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Bio-efficacy of Chemical Insecticides and Biopesticides against Gram Pod Borer, *Helicoverpa armigera* (Hubner) and Spotted Pod Borer, *Maruca testulalis* (Geyer) on Greengram, [*Vigna radiata* (L.) Wilczek]

V.P. Meena, S.K. Khinchi, D.K. Bairwa, Akhter Hussain, K.C. Kumawat, K. Anvesh 10.18805/LR-4416

ABSTRACT

Background: Gram pod borer, *Helicoverpa armigera* (Hubner) and spotted pod borer, *Maruca testulalis* (Geyer) are important pod boring insects infesting the greengram, [*Vigna radiata* (L.) Wilczek] throughout the India. A number of synthetic insecticides are known to be effective against these borers but most of them have been phased out as a result of high toxicity to the pollinators and other biotic fauna, therefore, a group of new chemical insecticides with biopesticides have been tested for bioefficacy against these insect pests.

Method: A field experiment was conducted at S.K.N. College of Agriculture, Jobner, Rajasthan during *kharif*, 2018 in randomized block design (RBD) with 9 treatments and 3 replications. The observations were recorded of *Helicoverpa armigera* (Hubner) and spotted pod borer, *Maruca testulalis* (Geyer) borers one day before and 1, 3, 7 and 15 days after application of insecticides and biopesticides in each the spray from ten randomly selected and tagged plants/ plot. From the data recorded per cent reduction in population over control was calculated. The per cent pod damage was calculated by counting damaged pods out of healthy pods of greengram.

Result: The spinosad 45 SC (0.01%) proved to be most effective, indoxacarb 14.5 SC (0.01%) followed by fipronil 5 SC (0.01%), whereas, treatments of neem leaf extract (10.00%), *Beauveria bassiana* 1.15 WP 1X10^{8} spore/ l proved to be least effective. The maximum seed yield of 9.13 q ha^{-1} was obtained in the plots treated with spinosad 45 SC (0.01%) followed by indoxacarb 14.5 SC (0.01%) (8.89 q ha^{-1}), fipronil 5 SC (0.01%) (8.60 q ha^{-1}).

Key words: Bio-efficacy, Greengram, *Helicoverpa armigera*, Insecticides, *Maruca testulalis.*

INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek] (family: Leguminosae) is one of the most important *Kharif* pulse crop grown in India. It is cultivated across seasons in different environments and in variable soil conditions in the South and South-East Asia, Africa, South America and Australia (Parihar *et al.,* 2017). It is one of the most widely cultivated pulse crop after chickpea and pigeonpea (Swaminathan *et al*., 2012). In India, during 2018-19 the total area and production of pulses is 29.03 million hectares, 23.39 million tonnes but greengram occupied 47.56 thousand hectares, 2339.75 thousand tonnes (Anonymous, 2019). The major producing states in India being Andhra Pradesh, Orissa, Maharashtra, Madhya Pradesh and Rajasthan accounting for about 70 per cent of total production.

About 65 species of insects has been recorded on greengram (Siddapaji *et al*., 1979). The insect pests exercising heavy toll of greengram crop include pod borer complex *viz,* gram pod borer, *Helicoverpa armigera* (Hubner), blue butter fly, *Lampides boeticus* L., spotted pod borer*, Maruca testulalis* (Geyer), pod bug, *Riptortus spp*. are major pests of greengram (Sundararajan and Chitra 2017). Gram pod borer, *H. armigera* is widely distributed throughout India and has been recorded feeding on 181 cultivated and uncultivated plant species belonging to 45 families (Manjunath *et al*., 1989). Sixty cultivated and sixty-seven wild host plants attacked by *H. armigera* have been recorded from India (Karim, 2000). Spotted pod borer*, M. testulalis* attributed to the regular outbreaks of greengram because of its extensive host range and destructiveness; it became a persistent pest in greengram. It is reported that 20-30 per cent pod damage in greengram is caused due to spotted pod borer (Zahid *et al*., 2008).

Department of Entomology, S.K.N. College of Agriculture, Sri Karan Narendra Agriculture University, Jobner-303 329, Rajasthan, India.

Corresponding Author: V.P. Meena, Department of Entomology, S.K.N. College of Agriculture, Sri Karan Narendra Agriculture University, Jobner-303 329, Rajasthan, India.
Email: vijaypalmeena16@gmail.com

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It is a common observation that the population of pod borers is brought down by the application of chemical insecticides and botanicals. The present study is an attempt at chemical insecticides and biopesticides were evaluated against pod borer complex with seed yield of greengram as well as at decipher the economics of different treatments.

MATERIAL AND METHODS

The present investigation was conducted at Agronomy Farm, S.K.N. College of Agriculture, Jobner, Rajasthan, India during *kharif*, 2018. The fertilizers and other cultural practices were followed as per the recommendations in the package of practices of Rajasthan. The experiment was laid out in a simple randomized block design (RBD) with nine treatments and each treatment replicated thrice. The individual plot size was 3.0 m x 2.5 m, keeping row to row and plant to plant distance of 30 cm and 10 cm, respectively. The seeds of greengram variety, IPM-02-03 were sown on first week of July.

Method of observation

The observations on larval populations of gram pod borer, *H. armigera* and spotted pod borer, *M. testulalis* were recorded from their appearance to harvesting of the greengram crop. For this purpose, ten plants were randomly selected from each plot and tagged. The incidence of *H. armigera* and *M. testulalis* was determined by counting the population of larvae on ten randomly selected tagged plants at weekly interval. The observations on pod borers population were recorded regularly one day before and 1, 3, 7 and 15 days after application of insecticides and biopesticides in both the sprays. The incidence was also studied in terms of mean pod damage by counting the total number of pods and damage pods on ten randomly selected tagged plants and mean damage was calculated by using the following formula:

The infestation was expressed as a percentage:

$$\text{Mean pod infestation (\%)} = \frac{\text{No. of infested pods}}{\text{No. of total pods}} \times 100$$

Interpretation of data

The population data thus recorded was converted to per cent reduction in population using the method utilized by Henderson and Tilton (1955). The statistical analysis (analysis of variance) was carried out by transforming the data of per cent reduction into angular transformation values (Gomez and Gomez, 1976). The data of seed yield influenced as a result of application of different treatments were also subjected to analysis of variance.

The avoidable loss and increase in seed yield over control was calculated for each treatment by the following formula.

$$\text{\% avoidable loss} = \frac{\text{Highest yield in treated plot} - \text{Yield in the untreated}}{\text{Highest yield in treated plot}} \times 100$$

$$\text{\% increase in yield} = \frac{\text{Yield in treated plot} - \text{Yield in control}}{\text{Yield in control}} \times 100$$

These formulae do not give the exact losses/ increase in yield because even in the best treatment some damage occurs. However, this is considered to be the most feasible method (Pradhan, 1964). The economics of each treatment was worked out by computing the cost of insecticides as well as their cost of application. The gross income was worked out by multiplying the yield with the whole sale rate of greengram seed prevailing at the time of threshing.

RESULTS AND DISCUSSION

The bioefficacy of different treatments were evaluated on the basis of per cent reduction of pod borers population on greengram.

First spray of insecticides and biopesticides

The pre treatment population of pod borer recorded ranged between 8 to 11 larvae for gram Pod borer, *H. armigera* and 13 to 17 larvae for spotted pod borer, *M. testulalis.* One day after application of treatments (Table 1), it was observed that all the treatments were found significantly superior over the untreated control. However, their existed a considerable difference in between the different insecticidal treatments. Maximum per cent reduction of *H. armigera* and *M. testulalis* population after three days of insecticidal application was recorded in all treatment and it ranged from 33.54 to 73.42 per cent reduction in pod borer population and proved significantly superior over control. The maximum reduction 73.42 per cent recorded in spinosad 0.01 per cent treated plots. Agale *et al.* (2021) reported that **s**pinosad 45 SC was most effective against *H. armigera* in pigeonpea. The next effective treatment was indoxacarb 0.01 per cent (71.39 per cent reduction) followed by fipronil 0.01 per cent (70.12 per cent reduction) which were at par with each other. The present findings are in agreement with that of Umbarkar and Parsana (2014) who reported that the spinosad 45 SC and indoxacarb 14.5 SC was the most effective and NSKE 10 per cent moderately effective insecticide in suppression of *M. testulalis* population on greengram. The *Ha* NPV 1 ml/ l reduction with 66.67 per cent reduction, azadirachtin 5 ml/ l with 61.53 per cent reduction, NSKE 10.00 per cent with 60.13 per cent reduction, *neem* oil 1.00 per cent with 55.94 per cent reduction and were at par with each other. Yadav *et al*. (2015) reported that novaluron, difllubenzuron, NSKE and *Metarrhizium anisopliae* were least effective against sucking insect pests in clusterbean. Turkhade *et al.* (2014) reported that the treatment azadirachtin 300 ppm @ 5ml/ l is moderately effective against *H. armigera*.

After seven days of application, all the treatments proved significantly superior in reducing the population of gram pod borer and spotted pod borer in the field. The maximum reduction 70.25 per cent was recorded in the treatment of spinosad 0.01 per cent. The next effective

Table 1: Relative efficacy of insecticides and biopesticide against gram pod borer, *Helicoverpa armigera* (Hubner) and spotted pod borer, *Maruca testulalis* (Geyer) on greengram.

Insecticides	Formulation	Concentration (%)	Per cent population reduction days after spray							
			1st Spray				2nd Spray			
			1 DAS	3 DAS	7 DAS	15 DAS	1 DAS	3 DAS	7 DAS	15 DAS
Indoxacarb	14.5 SC	0.01	66.67	71.39	67.33	63.04	72.52	76.11	70.25	65.90
			(54.74)	(57.66)	(55.14)	(52.56)	(58.38)	(60.74)	(56.95)	(54.27)
Spinosad	45 SC	0.01	69.03	73.42	70.25	65.65	74.46	77.80	72.35	68.32
			(56.19)	(58.97)	(56.95)	(54.12)	(59.64)	(61.89)	(58.28)	(55.75)
Fipronil	5 SC	0.01	65.76	70.12	67.10	61.87	71.29	74.35	69.43	65.65
			(54.19)	(56.86)	(55.00)	(51.87)	(57.60)	(59.57)	(56.43)	(54.12)
Neem leaf extract	Lab. Prepared	10.0	33.20	38.07	35.82	30.14	35.82	42.79	36.15	27.59
			(35.18)	(38.10)	(36.76)	(33.30)	(36.76)	(40.85)	(36.96)	(31.69)
NPV	Ha NPV	1 ml/l	61.81	66.67	63.31	58.77	67.98	71.39	65.90	61.69
			(51.83)	(54.74)	(52.72)	(50.05)	(55.54)	(57.66)	(54.27)	(51.76)
Beauveria bassiana	1.15 WP	$1X10^8$ spore/l	27.29	35.88	30.14	26.32	30.14	35.88	31.30	27.52
			(31.49)	(36.80)	(33.30)	(30.87)	(33.30)	(36.80)	(34.02)	(31.64)
Azadirachtin	0.03 EC	5 ml/l	57.30	61.53	58.97	55.81	63.04	70.12	61.87	57.98
			(49.20)	(51.67)	(50.17)	(48.33)	(52.56)	(56.86)	(51.87)	(49.59)
Neem oil	-	1.0	51.98	55.94	53.97	51.71	57.67	60.02	57.13	53.59
			(46.13)	(48.41)	(47.28)	(45.98)	(49.41)	(50.78)	(49.10)	(47.06)
NSKE	Lab. Prepared	10.0	55.74	60.13	57.48	54.20	61.69	64.15	60.48	56.45
			(48.30)	(50.84)	(49.30)	(47.41)	(51.76)	(53.22)	(51.05)	(48.71)
Control	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	SEM±		1.29	1.33	1.27	1.22	1.33	1.41	1.31	1.26
	CD (P=0.05)		3.72	3.85	3.67	3.52	3.87	4.08	3.79	3.64

Figures in the parentheses are angular values.

treatment was indoxacarb 0.01 per cent with 67.33 per cent reduction and fipronil 0.01 per cent with 67.10 per cent reduction followed by *Ha* NPV 1 ml/ l with 63.31 per cent reduction, azadirachtin 5 ml/ l with 58.97 per cent reduction, NSKE 10.00 per cent with 57.48 per cent reduction and neem oil 1.00 per cent with 53.97 per cent reduction, which were at par with each other. Kaushik *et al.* (2016). Mittal and Ujagir (2005) reported that spinosad is most effective treatment in reducing *M. testulalis* population. Srihari and Patnaik (2006) found that the indoxacarb, spinosad gave the greatest reduction in larval population of *M. testulalis.* The *neem* leaf extract 10.00 per cent was recorded with 35.82 per cent reduction, *B. bassiana* 1 g/ l with 30.14 per cent reduction and were at par with each other.

After fifteen days, maximum reduction in gram pod borer and spotted pod borer was found in spinosad 0.01 per cent treated plots (65.65 per cent reduction) followed by indoxacard 0.01 per cent (63.04 per cent reduction) and fipronil 0.01 per cent (61.87 per cent). Dabariya *et al.* (2010) reported that indoxacard 0.0075 per cent gave highest per cent mortality of *H. armigera* followed by spinosad 0.009 per cent, profenophos + cypermethrin 0.044 per cent and endosulfan 0.07 per cent in pigeonpea. The next effective treatments were *Ha* NPV 1 ml/ l with 58.77 per cent reduction, azadirachtin 5 ml/ l with 58.81 per cent reduction, NSKE 10.00 per cent with 54.20 per cent reduction, neem oil 1.00 per cent was 51.71 per cent reduction and all were at par with each other. The findings are in close agreement with Padmanaban and Arora (2002) who reported 3 sprays at weekly interval of *Ha* NPV 375 LEha-1 significantly lower larval population of 0.83/ ten plants. Jayaraj *et al*. (1987) reported 5 sprays of 250 LE *Ha* NPV at weekly intervals gave satisfactory results against *H. armigera*. Similar results was noticed by Gopali (1998). Deshmukh *et al.* (2010) found that flubendiamide 0.007 per cent was most effective in reducing the *H. armigera* population and pod damage in pigeonpea.

Second spray of insecticides and biopesticides

The maximum reduction of 74.46 per cent was recorded after one day in spinosad 0.01 per cent followed by indoxocarb 0.01 per cent and fipronil 0.01 per cent *i.e*. 72.52 per cent, 71.29 per cent reduction, respectively. The next effective treatments were *Ha* NPV 1 ml/ l, azadirachtin 5 ml/ l, NSKE 10.00 per cent, neem oil 1.00 per cent with 67.98, 63.04, 61.69 and 57.67 per cent reduction respectively, which were at par with each other. The minimum reduction was recorded in plots treated with *neem* leaf extract 10.00 per cent was 35.82 per cent reduction and *B. bassiana* 1 g/ l was 30.14 per cent reduction which was inferior to all the other insecticidal treatments. All the treatments significantly reduced the gram pod borer and spotted pod borer damage after three days of treatment and the per cent reduction ranged from 37.93 to 77.80 per cent. The maximum reduction of pod damage after three days of spraying with recorded in the plots treated with spinosad 0.01 per cent

Table 2: Effect of insecticidal application on the yield of greengram.

Insecticides	Formulation	Concentration (%) dosage ha^{-1}	Mean Yield (q ha^{-1})	Total increase in yield over control (q ha^{-1})	Cost of increased yield (`)*	Total cost of production (Rs)**	Net profit (` ha^{-1})	Benefit-cost ratio
Indoxacarb	14.5 SC	0.01	8.89	4.56	29640	4404	25236	5.73
Spinosad	45 SC	0.01	9.13	4.80	31200	6561.75	24638.25	3.75
Fipronil	5 SC	0.01	8.60	4.27	27755	5772	21983	3.80
Neem leaf extract	Lab. Prepared	10.00	6.10	1.77	11505	1936##	9569	4.94
NPV	Ha NPV	1 ml/l	8.13	3.80	24700	2092.80	2260.20	10.80
Beauveria bassiana	1.15 WP	$1X10^8$ spore/ l	5.26	0.93	6045	2862	3183	1.11
NSKE	Lab. Prepared	10.0	7.09	2.76	17940	1936##	16004	8.26
Neem oil	-	1.0	7.93	3.60	23400	1932	21468	11.11
Azadirachtin	0.03 EC	5 ml/ l	8.06	3.73	24245	4512	19733	4.37
Control	-	-	4.33	0.00	–	–	–	–

* Cost of grains of green gram at current season was ` 6500 'per quintal** It includes cost of insecticides and labour charges @ ` 242 /labour/day (3 labours/spray/ha)## It includes two extra labour for collection of leaves, neem seed and preparation of extract.

Table 3: Comparative economics of insecticidal treatment on greengram.

Insecticides	Formulation	Concentration (%) dosage ha^{-1}	Mean Yield (q ha^{-1})
Indoxacarb	14.5 SC	0.01	8.89
Spinosad	45 SC	0.01	9.13
Fipronil	5 SC	0.01	8.60
Neem leaf extract	Lab. Prepared	10.0	6.10
NPV	Ha NPV	1 ml/ l	8.13
Beauveria bassiana	1.15 WP	$1X10^8$ spore/ l	5.26
NSKE	Lab. Prepared	10.0	7.09
Neem oil	-	1.0	7.93
Azadirachtin	0.03 EC	5 ml/ l	8.06
Control	-	-	4.33
S. Em ±CD (p= 0.05)			0.290.86

was 77.80 per cent reduction and followed by indoxacarb 0.01 per cent and fipronil 0.01 per cent with 72.52 and 71.29 per cent reduction respectively. The next effective treatments were *Ha* NPV 1 ml/ l, azadirachtin 5 ml/ l, NSKE 10.00 per cent, neem oil 1.00 per cent was 71.39, 70.12, 64.15 and 60.02 per cent reduction respectively, which were at par with each other. The minimum reduction of 42.79 and 35.88 per cent was recorded in plots treated with neem leaf extract 10.00 per cent and *B. bassiana* 1 g/ l which were inferior to all the other insecticidal treatments. The per cent reduction after seven and fifteen days of application of treatments with the similar trend and proved significantly superior over control. Singh *et al.* (2014) revealed that Indoxacarb 14.5 SC was effective for *H. armigera* management. Yadav *et al.* (2015) also showed that Indoxacarb 14.5 SC was most effective in reducing the pod borer damage and approximately similar results were found by Sonune *et al*. (2010), Daharia and Katlam (2013) and Gadhiya *et al*. (2014).

Effect of insecticides and biopesticides on the seed yield of greengram

The data presented in the (Table 2) revealed that all the plots treated with insecticides and biopesticides gave significantly higher seed yield over control (4.33 q ha^{-1}). The maximum seed yield of 9.13 q ha^{-1} was obtained in the plots treated with spinosad 45 SC followed by indoxacarb 14.5 SC (8.89 q ha^{-1}) and fipronil 5 SC (8.60 q ha^{-1}) which were found statistically at par with each other. The seed yield (8.13 q ha^{-1}) obtained in the treatment of *Ha* NPV which was at par with treatment of azadirachtin 0.03 EC (8.06 q ha^{-1}), followed by the treatment NSKE 10.00 per cent with seed yield (7.93 q ha^{-1}). The minimum seed yield of (5.26 q ha^{-1}) was obtained in the plots treated with *B. bassiana* 1.15 WP followed by the treatment neem leaf extract (6.10 q ha^{-1}) which was found statistically at par with each other. Jat *et al*. (2012), Chandel *et al*. (2014), Sharma *et al*. (2014) reported that the highest yield was recorded in spinosad 0.01 per cent followed by indoxacarb 0.01 per cent plot.

Economics of insecticides and biopesticides

The highest benefit cost ratio was obtained from the plot treated with Neem oil 1.0 per cent (11.11:1), followed by NPV 1m/l (10.80:1), NSKE (8.26:1), indoxacarb 0.01 per cent (5.73:1), neem leaf extract (4.94:1), azadirachtin (4.37:1), fipronil 0.01 per cent (3.80:1), spinosad 0.01 per cent (3.75:1) these treatment were proved to be most economic (Table 3). The lowest benefit cost ratio was computed in the plot treated with *B. basssiana* (1.11:1). The findings get full support from Gautam *et al*. (2018) who reported maximum benefit cost ratio in neem oil 5ml/ l and followed by NSKE.

CONCLUSION

Out of nine treatments evaluated against gram pod borer, *H. armigera* and spotted pod borer, *M. testulalis*. The spinosad 45 SC (0.01%) proved to be most effective, indoxacarb 14.5 SC (0.01%) followed by fipronil 5 SC (0.01%), whereas, treatments of neem leaf extract (10.00%), *Beauveria bassiana* 1.15 WP $1X10^8$ spore/ l proved to be least effective. The maximum seed yield of 9.13 q ha^{-1} was obtained in the plots treated with spinosad 45 SC (0.01%) followed by indoxacarb 14.5 SC (0.01%) (8.89 q ha^{-1}), fipronil 5 SC (0.01%) (8.60 q ha^{-1}). The highest benefit cost ratio was obtained from the plot treated with Neem oil 1.00 per cent (11.11), followed by *Ha* NPV 1m/ l (10.80), NSKE (8.26), indoxacarb 0.01 per cent (5.73), neem leaf extract (4.94), azadirachtin (4.37), fipronil 0.01 per cent (3.80) and spinosad 0.01 per cent (3.75).

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