.06	0.07	0.03	0.06	0.06	0.06	0.03	0.03
		P	-	-	-	-	0.02	-	-	-	0.02	0.01
		S	-	-	-	-	-	-	-	-	-	0.01
		T×P	-	-	-	-	0.07	-	-	-	0.06	0.04
		T×S	-	-	-	-	-	-	-	-	-	0.04
		P×S	-	-	-	-	-	-	-	-	-	0.02
		T×P×S	-	-	-	-	-	-	-	-	-	0.06
	C. D. at 5%	T	N.S.	0.20	0.19	0.20	0.09	0.19	0.18	0.19	0.09	0.07
	C. V. (%)		8.50	8.41	8.31	8.36	8.36	9.04	8.72	9.08	8.95	8.23

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

Treatment means with the letter(s) in common are not significantly different by DNMRT at 5% level of significance

3.2.2 Second spray

The results showed that significantly lowest (0.25 larva/plant) population was recorded from plots treated with flubendiamide 39.35 SC @ 0.008% which was at par with chlorantraniliprole 18.5 SC @ 0.006% (0.46 larva/plant) at three days after second spray. The next best effective group of treatments were spinosad 45 SC @ 0.015% (0.78 larva/plant), emamectin benzoate 5 SG @ 0.002% (0.84 larva/plant), chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (0.95 larva/plant) and indoxacarb 14.5 SC @ 0.010% (1.06 larvae/plant) which were at par with each other. Novaluron 10 EC @ 0.005% was significantly least effective (1.35 larvae/plant) but which was superior over the untreated control (2.47 larvae per plant).

The data on larval population of *M. vitrata* recorded at seven days after second spray of insecticides showed that flubendiamide 39.35 SC @ 0.008% was significantly most effective treatment which recorded minimum population (0.14 larva/plant) and remained at par with chlorantraniliprole 18.5 SC @ 0.006% (0.34 larva/plant). Spinosad 45 SC @ 0.015% (0.67 larva/plant), emamectin benzoate 5 SG @ 0.002% (0.73 larva/plant), chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (0.84 larva/plant) and indoxacarb 14.5 SC @ 0.010% (0.95 larva/plant) were at par with each other. Plot treated with novaluron 10 EC @ 0.005% was least effective (1.24 larvae/plant) but was superior over the untreated control (2.55 larvae/plant).

Fifteen days after second spray the lowest population (0.19 larva/plant) was recorded from the plots treated with flubendiamide 39.35 SC @ 0.008% which remained at par with chlorantraniliprole 18.5 SC @ 0.006% (0.39 larva/plant). The next effective group of treatments were spinosad 45 SC @ 0.015% (0.73 larva/plant) and emamectin benzoate 5 SG @ 0.002% (0.79 larva/plant), chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (0.89 larva/plant) and indoxacarb 14.5 SC @ 0.010% (1.00 larva/plant) which were at par with each other. Plot treated with novaluron 10 EC @ 0.005% was found least effective (1.29 larvae/plant) but which was superior over the untreated control (2.62 larvae/plant).

The mean results of pooled data after second spray presented in Table 3.2 recorded that the plots treated with flubendiamide 39.35 SC @ 0.008% was found significantly superior (0.19 larva/plant) which was followed by chlorantraniliprole 18.5 SC @ 0.006% (0.39 larva/plant). The next effective treatments were spinosad 45 SC @

0.015% (0.73 larva/plant) and emamectin benzoate 5 SG @ 0.002% (0.78 larva/plant) which were at par with each other. Among the studied insecticides, plots treated with novaluron 10 EC @ 0.005% was significantly least effective (1.29 larvae/plant) but was superior over the untreated control. The untreated control recorded significantly highest population of 2.55 larvae per plant.

3.3 Pooled over year (2021-22 and 2022-23)

The pooled data (2021-22 and 2022-23) for efficacy of different chemical insecticides against management of *M. vitrata* populations are presented in Table 3.3. The results showed that the population of *M. vitrata* day before spray was homogeneously distributed in all the plots, ranging between 2.19 and 2.39 larvae per plant, which was not statistically significant.

During 2021-22, the results of pooled data are presented in Table 3.3 and illustrated in Fig. 3.1 which showed that the plots treated with flubendiamide 39.35 SC @ 0.008% was significantly most effective with 0.50 larva per plant which was followed by chlorantraniliprole 18.5 SC @ 0.006% (0.72 larva/plant), spinosad 45 SC @ 0.015% (1.01 larvae/plant) and emamectin benzoate 5 SG @ 0.002% (1.09 larvae/plant). The next best effective treatment was chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (1.27 larvae/plant) which was followed by indoxacarb 14.5 SC @ 0.010% (1.35 larvae/plant), profenofos 40 + cypermethrin 4 EC @ 0.088% (1.43 larvae/plant) and novaluron 10 EC @ 0.005% (1.46 larvae/plant). Among the investigated insecticides, plots treated with novaluron 10 EC @ 0.005% was shown to be the least effective (1.46 larvae/plant) but superior to the untreated control. The untreated control recorded the highest population of 2.74 larvae per plant.

During 2022-23, the results of pooled over period over spray after second spray are presented in Table 3.3 and graphically depicted in Figure 3.1 revealed that untreated control exhibited maximum incidence of *M. vitrata* (2.42 larvae/plant) while the plots treated with flubendiamide 39.35 SC @ 0.008% was found significantly most effective which showed lowest population of 0.40 larva per plant. It was followed by chlorantraniliprole 18.5 SC @ 0.006% (0.64 larva/plant). Spinosad 45 SC @ 0.015% (0.95 larva/plant), emamectin benzoate 5 SG @ 0.002% (1.01 larvae/plant) and chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (1.11 larvae/plant) were statistically at par with each other and constructed next

group of effective treatments. Plots treated with novaluron 10 EC @ 0.005% showed least effective (1.43 larvae/plant). The findings of pooled data of the first and second year (Table 3.3 and Fig. 3.1) showed that the plots treated with flubendiamide 39.35 SC @ 0.008% was significantly most effective which showed lowest population of 0.44 larva per plant followed by chlorantraniliprole 18.5 SC @ 0.006% (0.67 larva/plant). The next best effective treatments were

spinosad 45 SC @ 0.015% (0.99 larva/plant) and emamectin benzoate 5 SG @ 0.002% (1.04 larvae/plant) and remained statistically at par with each other. Among the investigated insecticides, plots treated with novaluron 10 EC @ 0.005% was significantly least (1.46 larvae/plant) effective but superior to the untreated control. The untreated control had recorded the maximum population of 2.56 larvae per plant.

Table 3.3: Efficacy of different chemical insecticides against *M. vitrata* on pigeonpea (Pooled)

Tr. No.	Treatments	Conc. (%)	Day before spray	No. of larvae /plant		
				Year		Pooled over year
				2021-22	2022-23	
T ₁	Chlorantraniliprole 18.5 SC	0.006	1.67 (2.29)	1.10 ^b (0.72)	1.07 ^b (0.64)	1.08 ^b (0.67)
T ₂	Spinosad 45 SC	0.015	1.68 (2.32)	1.23 ^c (1.01)	1.20 ^c (0.95)	1.22 ^c (0.99)
T ₃	Flubendiamide 39.35 SC	0.008	1.67 (2.29)	1.00 ^a (0.50)	0.95 ^a (0.40)	0.97 ^a (0.44)
T ₄	Indoxacarb 14.5 SC	0.010	1.69 (2.36)	1.36 ^d (1.35)	1.30 ^d (1.19)	1.33 ^{de} (1.27)
T ₅	Chlorantraniliprole 9.30 + Lambda cyhalothrin 4.60 ZC	0.006	1.68 (2.32)	1.33 ^d (1.27)	1.27 ^{cd} (1.11)	1.30 ^d (1.19)
T ₆	Novaluron 10 EC	0.005	1.70 (2.39)	1.40 ^d (1.46)	1.39 ^e (1.43)	1.40 ^f (1.46)
T ₇	Profenofos 40 + Cypermethrin 4 EC	0.088	1.70 (2.39)	1.39 ^d (1.43)	1.36 ^{de} (1.35)	1.38 ^{ef} (1.40)
T ₈	Emamectin benzoate 5 SG	0.002	1.69 (2.36)	1.26 ^{cd} (1.09)	1.23 ^{cd} (1.01)	1.24 ^c (1.04)
T ₉	Untreated control	-	1.64 (2.19)	1.80 ^e (2.74)	1.71 ^f (2.42)	1.75 ^g (2.56)
S. Em. ±		T	0.06	0.03	0.03	0.02
		P	-	0.01	0.01	0.01
		S	-	0.01	0.01	0.01
		Y	0.03	-	-	0.01
		T×P	-	0.04	0.04	0.03
		T×S	-	0.04	0.04	0.03
		P×S	-	0.02	0.02	0.01
		Y×T	0.08	-	-	0.03
		Y×P	-	-	-	0.01
		Y×S	-	-	-	0.01
		T×P×S	-	0.06	0.06	0.04
		Y×S×T	-	-	-	0.04
		Y×S×P	-	-	-	0.02
		Y×P×T	-	-	-	0.04
		Y×S×P×T	-	-	-	0.06
C. D. at 5%		T	NS	0.07	0.07	0.05
		Y×T	-	-	-	NS
C. V. (%)			8.57	8.06	8.23	8.14

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

Treatment means with the letter(s) in common are not significantly different by DNMRT at 5% level of significance

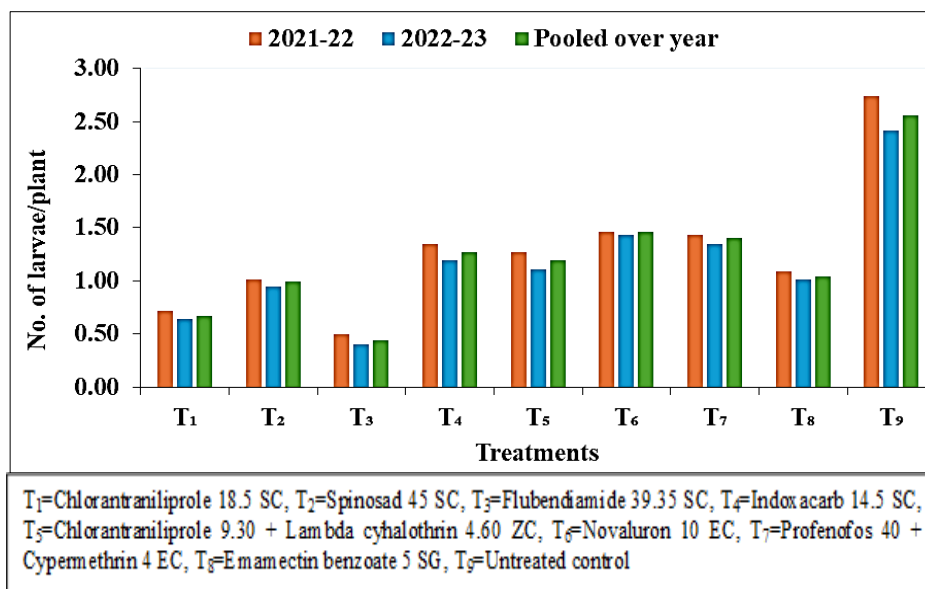


Fig 3.1: Efficacy of different chemical insecticides against *M. vitrata* on pigeonpea

Earlier, Bhagat *et al.* (2022) ^[1] at Raipur, Chhattisgarh reported that among all the treatments, flubendiamide 480 SC was found to be the best treatment against pod borer complex viz., tur pod borer, spotted pod borer and tur pod fly and also gave the highest grain yield (1384.48 kg/ha) of pigeonpea. Chandra *et al.* (2022) ^[2] at Nadia, West Bengal revealed that flubendiamide recorded the lowest mean larval population of *M. vitrata* (0.65 larva/ plant) with highest seed yield. Thus, the current study's findings are very similar to those published by previous research workers.

3.4 Seed yield

3.4.1 First year (2021-22)

The data on seed yield of pigeonpea obtained after application of various treatments are presented in Table 3.4. The significantly higher yield of pigeonpea (1370 kg/ha) was obtained in plots treated with chlorantraniliprole 18.5 SC @ 0.006% and remained at par with flubendiamide 39.35 SC @ 0.008% with 1240 kg per ha and emamectin benzoate 5 SG @ 0.002% with 1179 kg per ha during the year 2021-22. However, the treatments of spinosad 45 SC @ 0.015% (1105 kg/ha), chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% (1089 kg/ha) and indoxacarb 14.5 SC @ 0.010% (1038 kg/ha) were statistically at par with each other. The plots treated with remaining treatments recorded less yield which varied from 1001 to 990 kg per ha but performed superior over untreated control (723 kg/ ha).

Table 3.4: Impact of different chemical insecticides on seed yield of pigeonpea

Tr. No.	Treatments	Conc. (%)	Seed yield (kg/ha)		
			Year		Pooled over year
			2021-2022	2022-2023	
T ₁	Chlorantraniliprole 18.5 SC	0.006	1370 ^a	1590 ^a	1480 ^a
T ₂	Spinosad 45 SC	0.015	1105 ^{bc}	1305 ^{bcd}	1205 ^{cd}
T ₃	Flubendiamide 39.35 SC	0.008	1240 ^{ab}	1494 ^{ab}	1367 ^{ab}
T ₄	Indoxacarb 14.5 SC	0.010	1038 ^{bc}	1219 ^{cd}	1129 ^{de}
T ₅	Chlorantraniliprole 9.30 + Lambda cyhalothrin 4.60 ZC	0.006	1089 ^{bc}	1257 ^{bcd}	1173 ^{cde}
T ₆	Novaluron 10 EC	0.005	990 ^c	1102 ^d	1046 ^e
T ₇	Profenofos 40 + Cypermethrin 4 EC	0.088	1001 ^c	1166 ^{cd}	1084 ^{de}
T ₈	Emamectin benzoate 5 SG	0.002	1179 ^{abc}	1413 ^{abc}	1296 ^{bc}
T ₉	Untreated control	-	723 ^d	808 ^e	765 ^f
S. Em. ±		T	70.44	77.87	48.56
		Y	-	-	24.75
		Y×T	-	-	74.25
C. D. at 5%		T	211.17	233.45	138.78
		Y×T	-	-	NS
C. V. (%)			11.28	10.69	10.98

Treatment means with the letter(s) in common are not significantly different by DNMRT at 5% level of significance

3.4.2 Second year (2022-23)

The results indicated that all the treatments performed significantly superior over untreated control (808 kg/ha). The significantly maximum yield was recorded in the treatment chlorantraniliprole 18.5 SC @ 0.006% (1590 kg/ha) which was statistically at par with flubendiamide

39.35 SC @ 0.008% (1494 kg/ha) and emamectin benzoate 5 SG @ 0.002% (1413 kg/ha). The treatments of spinosad 45 SC @ 0.015%, chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% and indoxacarb 14.5 SC @ 0.010% was statistically at par with each other and formed second best group of effective treatments during the second

year which recorded grain yield of 1305, 1257 and 1219 kg per ha, respectively. Among the studied insecticides, novaluron 10 EC @ 0.005% recorded significantly minimum (1102 kg/ha) yield.

3.4.3 Pooled over year (2021-22 and 2022-23)

The pooled results of 2021-22 and 2022-23 obtained on seed yield of pigeonpea are provided in Table 3.4 and represented in Fig. 3.2 revealed that significantly higher (1480 kg/ha) yield was obtained in plots treated with chlorantraniliprole 18.5 SC @ 0.006% and it remained at par with flubendiamide 39.35 SC @ 0.008% (1367 kg/ha). The treatments of emamectin.

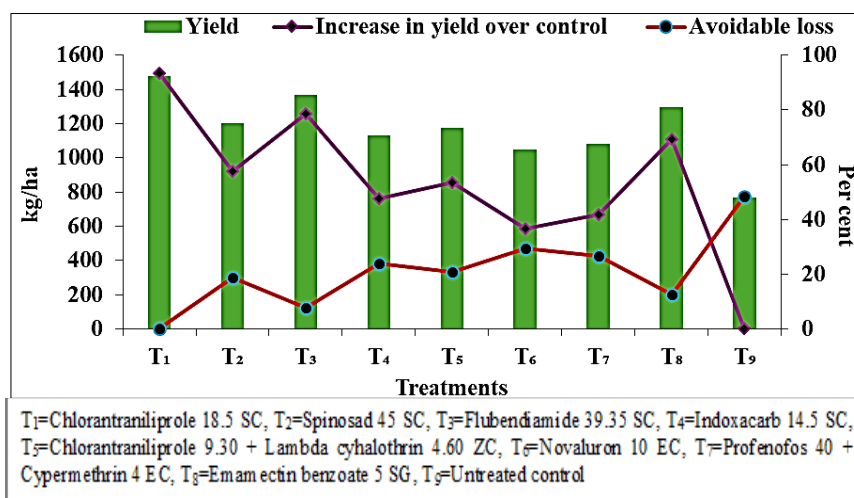


Fig 3.2: Effect of different chemical insecticides on seed yield, increase in yield over untreated control and avoidable loss in pigeonpea (Pooled)

Benzoate 5 SG @ 0.002%, spinosad 45 SC @ 0.015%, chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% and indoxacarb 14.50 SC @ 0.010% recorded moderate yield of pigeonpea 1296, 1205, 1173 and 1129 kg per ha, respectively. The treatments comprised of profenofos 40 + cypermethrin 4 EC @ 0.088% (1084 kg/ha) and novaluron 10 EC @ 0.005% (1046 kg/ha) recorded minimum yield but performed superior over untreated control plots (765 kg/ ha).

Patange and Chiranjeevi (2017) [7] at Parbhani, Maharashtra studied that chlorantraniliprole 18.5 SC @ 30 g a.i./ha was the most effective insecticide in minimizing the larval population and also shown the lowest pod damage (5.59%) due to pigeonpea pod borers and recorded highest grain yield of pigeonpea (7.60 q/ha). Sonune and Bhamare (2018) [8] at Parbhani, Maharashtra found that the significantly maximum grain yield, gross and net profit was recorded in the plots treated with the chlorantraniliprole 18.5 SC (8.79 q/ha with Rs. 20400/- and Rs.14150/-) followed by flubendiamide 39.37 SC (7.83 q/ha. with Rs. 15650/- and Rs.14020/-). Jagtap *et al.* (2023) [4] at Rahuri, Maharashtra reported that spraying of chlorantraniliprole 18.5% EC (0.30

ml/lit.) at fortnightly interval was most effective in controlling pod borers and also gave the highest grain yield (30.54 q/ha) of pigeonpea. Thus, the current study's findings are broadly consistent with those reported by previous researchers.

3.5 Increase in yield over untreated control

The pooled data on increase in yield over untreated control are presented in Table 3.5 and depicted in Fig. 3.2. The results indicated that maximum increase in yield over untreated control was observed in the treatment of chlorantraniliprole 18.5 SC @ 0.006% (93.46%) followed by flubendiamide 39.35 SC @ 0.008% (78.69%) and emamectin benzoate 5 SG @ 0.002% (69.41%). The treatments of spinosad 45 SC @ 0.015%, chlorantraniliprole 9.30 + lambda cyhalothrin 4.6 ZC @ 0.006% and indoxacarb 14.50 SC @ 0.010% recorded 57.52, 53.33 and 47.58% increase in yield over untreated control, respectively. The plots treated with novaluron 10 EC @ 0.005% recorded lowest (36.73%) increase in yield over untreated control.

Table 3.5: Effect of different chemical insecticides on increase in yield over untreated control and avoidable loss in pigeonpea

Tr. No.	Treatments	Conc. (%)	Increase in yield over untreated control (%)			Avoidable loss (%)		
			Year		Average	Year		Average
			2021-22	2022-23		2021-22	2022-23	
T ₁	Chlorantraniliprole 18.5 SC	0.006	89.49	96.78	93.46	-	-	-
T ₂	Spinosad 45 SC	0.015	52.84	61.51	57.52	19.34	17.92	18.58
T ₃	Flubendiamide 39.35 SC	0.008	71.51	84.90	78.69	9.49	6.04	7.64
T ₄	Indoxacarb 14.5 SC	0.010	43.57	50.87	47.58	24.23	23.33	23.72
T ₅	Chlorantraniliprole 9.30 + Lambda cyhalothrin 4.60 ZC	0.006	50.62	55.57	53.33	20.51	20.94	20.74
T ₆	Novaluron 10 EC	0.005	36.93	36.39	36.73	27.74	30.69	29.32
T ₇	Profenofos 40 + Cypermethrin 4 EC	0.088	38.45	44.31	41.70	26.93	26.67	26.76
T ₈	Emamectin benzoate 5 SG	0.002	63.07	74.88	69.41	13.94	11.13	12.43
T ₉	Untreated control	-	-	-	-	47.23	49.18	48.31

3.6 Avoidable loss

The pooled result on avoidable losses in yield is presented in Table 4.28 and graphically depicted in Fig. 4.11. The results revealed that the avoidable loss in pigeonpea crop sprayed with various treatments varied from 7.64 to 48.31%. The plots treated with flubendiamide 39.35 SC @ 0.008% found least avoidable loss with 7.64% followed by emamectin benzoate 5 SG @ 0.002% (12.43%). Moreover, the highest avoidable loss showed in untreated control plots with 48.31%.

4. Conclusion

The present study revealed that the treatment of flubendiamide 39.35 SC @ 0.008% performed as the best treatment supporting lowest *M. vitrata* population of 0.44 larva per plant followed by chlorantraniliprole 18.5 SC @ 0.006% (0.67 larva/plant). The significantly higher (1480 kg/ha) seed yield was obtained in plots treated with chlorantraniliprole 18.5 SC @ 0.006% and it remained at par with flubendiamide 39.35 SC @ 0.008% (1367 kg/ha). However, the treatment of novaluron 10 EC @ 0.005% recorded minimum (1046 kg/ha) yield.

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