Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(3): 3307-3309
Received: 15-03-2018
Accepted: 20-04-2018

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Comparative efficacy of selected chemicals and biopesticides against gram pod borer [*Helicoverpa armigera* (Hubner)] (Lepidoptera: Noctuidae) on cowpea [*Vigna unguiculata* (L.) Walp.]

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Abstract
The present field studies were conducted during *Kharif* 2017 at Central agriculture field, SHUATS (Sam Higginbottom University of Agriculture, Technology and Sciences), Allahabad, Uttar Pradesh (India). All the eight treatments Chlorpyrifos, Cypermethrin, Spinosad, Novaluron, Neem oil, NSKE and *Beauveria bassiana* including control reduced the infestation as compared to the untreated plot of control. The minimum per cent of infestation was observed in Spinosad 45%SC (1.036%) followed by Cypermethrin 10%EC (1.053%), Novaluron 10%EC (1.074%), Chlorpyrifos 20%EC (1.080%), Neem oil 5% (1.092%), *Beauveria bassiana (*1.105%) and NSKE 5% (1.130%) are least among all the treatments. When Cost benefit ratio was worked out, interesting result was achieved. Among the treatment studied, the best and most economical treatment was T_3 Spinosad (1:2.22) followed by T_2 Cypermethrin (1:2.17), T_4 Novaluron (1:1.88), T_1 chlorpyrifos (1:1.74), T_6 Neem oil (1:1.54), T_7 Beauveria bassiana (1:1.25), T_5 NSKE (1:1.15) as compared to T_8 Control (1:0.81).

Keywords: cowpea, *Helicoverpa armigera*, chemicals, biopesticides, cost-benefit ratio

Introduction
The cowpea (*Vigna unguiculata*) is an annual herbaceous legume from the genus Vigna. Due to its tolerance for sandy soil and low rainfall it is an important crop in the semi-arid regions across Africa and other countries. It requires very few inputs, as the plants root nodules are able to fix atmospheric nitrogen, making it a valuable crop for resource poor farmers and well-suited to intercropping with other crops. The whole plant is used as forage for animals, with its use as cattle feed likely responsible for its name.

Four subspecies of cowpea are recognized, of which three are cultivated. There is a high level of morphological diversity found within the species with large variations in the size, shape and structure of the plant. Cowpeas can be erect, semi erect (trailing) or climbing. The crop is mainly grown for its seeds, which are extremely high in protein, although the leaves and immature seed pods can also be consumed (Anonymous, 2015) [3].

It is an important grain legume in the tropics and subtropics. It is a native to central Africa and belongs to the family Fabaceae and is eaten in the form of grain, green pods and leaves. Cowpea is known as vegetable meat due to high amount of protein in the grain with better biological value on dry weight basis. The grain contains 26.61 per cent protein, 3.99 per cent lipid, 56.24 per cent carbohydrates, 8.60 per cent moisture, 3.84 per cent ash, 1.38 per cent crude fibre, 1.51 per cent gross energy, and 54.85 per cent nitrogen free extract (Oyewale *et al.*, 2013) [6].

Rough estimates indicate that annual global production is around 2 MT from an area of 5m.ha. India accounts for about 0.5 MT production from around 1.5 m.ha. In India, the major area under grain cowpea is mainly confined to the states of Uttar Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh and Kerala where, it is mainly sown as a mixed crop with other pulses and cereals. In spite of its importance in food farming, the acreage and production are not being recorded in the crop census of the country as it is rarely grown as an entire crop.

The gram pod borer which is also known as legume pod borer, *Helicoverpa armigera* (Lepidoptera: Noctuidae) is a serious pest of grain legumes in the tropics and subtropics because of its extensive host range, distribution and destructiveness. Due to its destructiveness at critical stages of crop growth *viz.*, flowering and pod development stages especially to the economic plant parts such as flower buds, flowers and pods, it become as a significant constraint to attain the maximum productivity from grain legumes.

Incidence of *Helicoverpa armigera* in cowpea provides information on the initiation and extent of damage at different growth stages of the crop and the relation with weather parameters is of great help to plan appropriate management.

Materials and Methods

The trial was conducted in *Kharif*, season 2017 the central research field, SHUATS, Allahabad (U.P.). Trial was laid out in a randomized block design consisting of eight different treatments. Each treatment was replicated thrice and Cowpea variety Kashi Kanchan was used for study. After observing a sufficient level of insect population, application of treatments for the management of the gram pod borer was undertaken. The data were subjected to statistical analysis. The yield per plot was also recorded.

Results and Discussion

Evaluation of selected chemicals and biopesticides against gram pod borer [*Helicoverpa armigera*] (Hubner) on cowpea. (First spray)

The data on the per cent infestation of gram pod borer on three days after spray revealed that chemicals and biopesticides treatments were significantly superior over control. Among all the treatments lowest per cent infestation of gram pod borer was recorded in (T_3) Spinosad (1.444%) followed by (T_2) Cypermethrin (1.535%), (T_4) Novaluron (1.695%), (T_1) Chlorpyrifos (1.761%), (T_6) Neem oil (1.809%), (T_7) *Beauveria bassiana* (1.903%) and (T_5) NSKE (2.017%) are least among all the treatments. All the treatments were found significantly differ over control.

The data on the percent infestation of gram pod borer on seven days after spray revealed that chemicals and biopesticides treatments were significantly superior over control. Among all the treatments lowest per cent infestation of gram pod borer was recorded in (T_3) Spinosad (1.226%) followed by (T_2) Cypermethrin (1.342%), (T_4) Novaluron (1.454%), (T_1) Chlorpyrifos (1.513%), (T_6) Neem oil (1.562%), (T_7) *Beauveria bassiana* (1.636%) and (T_5) NSKE (1.794%) are least among all the treatments.

All the treatments were found significantly differ but the non-significant difference found in between the treatments (T_7, T_6) (T_1, T_2) (T_1, T_6) (T_1, T_4) (T_6, T_4).

The data on the per cent infestation of gram pod borer on fourteen days after spray revealed that chemicals and biopesticides treatments were significantly superior over control. Among all the treatments lowest per cent infestation of gram pod borer was recorded in (T_3) Spinosad (1.426%) followed by (T_4) Novaluron (1.512%), (T_2) Cypermethrin (1.568%), (T_6) Neem oil (1.581%), (T_1) Chlorpyrifos (1.590%), (T_7) *Beauveria bassiana* (1.607%) and (T_5) NSKE (1.856%) are least among all the treatments. All the treatments were found significantly differ over control.

The mean data on the per cent infestation of gram pod borer revealed that all the chemicals and biopesticides treatments were significantly superior over control. Among all the treatments lowest per cent infestation of gram pod borer was recorded in (T_3) Spinosad (1.166%) followed by (T_2) Cypermethrin (1.215%), (T_4) Novaluron (1.247%), (T_1) Chlorpyrifos (1.276%), (T_6) Neem oil (1.280%), (T_7) *Beauveria bassiana* (1.307%) and (T_5) NSKE (1.379%) are least among all the treatments. All the treatments were found significantly differ from control.

All the treatments were found significantly differ but the non-significant difference found in between the treatments (T_7, T_6) (T_1, T_4) (T_1, T_6) (T_3, T_4) (T_6, T_4).

All the treatments were found significantly differ but the non-significant difference found in between the treatments (T_1, T_7) (T_6, T_2) (T_2, T_3) (T_6, T_4).

Evaluation of selected chemicals and biopesticides against gram pod borer [*Helicoverpa armigera*] (Hubner) on cowpea. (Second spray)

The data on the per cent infestation of gram pod borer on three days after second spray revealed that chemicals and biopesticides treatments were significantly superior over control. Among all the treatments lowest per cent infestation of gram pod borer was recorded in (T_3) Spinosad (1.217%) followed by (T_2) Cypermethrin (1.283%), (T_4) Novaluron (1.305%), (T_1) Chlorpyrifos (1.379%), (T_6) Neem oil (1.435%), (T_7) *Beauveria bassiana* (1.509%) and (T_5) NSKE (1.725%) are least among all the treatments. All the treatments were found significantly differ over control.

The data on the per cent infestation of gram pod borer on seven days after second spray revealed that chemicals and biopesticides treatments were significantly superior over control. Among all the treatments lowest per cent infestation of gram pod borer was recorded in (T_3) Spinosad (0.908%) followed by (T_2) Cypermethrin (1.078%), (T_4) Novaluron (1.207%), (T_6) Neem oil (1.274%), (T_1) Chlorpyrifos (1.326%), (T_7) *Beauveria bassiana* (1.379%) and (T_5) NSKE (1.509%) are least among all the treatments. All the treatments were found significantly differ over control.

The data on the per cent infestation of gram pod borer on fourteen days after second spray revealed that chemicals and biopesticides treatments were significantly superior over control. Among all the treatments lowest per cent infestation of gram pod borer was recorded in (T_3) Spinosad (0.777%) followed by (T_2) Cypermethrin (0.804%), (T_4) Novaluron (0.861%), (T_1) Chlorpyrifos (0.923%), (T_6) Neem oil (0.953%), (T_7) *Beauveria bassiana* (1.137%) and (T_5) NSKE (1.207%) are least among all the treatments. All the treatments were found significantly differ over control.

The mean data on the per cent infestation of gram pod borer revealed that all the chemical treatments were significantly superior over control. Among all the treatments lowest per cent infestation of gram pod borer was recorded in (T_3) Spinosad (0.971%) followed by (T_2) Cypermethrin (1.025%), (T_4) Novaluron (1.053%), (T_1) Chlorpyrifos (1.095%), (T_6) Neem oil (1.109%), (T_7) *Beauveria bassiana* (1.153%) and (T_5) NSKE (1.214%) are least among all the treatments. All the treatments were found significantly differ over control.

All the treatments were found significantly differ but the non-significant difference found in between the treatments (T_1, T_2) (T_1, T_6) (T_1, T_4) (T_3, T_4).

Evaluation of selected chemicals and biopesticides against gram pod borer [*Helicoverpa armigera*] (Hubner) on cowpea. (First spray and Second spray overall mean) and Benefit Cost Ratio (BCR)

The result represented in the overall mean (First & Second Spray) reveals that all the treatments were significantly superior over control. Among all the treatments lowest per cent infestation of gram pod borer was recorded in (T_3) Spinosad (1.036%) followed by (T_2) Cypermethrin (1.053%), (T_4) Novaluron (1.074%), (T_1) Chlorpyrifos (1.080%), (T_6) Neem oil (1.092%), (T_7) *Beauveria bassiana* (1.105%) and (T_5) NSKE (1.130%) are least among all the treatments. All the treatments were found significantly differ over control.

All the treatments were found significantly differ but the non-significant difference found in between the treatments (T_5, T_7) (T_7, T_6) (T_1, T_2) (T_1, T_6) (T_1, T_4) (T_6, T_4).

The yields among the treatment were significant. The highest yield was recorded in T_3 Spinosad (12.3 q/ha) followed by T_2 Cypermethrin (11.1 q/ha), T_4 Novaluron (10.9 q/ha), T_1 chlorpyrifos (9.72 q/ha), T_6 Neem oil (8.74 q/ha), T_7 Beauveria bassiana (8.17q/ha), T_5 NSKE (7.43q/ha) as compared to T_8 Control (5.89 q/ha). When Cost benefit ratio was worked out, interesting result was achieved. Among the treatment studied, the best and most economical treatment was T_3 Spinosad (1:2.22) followed by T_2 Cypermethrin (1:2.17), T_4 Novaluron (1:1.88), T_1 chlorpyrifos (1:1.74), T_6 Neem oil (1:1.54), T_7 Beauveria bassiana (1:1.25), T_5 NSKE (1:1.15) as compared to T_8 Control (1:0.81).

The above findings similarly, they studied effects of five insecticides i.e. chlorpyriphos, (2500 ml/ha), Endosulfan (2500 ml/ha), Indoxocarb (425 ml/ha), Profenophos (2500 ml/ha) and spinosad (200 ml/ha) along with untreated check, among the insecticides tested, Rashid *et al.* (2003) [7] revealed that Spinosad (Tracer) and Indoxacarb (Steward) were highly effective against *Helicoverpa armigera*, while Endosulfan was found to be the least effective insecticide.

The results of the investigation on chemical control of gram pod borer, *Helicoverpa armigera* (Hubner) infesting pigeon pea and indicated that among the different insecticides tested indoxacarb 0.0075% gave the highest per cent mortality of the pest followed by Spinosad 0.009%, Profenophos + Cypermethrin 0.044% and Endosulfan 0.07%. Babariya *et al.* (2010) [4] reported Indoxacarb 0.0075% recorded significantly highest grain yield (1486 kg/ha). While, highest cost benefit ratio of 1: 18.94 was obtained from the treatment of Endosulfan 0.07%. Flubendiamide 480 SC @ 36 g a.i. /ha (9.07 q/ha), Indoxacarb (8.14 q/ha) Chlorpyriphos (7.23 q/ha), Quinalphos (7.10 q/ha), Spinosad (6.93 q/ha) and Endosulfan (6.86 q/ha).

Table 1

S. No.	Treatments	Dosage (gm/ml)	% Infestation							Overall mean
			First spray				Second spray			
			1 DBS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	Mean
T1	Chlorpyrifos 20%EC	1.25ml/lit	2.234 (5.008)	1.761 (3.103)	1.513 (2.296)	1.590 (2.551)	1.379 (1.883)	1.326 (1.766)	0.923 (0.840)	1.080 (1.185)
T_2	Cypermethrin 10%EC	0.6ml/lit	2.277 (5.17)	1.535 (2.350)	1.342 (1.818)	1.568 (2.463)	1.283 (1.633)	1.078 (1.156)	0.804 (0.649)	1.053 (1.120)
T_3	Spinosad 45% SC	0.4ml/lit	2.240 (5.02)	1.444 (2.091)	1.226 (1.498)	1.426 (2.049)	1.217 (1.477)	0.908 (0.812)	0.777 (0.590)	1.036 (1.065)
T_4	Novaluron 10% EC	1ml/lit	2.184 (4.769)	1.695 (2.854)	1.454 (2.126)	1.512 (2.290)	1.305 (1.704)	1.207 (1.453)	0.861 (0.759)	1.074 (1.150)
T_5	NSKE 5%	5ml/lit	2.253 (5.105)	2.017 (4.055)	1.794 (3.226)	1.856 (3.426)	1.725 (2.978)	1.509 (2.258)	1.207 (1.464)	1.130 (1.25)
T_6	Neem oil 5%	5ml/lit	2.260 (5.12)	1.809 (3.265)	1.562 (2.453	1.581 (2.502)	1.435 (2.059)	1.274 (1.627)	0.953 (0.923)	1.092 (1.195)
T_7	*Beauveria bassiana*	2gm/lit	2.233 (5.008)	1.903 (3.612)	1.636 (2.677)	1.607 (2.572	1.509 (2.258)	1.379 (1.898)	1.137 (1.285)	1.105 (1.230)
T_8	Untreated	-	2.277 (5.17)	2.372 (5.662)	2.369 (5.638)	2.476 (6.123)	2.657 (7.030)	2.231 (5.003)	1.850 (3.449)	1.238 (1.525)
F- test		-	NS	S	S	S	S	S	S	S
S. Ed. (±)		-	0.063	0.044	0.050	0.036	0.036	0.051	0.025	0.036
C. D. (P = 0.05)		-	-	0.038	0.114	0.024	0.028	0.035	0.019	0.038

*Figures in parenthesis are Square root transformation.
*Figures in (Mean values) are No transformation.
DBS: Day Before Spray; DAS: Day After Spray.

Acknowledgement
We are grateful to Honourable VC, Dean, Head, Department of Entomology and Director of Research, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, U.P. for providing facilities for this research work.

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