Bio-efficacy of selected new generation insecticides and azadirachtin against legume pod borer (*Maruca vitrata*) infesting cowpea

ABSTRACT

In the present study, various combinations of newer generation insecticides and azadirachtin were tested and among them, chlorantraniliprole followed by flubendiamide and novaluron followed by emamectin benzoate were found to be equally effective in reducing the inflorescence and pod damage by *Maruca vitrata* in cowpea. The treatments in which botanicals were alternated with insecticides i.e., azadirachtin followed by chlorantraniliprole and azadirachtin followed by novaluron were found to be on par in efficacy with chlorantraniliprole followed by flubendiamide and novaluron followed by emamectin benzoate. Natural enemy population i.e., wasp, spider and coccinellids was more in plots received no insecticide sprays. Next to these, azadirachtin included treatments have recorded more natural enemy population. In insecticides sprayed plots, wasps were not noticed but spiders were found here and there. High yield was recorded in the treatment, chlorantraniliprole followed by flubendiamide with high BC ratio followed by novaluron followed by emamectin benzoate. Treatments in which azadirachtin was alternated with newer insecticides, BC ratio was slightly lower than the chemicals alone sprayed treatments. However, combining the sprays of novel insecticides with azadirachtin was proved to be ecologically safe as these treatments supported natural enemy population.

Keywords:Cowpea, Maruca vitrata, new generation insecticides, Azadirachtin, natural enemies, yield

1. INTRODUCTION

Legumes are rich in proteins and they serve as the important dietary component in maintaining the health of poor people in tropical regions. Among the legume crops cowpea, the black eyed pea is drought hardy besides nutritious. It's leaves are wide and droopy and hence, conserves the soil moisture due to shading effect (Gomes *et al.,* 2019). It is a versatile crop with diversified uses as food, fodder, vegetable and also used for green manuring. Cowpea is also called as poor men's meat due to the high protein content in leaves, pods, and grains. Cowpea (*Vigna unguiculata* L. [Walp.]) in one of the main grain legumes contributing to food security and poverty alleviation particularly (Ba *et.al.*, 2019) in Sub-Saharan Africa.

Annually, about 6.5 million metric tons of cowpea were reported to be produced in about 14.5 million hectares worldwide (Boukar *et al.*, 2018). Several insect pests occur in cowpea from germination to harvesting stage and hamper to get good yield. In cowpea, 21 insect pests belonging to various orders were reported by Sardhana and Verma, 1986. Among those insects, the legume pod borer, *Maruca vitrata* Fabricius (Lepidoptera: Crambidae) is a key pest both in tropics and sub-tropics. *M.vitrata* larvae feed by remaining inside the flowers, webbed mass of flowers and pods. This concealed feeding complicates the management of this pest as pesticides and natural enemies have difficulty in penetrating the shelter to reach the larvae (Sharma, 1998). *M.vitrata* became a persistent pest in cowpea and is seen throughout the year and in different seasons. It establishes early on the crop, young larvae cause substantial damage at flower bud stage itself and reduces the crop potential for flowering and fruit setting. Due to it's cryptic habitat, this insect remains unnoticed in the field by the farmers. Hence, the present study was undertaken to evaluate the plant based insecticide, azadiractin and insecticide molecules with novel modes of action and various combinations of the both.

2. MATERIALS AND METHODS

The trial was conducted in the Agricultural College and Research Institute, Madurai (9.9755 N, 78.2081 E), Tamil Nadu during the rabi season in 2023, with the treatments given below.

List 1: Treatments details

S. No.	Treatments
1	Azadirachtin 1% EC (1000 ml/ha) followed by novaluron 10 EC @ 750 ml/ha
2	Chlorantraniliprole 18.5 SC 100 ml/ha followed by flubendiamide 39.35 SC @ 100 ml/ha
3	Novaluron 10 EC (750 ml/ha) followed by emamectin benzoate 5 SG @ 220 g/ha
4	Thiamethoxam 25 EG (100g/ha) followed by indoxacarb 14.5 SC @ 350 ml/ha
5	Azadirachtin 1% EC (1000 ml/ha) followed by chlorantraniliprole 18.5 SC @ 150ml/ha
6	Dimethoate 30 EC (500 ml/ha) followed by azadirachtin 0.03 WSP @ 2.5 kg/ha
7	Untreated control

This trial was conducted with the cowpea variety, Ankur. The crop was grown by following the normal agronomic practices. The trial was conducted in a randomized block design with three replications. On the initiation of infestation of legume pod borer in flowering stage of cowpea, first spray was given in 50th standard meteorological week. Before first spraying, pretreatment count was taken in all the treatments and replications on number of *M.vitrata* damaged flowers per plant, number of *M.vitrata* larvae/plant, number of natural enemies *i.e.*, wasps, spiders and coccinellid beetles. After seven and fourteen days of first spraying, post treatment counts were taken.

Second spraying was done after fifteen days of first spray (52nd standard meteorological week) during early pod formation stage. After seven and fourteen days of second spraying, post-treatment counts were taken on legume pod borer incidence in all the treatments and replications. Per cent pod damage was calculated by the following formula.

Number of damaged pods / total number of pods x 100

Population of natural enemies *i.e.*, coccinellids, spiders and wasps was also recorded in all the treatments. Yield was recorded at harvest and benefit cost ratio was calculated for each treatment. BC Ratio was calculated by dividing the present value of benefits by the present value of costs

3. RESULTS AND DISCUSSION

3.1. First spraying

At 7 days after first spraying, mean number of flowers damaged by *M.vitrata* (1.7/plant) were less in T2 (chlorantraniliprole followed by flubendiamide) while in untreated control, 8 damaged flowers/plant were recorded (Table 1). This treatment was followed by T3 (novaluron followed by emamectin benzoate) and T5 (azadirachtin followed by chlorantraniliprole) with 2.7 and 3.7 damaged flowers/plant respectively. T5 was on par with T4 (thiamethoxam followed by indoxacarb) in which 4.7 flowers were damaged per plant. No larval population was found in T2 (chlorantraniliprole followed by flubendiamide) and this treatment was followed by T3 (novaluron followed by emamectin benzoate) in which 0.7 larvae/plant were observed. In unsprayed plots (control), 5 larvae were noted per plant (Table 1). T1 (azadirachtin followed by novaluron) with 3 larvae/plant was on par with T3 (novaluron followed by emamectin benzoate).

At 14 days after first spraying among all the treatments, T2 (chlorantraniliprole followed by flubendiamide) recorded less number of *M.vitrata* damaged flowers (3.0/plant). Next to this, T3 (novaluron followed by emamectin benzoate) was found to be effective in reducing the flower damage (4.3/plant). In untreated control, damaged flowers/plant were 9.3 (Table 1). T3 (Novaluron followed by emamectin benzoate) and T5 (azadirachtin followed by chlorantraniliprole) were on par in efficacy by recording 4.3 and 5.3 damaged flowers/plant respectively. At 14 days after first spraying, chlorantraniliprole followed by flubendiamide (T2) was found to be effective in reducing the larval population (0.7/plant) followed by T3 (novaluron followed by emamectin benzoate) with 1.7 larvae/plant. In untreated control, 9 larvae were recorded per plant.

Wasp (0.20-0.35/plant), spider (0.45-0.55/plant) and coccinellid (0.20-0.35/plant) population was more in untreated plots followed by azadirachtin sprayed treatments. In insecticide sprayed plots, wasps were not recorded. Among the natural enemies, spider population was found here and there in insecticide sprayed plots.

Table1. Evaluation of newer chemicals against *Maruca vitrata* in cowpea (I spraying)

Treatments	Mean no. of *M.vitrata* damaged flowers/plant		Mean no. of *M.vitrata* larvae/plant		Mean no. of natural enemies /plant					
					Wasp		Spider		Coccinellid	
	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS
T1-Azadirachtin foll. by novaluron	4.0 (2.00)^{c}	5.7 (2.39)^{bcd}	2.0 (1.41)^{c}	3.0 (1.73)^{bc}	0.05 (0.22)^{b}	0.20 (0.45)^{ab}	0.20 (0.45)^{b}	0.25 (0.50)^{b}	0.05 (0.22)^{bc}	0.15 (0.39)^{b}
T2- Chlorantraniliprole foll. by flubendiamide	1.7 (1.30)^{a}	3.0 (1.73)^{a}	0.0 (0.00)^{a}	0.7 (0.84)^{a}	0.00 (0.00)^{c}	0.00 (0.00)^{d}	0.00 (0.00)^{d}	0.05 (0.22)^{c}	0.05 (0.22)^{bc}	0.00 (0.00)^{c}
T3-Novaluron foll. by emamectin benzoate	2.7 (1.64)^{b}	4.3 (2.07)^{b}	0.7 (0.84)^{b}	1.7 (1.30)^{b}	0.00 (0.00)^{c}	0.00 (0.00)^{d}	0.05 (0.22)^{cd}	0.00 (0.00)^{d}	0.00 (0.00)^{cd}	0.00 (0.00)^{c}
T4-Thiamethoxam foll. by indoxacarb	4.7 (2.17)^{c}	7.0 (2.65)^{cd}	2.7 (1.64)^{c}	5.0 (2.24)^{de}	0.00 (0.00)^{c}	0.00 (0.00)^{d}	0.00 (0.00)^{d}	0.05 (0.22)^{c}	0.00 (0.00)^{d}	0.00 (0.00)^{c}
T5-Azadirachtin foll. by chlorantraniliprole	3.7 (1.92)^{bc}	5.3 (2.30)^{bc}	1.3 (1.14)^{bc}	3.7 (1.92)^{cd}	0.05 (0.22)^{b}	0.10 (0.32)^{bc}	0.15 (0.39)^{bc}	0.20 (0.45)^{b}	0.15 (0.39)^{ab}	0.10 (0.32)^{b}
T6-Dimethoate foll. by azadirachtin	5.0 (2.24)^{c}	7.3 (2.70)^{d}	3.0 (1.73)^{cd}	6.0 (2.45)^{e}	0.05 (0.22)^{b}	0.05 (0.22)^{c}	0.10 (0.32)^{bc}	0.05 (0.22)^{c}	0.05 (0.22)^{bc}	0.10 (0.32)^{b}
T7-Untreated control	8.0 (2.83)^{d}	9.3 (3.05)^{e}	5.0 (2.24)^{d}	9.0 (3.00)^{f}	0.20 (0.45)^{a}	0.35 (0.59)^{a}	0.45 (0.68)^{a}	0.55 (0.74)^{a}	0.20 (0.45)^{a}	0.35 (0.59)^{a}
CD (0.05)	0.3218	0.3433	0.6020	0.5078	0.1477	0.1677	0.2196	0.1576	0.1852	0.2204
SEd	0.1477	0.1575	0.2763	0.2331	0.0678	0.0770	0.1008	0.0723	0.0850	0.1012

Pretreatment count – 7.7 to 9.0 (damaged flowers)., 4.3 to 5.0 (no. of larvae)

3.2. Second spraying

At 7 days after second spraying, per cent pod damage by *M.vitrata* (1.3) was less in T2 (chlorantraniliprole followed by flubendiamide) as against 13% in untreated control (Table 2). T3 (novaluron followed by emamectin benzoate) and T5 (azadirachtin followed by chlorantraniliprole) were equally effective as T2 with 2.0% pod damage. In T2 (chlorantraniliprole followed by flubendiamide), larval population was nil. Next to this, less larvae (0.3/plant) were recorded in T3 (novaluron followed by emamectin benzoate). T1 (azadirachtin followed by novaluron) and T5 (azadirachtin followed by chlorantraniliprole) were on par with T3 with 1.3 and 1.7 larvae/plant respectively. However, these treatments were on par with T4 (Thiamethoxam followed by indoxacarb) also which recorded 2.0 larvae/plant. In untreated plots, 5 larvae/plant were recorded (Table 2).

At 14 days after first spraying, mean per cent damage was less (0.3%) in T2 (chlorantraniliprole followed by flubendiamide). Followed by this treatment, T5 (azadirachtin followed by chlorantraniliprole), T3 (novaluron followed by emamectin benzoate) and T1 (azadirachtin followed by novaluron) were found to be equally effective with 0.7, 1.0 and 1.0 larvae/plant respectively. In untreated plots, 12.3% pod damage was noted. No larval population was recorded in the plots received chlorantraniliprole followed by flubendiamide

(T2) sprays. T3 (novaluron followed by emamectin benzoate) and T5 (azadirachtin followed by chlorantraniliprole) were equally effective by recording 0.3 larvae/plant. In untreated control, 8.0 larvae were recorded per plant (Table 2).

Wasp (0.15-0.25/plant), spider (0.35-0.50/plant) and coccinellid (0.10/pllant) population was more in plots received no insecticide sprays. Next to these, plots in which azadirachtin was sprayed as one of the sprays have recorded the natural enemy population. In insecticide sprayed plots, wasps were not recorded. Among the natural enemies, spider and coccinellid population was found sparsely in insecticide sprayed plots.

Table2. Evaluation of newer chemicals against *Maruca vitrata* in cowpea (II spraying)

Treatments	Mean % pod damage by *M.vitrata*		Mean no. of *M.vitrata* larvae/plant		Mean no. of natural enemies /plant					
					Wasp		Spider		Coccinellid	
	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS
T1-Azadirachtin foll. by novaluron	2.7 (9.46)^{bc}	1.0 (5.74)^{ab}	1.3 (1.40)^{bc}	0.7 (0.84)^{ab}	0.05 (0.22)^{b}	0.00 (0.00)^{b}	0.1 (0.32)^{c}	0.10 (0.32)^{b}	0.00 (0.00)^{b}	0.00 (0.00)^{b}
T2- Chlorantraniliprole foll. by flubendiamide	1.3 (6.55)^{a}	0.3 (3.14)^{a}	0.00 (0.00)^{a}	0.00 (0.00)^{a}	0.00 (0.00)^{c}	0.00 (0.00)^{b}	0.00 (0.00)^{d}	0.05 (0.22)^{bc}	0.00 (0.00)^{b}	0.00 (0.00)^{b}
T3-Novaluron foll. by emamectin benzoate	2.0 (8.13)^{ab}	1.0 (5.74)^{ab}	1.0 (1.00)^{b}	0.3 (0.55)^{a}	0.00 (0.00)^{c}	0.00 (0.00)^{b}	0.00 (0.00)^{d}	0.00 (0.00)^{c}	0.00 (0.00)^{b}	0.00 (0.00)^{b}
T4-Thiamethoxam foll. by indoxacarb	3.7 (11.09)^{bcd}	2.0 (8.13)^{bc}	2.0 (1.41)^{c}	1.3 (1.14)^{bc}	0.00 (0.00)^{c}	0.00 (0.00)^{b}	0.00 (0.00)^{d}	0.05 (0.22)^{bc}	0.00 (0.00)^{b}	0.00 (0.00)^{b}
T5-Azadirachtin foll. by chlorantraniliprole	2.0 (8.13)^{ab}	0.7 (4.80)^{ab}	1.7 (1.30)^{bc}	0.3 (0.55)^{a}	0.05 (0.22)^{b}	0.10 (0.32)^{a}	0.25 (0.50)^{b}	0.15 (0.39)^{ab}	0.10 (0.32)^{a}	0.05 (0.22)^{a}
T6-Dimethoate foll. by azadirachtin	5.0 (12.92)^{d}	3.3 (10.47)^{c}	3.3 (1.82)^{d}	2.7 (1.64)^{c}	0.15 (0.39)^{ab}	0.05 (0.22)^{a}	0.05 (0.22)^{c}	0.10 (0.32)^{b}	0.05 (0.22)^{a}	0.05 (0.22)^{a}
T7-Untreated control	13.0 (21.13)^{e}	12.3 (20.53)^{d}	9.00 (3.00)^{e}	8.0 (2.83)^{d}	0.25 (0.50)^{a}	0.15 (0.39)^{a}	0.50 (0.71)^{a}	0.35 (0.59)^{a}	0.10 (0.32)^{a}	0.10 (0.32)^{a}
CD (0.05)	2.2849	3.8844	0.3403	0.6819	0.1919	0.1871	0.1801	0.2351	0.1599	0.1376
SEd	1.0487	1.7828	0.1562	0.3129	0.0881	0.0859	0.0826	0.1079	0.0734	0.0631

At harvest, high yield of 950 kg/ha (Table 3) was recorded in T2 (chlorantraniliprole followed by flubendiamide) while in untreated control, it was 950 kg/ha. Next to this treatment, high yield was recorded in T3 (novaluron followed by emamectin benzoate) and T5 (azadirachtin followed by chlorantraniliprole) *i.e.*, 920 kg/ha and 825 kg/ha respectively. T2 (chlorantraniliprole followed by flubendiamide) while in untreated control, it was 950 kg/ha. BC ratio was high (2.20) in T2 (chlorantraniliprole followed by flubendiamide) followed by T3 (novaluron followed by emamectin benzoate) (2.17) and in untreated control, it was 1.37.

Table 3. Economics of newer chemicals in the management of *Maruca vitrata* in cowpea

S.No.	Treatments	Yield (kg/ha)	BC ratio
1	T1-Azadirachtin foll. by novaluron	790.0[d]	1.80
2	T2- Chlorantraniliprole foll. by flubendiamide	950.0[a]	2.20
3	T3-Novaluron foll. by emamectin benzoate	920.0[b]	2.17
4	T4-Thiamethoxam foll. by indoxacarb	710.0[e]	1.79
5	T5-Azadirachtin foll. by chlorantraniliprole	825.0[c]	1.93
6	T6-Dimethoate foll. by azadirachtin	640.0[f]	1.62
7	T7-Untreated control	490.0[g]	1.37
	CD (0.05)	15.1602	
	SEd	6.9579	

During the first spraying in T1, T2, T3, T4, T5 and T6, azadirachtin, chlorantraniliprole, novaluron, thiamethoxam, azadirachtin and dimethoate were sprayed. At fourteen days after first spraying, chlorantraniliprole sprayed plots recorded less *M.vitrata* damage and their larval population. Next to this, novaluron was found to be effective in reducing this pod borer damage followed by azadirachtin treatment. This finding is in agreement with Chandrayudu *et. al.*, 2006 who tested novaluron for the management of legume pod borer and reported it's moderate efficacy to this pod borer.

During the second spraying in T1, T2, T3, T4, T5 and T6, novaluron, flubendiamide, emamectin benzoate, indoxacarb, chlorantraniliprole and azadirachtin were sprayed. Chlorantraniliprole (I spray) and flubendiamide (II spray) was found to be the superior in reducing the spotted pod borer damage in cowpea. In blackgram, flubendiamide 24%+thiacloprid 24-48% recorded very less larval population of *Maruca* in blackgram (Shivaraju *et. al.*, 2011). In line of our findings, Lok Nath Aryal *et.al.*, 2021 stated that chlorantraniliprole 18.5 % SC @ 0.2 ml/lt is a viable option to manage spotted pod borer in cowpea. Efficacy of chlorantraniliprole in reducing the inflorescence damage and pod damage due to legume pod borer with high grain yield was also reported by Sreekanth *et.al.* (2015). The efficacy of Chlorantraniliprole 18.5 SC in reducing *M.vitrata* infestation in greengram was reported by Addigam Gopal Krishna and Ashwani Kumar (2022).

Treatment plots received azadirachtin spray during the first spray, when received novaluron and chlorantraniliprole during second spray were on par with the best treatment in reducing *Maruca* damage. Several previous reports confirmed the effectiveness of botanical formulations based on neem. Neem based formulations prepared from leaves, seed and neem oil were previously reported to be effective for the management of *M.vitrata* (Jackai and

Oyediran 1991; Tanzubil 2000). Jackai *et al.* (1992) attributed less seed damage by *M.vitrata* due to the antifeedant effects of neem based formulations. Emosairue and Ubana (1998) reported increased pod yield due to neem based sprays as they reduced the damage by *M.vitrata.*

Wasp, spider and coccinellids were more in unsprayed plots. Next to these, azadirachtin sprayed treatments have recorded more natural enemy population. In insecticides sprayed plots, wasps were not noticed but spiders were found here and there. Plots sprayed with chlorantraniliprole followed by flubendiamide (T2) have recorded comparatively high yield of 950 kg/ha with 2.20 BC ratio and next to this was novaluron followed by emamectin benzoate (T3) with 920 kg/ha and 2.17 BC ratio. In untreated control, 490 kg/ha and 1.37 BC ratio was recorded.

4. CONCLUSION

Among the various combinations of insecticides with novel modes of action and neem based insecticides, azadirachtin followed by chlorantraniliprole spray and azadirachtin followed by novaluron spray were found to be effective in reducing the legume pod borer damage. These treatments were found to be on par with the chemical sprays alone treatments *i.e.*, chlorantraniliprole followed by flubendiamide sprays and novaluron followed by emamectin benzoate sparys. Moreover, natural enemy *i.e.*, wasps, spiders and coccinellid beetle population was comparatively more in botanicals and chemicals sprayed plots when compared to the chemicals sprayed plots. BC ratio was slightly lower in the azadirachtin included treatments than the chemicals alone sprayed treatments. However, in terms of environment friendly, alternating newer generation insecticides with azadirachtin proved to be a very viable option. As inclusion of neem based insecticides support the natural enemies, maintenance of pest defender ratio is possible which will further reduce the insect population.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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