International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(2): 3435-3439

Received: 11-01-2018
Accepted: 12-02-2018

Y Sai
Department of Entomology, College of Agriculture, Bapatla, Guntur, Andhra Pradesh, India

M Sreekanth
Scientist (Entomology), RARS, Lam, Guntur, Andhra Pradesh, India

DV Sairam Kumar
Department of Entomology, College of Agriculture, Bapatla, Guntur, Andhra Pradesh, India

V Manoj Kumar
Department of Entomology, College of Agriculture, Bapatla, Guntur, Andhra Pradesh, India

Correspondence
Y Sai
Department of Entomology, College of Agriculture, Bapatla, Guntur, Andhra Pradesh, India

Bio-intensive management of *Helicoverpa armigera* (Hubner) and *Maruca vitrata* (Geyer) in Pigeonpea

Y Sai, M Sreekanth, DV Sairam Kumar and V Manoj Kumar

Abstract
An experiment was conducted to evaluate different bio-pesticides for the management of pod borers in pigeonpea [*Cajanus cajan* (L.) Millsp.] during *Kharif* 2014 at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh, India. The results showed that the larval population, pod damage and grain damage due to *Helicoverpa armigera* in the experimental area ranged from 0.03 to 7.12 larvae / plant, 6.7 to 24.6% and 5.8 to 18.3% respectively. Similarly, the larval population, pod damage and grain damage due to *Maruca vitrata* ranged from 0.1 to 7.9 larvae / plant, 6.4 to 27.3% and 4.0 to 20.3%, respectively. Among the different bio-pesticides, spinosad 45% SC @ 73g a.i/ha was most effective, followed by recommended insecticide, chlorpyriphos 20EC @ 250g a.i/ha + DDVP 76EC @ 380g a.i/ha which have recorded less pod damage (13.1 and 15.3%, respectively) and grain damage (9.8 and 11.1%, respectively), highest yield (1671 and 1303 kg ha^{-1}, respectively) and highest incremental cost benefit ratio (2.47 and 2.35, respectively).

Keywords: bio-insecticides, *Helicoverpa armigera*, *Maruca vitrata*, pigeonpea, pod borers

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is an important food legume crop in semi-arid tropical and sub-tropical farming systems. It is the most drought tolerant leguminous crop representing about 5% of world legume production. The plant is known to provide several benefits to soil by fixing atmospheric nitrogen, breaking hard plough pans with its long tap root system and helps in releasing soil bound phosphorus in vertisols. The crop can be grown successfully in a wide range soil types including degraded soils with minimum inputs. It is rich in carbohydrates (67%), proteins (18-25%), lipids (0.6-3.8%), crude fiber (1.2-8.1%), sulfur containing amino acids, calcium, manganese, trace elements and good amount of minerals.

In India pigeonpea was grown in 3.96 million ha with a production of 2.56 million tonnes and productivity of 646 kg / ha, whereas, in Andhra Pradesh, the area, production, productivity of pigeonpea was 2.2 lakh ha, 1.32 lakh tonnes and 600kg / ha, respectively during 2015-16 (AICRP report, 2017). The average global productivity of pigeonpea has remained static over the last three decades (Choudhary *et al.*, 2013) [6]. The yield gap was observed between potential yield and on-farm yield due to prevalence of various abiotic and biotic factors together, with the cultivation of pigeonpea in marginal lands with low input supply and lack of implementation of efficient management practices.

Nearly 300 species of insect pests are known to infest pigeonpea at its various growth stages in India. Among these insect pests, gram pod borer, *Helicoverpa armigera* (Hubner) and spotted pod borer, *Maruca vitrata* (Geyer) cause significant economic loss, especially cause damage to economical parts such as flowers, buds and pods. Under favorable conditions, this pod borer causes 60 to 90 per cent loss in grain yield. In all crops put together it was estimated to cause loss of US $400 million annually (ICRISAT, 2007) [9]. The yield loss due to *M. vitrata* was estimated to be 9-84% (Vishakantaiah and Jagadeesh Babu, 1980) with annual monitory loss in India was estimated around US $30 million (Saxena *et al.*, 2002) [18].

Under field conditions, large array of insecticides were used for pest control, but over the period of time, indiscriminate and over use of insecticides provoked counterproductive in crop ecosystem on many aspects such as development of insecticidal resistance, residues on produce, resurgence, destruction of natural enemies and above all endangering human habitat. Under these circumstances bio-pesticides are found to be promising and reliable as they are safer to environment, with almost no side effects and are good substitute to chemical pesticides. Keeping all these in view, the present studies were contemplated to manage these pests.

Materials and Methods

A field trail was conducted to evaluate different formulations of biopesticides for the management of pod borers of pigeonpea, *C. cajan* (L.) Millsp. during *Kharif* 2014 at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh, India. The pigeonpea cultivar, ICPL 85063 (Lakshmi) was used for the experiment in a randomized complete block design with three replicates. Seven treatments (Table 1) were imposed with an untreated control. The plot size was 28.8 m^2 and spacing between rows and plants was 180 cm and 20 cm, respectively. The treatments were imposed by using knapsack sprayer @ 500 L of spray solution ha^{-1}. Each treatment was sprayed 3 times, the first being given at 50% flowering, while second and third sprays were imposed at 10 days interval.

Pre spraying and post spraying counts (5th and 7th day after spraying) of larval population of both pod borers, *H. armigera* and *M. vitrata* were recorded on five randomly selected tagged plants per replication. The number of webs caused due to *M. vitrata* before and 7th day after each spraying was also recorded.

Table 1. Particulars of bio-pesticides used for evaluation against *H. armigera* and *M. vitrata* in pigeonpea during *kharif* 2014.

T. No	Treatments	Trade name	Formulation	Dosage
T_1	NSKE 5%	Locally prepared	Locally prepared	50 g L^{-1}
T_2	*Bacillus thuringeneisis* var. *Kurstaki*	Halt	-	3 g L^{-1}
T_3	*Metarrhizium anisopliae*	Meta power	2×10^8 cfu WP	3 g L^{-1}
T_4	*Beauveria bassiana*	BB power	2×10^8 cfu WP	3 g L^{-1}
T_5	Spinosad	Tracer	45 SC	0.3 ml L^{-1}
T_6	Chlorpyriphos + DDVP	Lentreck + Nuvan	20 EC +76 EC	2.5 ml +1 ml L^{-1}
T_7	Control	-	-	-

To assess the degree of infestation caused by *H. armigera* and *M. vitrata*, two hundred pods were picked out randomly from each replication at the time of harvest and the per cent pod damage was calculated. The pods damaged by *Helicoverpa* have characteristic large round and regular holes; irregular and comparatively small holes with scrapped margins with entrance holes plugged with larval excreta by *Maruca*.

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

The pods were split open to count the healthy and damaged grains and the per cent grain damage was calculated.

$$\text{Per cent grain damage} = \frac{\text{Number of damaged grains}}{\text{Total number of grains}} \times 100$$

The plot yields recorded were converted to kg ha^{-1}. Yield gain was also calculated based on the differences between sprayed and unsprayed yields expressed as proportions of the unsprayed plot yields.

$$\text{Yield Gain} = \frac{\text{Yield}_{\text{(Sprayed)}} - \text{Yield}_{\text{(Unsprayed)}}}{\text{Yield}_{\text{(Unsprayed)}}} \times 100$$

The incremental cost benefit ratio (ICBR) was also calculated by using the formula

$$\text{ICBR} = \frac{\text{Net returns}}{\text{Plant protection cost}} \times 100$$

Net returns (Rs.) = Value of additional yield (Rs.) - Plant protection cost (Rs.)

The data does obtained was subjected to RBD analysis using AGRES package (Gomez and Gomez, 1984) [8].

Results and Discussion

The data recorded on *H. armigera* larval population at 5 days and 7 days after spraying (DAS) revealed that all the treatments were significantly superior over control in reducing the larval population. The cumulative efficacy data of bio-pesticides on *H. armigera* larval population 5 DAS and 7 DAS revealed that spinosad 45% SC was very effective, followed by chlorpyriphos 20EC + DDVP 76EC. The treatments, *Bacillus thuringiensis* var. *kurstaki*, followed by *Beauveria bassiana* and NSKE 5% were next best treatments. The least effective bio-pesticide was found to be *Metarrhizium anisopliae*. Overall efficacy of bio-pesticides against *H. armigera* larval population revealed that spinosad 45% SC @ 73g a.i/ha was most effective, followed by chlorpyriphos 20EC @ 250g a.i/ha + DDVP 76EC @ 380g a.i/ha which have recorded 0.03 and 0.40 larvae per plant respectively with 99.6 and 94.4 % reduction of larval population over control. The next best treatments were *B.thuringiensis* var *kurstaki* @ 1.5kg/ha, followed by *B. bassiana* @ 1.5kg/ha, NSKE 5% and *M. anisopliae* which have recorded 1.20, 1.48, 1.87 and 1.95 larvae per plant respectively with 83.2, 79.2, 73.7 and 72.6% reduction of larval population over control respectively (Table 2).

The data pertaining to the effect of bio-pesticides on *M. vitrata* larval population 5days and 7days after spraying (DAS) also showed that all the treatments were significantly superior over control in reducing the larval population. The cumulative efficacy data of bio-pesticides on *M. vitrata* larval population 5DAS and 7 DAS showed that spinosad 45% SC was most effective and was significantly superior over rest of treatments. The next best treatments were chlorpyriphos 20EC + DDVP 76EC and *B.thuringiensis* var. *kurstaki.* However, the overall efficacy results showed that spinosad 45 % SC @ 73g a.i/ha (0.1 larvae per plant) with 98.7% reduction of larval population over control was most effective, followed by chlorpyriphos 20EC @250g a.i/ha + DDVP 76EC @ 380g a.i/ha (0.5 larvae per plant) with 93.7% reduction of *M. vitrata* larval population over control (Table 3).

The pod damage caused by *H. armigera* ranges from 6.7 to 24.6% among different treatments. Spinosad, followed by chlorpyriphos + DDVP respectively recorded 6.7 and 7.8%

pod damage with 72.9 and 68.3% reduction over control. The same two chemicals also recorded 5.8% and 6.7 % grain damage respectively with 68.1 and 63.8% reduction over control were proved to be best and promising (Table 2 and Fig. 1).

Further, the same two chemicals in the order were also effective in recording less pod damage and grain damage caused due to *M. vitrata.* Spinosad recorded 76.4 and 80.5% reduction of pod damage and grain damage due to *M. vitrata* respectively over control. The treatment, NSKE 5% was found least effective against pod and grain damage caused due to *H. armigera* and *M. vitrata* (Table 3 and Fig. 2).

The results showed that all the treatments were able to record higher yields over control (1069 kg/ha). Spinosad 45 % SC recorded highest yield (1672 kg/ha), followed by chlorpyriphos 20 EC+ DDVP 76 EC, *B. thuringiensis* var. *kurstaki*, *M. anisopliae*, *B.bassiana* and NSKE 5% respectively recorded 1303, 1236, 1210, 1205 and 1134 kg/ha. Similarly, the same treatments in the order were able to record more yield gain *i.e*., 603, 234, 167, 141, 136 and 65 kg/ha respectively over control. The incremental cost benefit ratio (ICBR) ranged from 0.44 to 2.47 among different bio-pesticides evaluated against *H. armigera* and *M. vitrata.* The highest ICBR was recorded with spinosad (2.47), followed by chlorpyriphos (2.35), *Bacillus thuringiensis* var. *kurstaki* (1.93), *Beauveria bassiana* (1.46), *Metarrhizium anisopliae* (1.40) and NSKE 5% (0.44) (Table 4 and Fig. 3).

The present findings with regard to spinosad were in agreement with that of Ghosh *et al*. (2010) [7], Sreekanth and Seshamahalakshmi (2012) [19], Jagadish *et al.* (2014) [10], Sahoo *et al.* (2014) [17] and Rao *et al*. (2014) [15] who reported that spinosad 45 % SC was found effective in controlling pod borers and thereby reducing pod damage with increased yield.

The present findings with regard to chlorpyriphos + DDVP were in agreement with that of Chaitanya *et al.* (2013) [5] and Vinayaka *et al.* (2013) [20] who reported that chlorpyriphos or DDVP alone or in combination were found effective in reducing the pod damage by pod borers.

The efficacy of *Bacillus thuringiensis* var. *kurstaki* against pod borers was also in agreement with findings of Ankali *et al*. (2011) [3] and Rathod *et al*. (2014) [16].

Similarly, the present findings on *Metarrhizium anisopliae* and *Beauveria bassiana* were also in consonance with the findings of Prasad *et al.* (2010) [14], Kpindou *et al.* (2012) [11], Narasimhamurthy and Keval (2013) [13], Agarwal *et al.* (2014) [1], Mehinto *et al.* (2014) [12] and Bajya *et al.* (2015) [4].

Thus, from the present findings it was concluded that new generation insecticide spinosad 45% SC @ 73g a.i/ha was most effective with less pod (13.1%) and grain (9.8%) damage, with more yield (1671 kg ha^{-1}) and highest incremental cost benefit ratio (2.47).

Table 2: Evaluation of bio-pesticides against *Helicoverpa armigera* on pigeonpea during *Kharif* 2014

T. No	Treatment details	Dosage L^{-1}	No. of *H. armigera* larvae / plant#							Pod damage (%)	Reduction over control (%)	Grain damage (%)	Reduction over control (%)
			Pre count	5 DAS	Reduction over control (%)	7 DAS	Reduction over control (%)	Over all efficacy	Overall reduction over control (%)				
T_1	NSKE 5 %	50 g	3.5 (2.12)*	1.77 (1.66)*	73.7	1.97 (1.72)*	73.7	1.87 (1.69)*	73.7	17.4 (24.66)**	29.2	12.7 (20.85)**	30.8
T_2	*Bacillus thuringiensis* var. *kurstaki* @ 1.5 kg/ ha	3 g	4.1 (2.25)	1.33 (1.53)	80.2	1.07 (1.44)	85.7	1.20 (1.48)	83.2	14.0 (21.97)	43.1	9.0 (17.46)	50.8
T_3	*Metarrhizium anisopliae* @ 1.5 kg/ha	3 g	4.3 (2.30)	2.13 (1.77)	68.4	1.77 (1.66)	76.4	1.95 (1.72)	72.6	15.70 (23.34)	36.2	12.3 (20.50)	33.0
T_4	*Beauveria bassiana* @ 1.5 kg/ ha	3g	3.7 (2.16)	1.63 (1.62)	75.8	1.33 (1.53)	82.3	1.48 (1.58)	79.2	14.5 (22.36)	41.2	10.5 (18.94)	42.4
T_5	Spinosad 45 % SC @ 73 g a.i/ ha	0.3ml	3.8 (2.19)	0.03 (1.02)	99.6	0.03 (1.02)	99.6	0.03 (1.02)	99.6	6.7 (14.96)	72.9	5.8 (13.98)	68.1
T_6	Chlorpyriphos 20 EC @ 250 g a.i/ ha + DDVP 76 EC @ 380 g a.i/ha	2.5 ml + 1 ml	3.6 (2.14)	0.33 (1.15)	95.1	0.47 (1.21)	93.7	0.40 (1.18)	94.4	7.8 (16.22)	68.3	6.7 (15.00)	63.8
T_7	Control	--	3.9 (2.20)	6.73 (2.78)	--	7.5 (2.92)	--	7.12 (2.85)	--	24.6 (29.71)	--	18.3 (25.35)	--
F-test		--	NS	Sig.	--	Sig.	--	Sig.	--	Sig.	--	Sig.	--
SEm±		--	0.11	0.06	--	0.06	--	0.06	--	0.61	--	1.64	--
CD (P=0.05)		--	0.35	0.19	--	0.19	--	0.19	--	1.87	--	5.08	--
C.V (%)		--	9.08	6.00	--	6.57	--	6.29	--	4.81	--	13.12	--

* Figures in () are SQRT (n+1) transformed values; ** Figures in () are arc sin transformed values; # Mean of 3 sprays; Sig.- Significant; NS - Non Significant; DAS: Days after spraying

Table 3: Evaluation of bio-pesticides against *Maruca vitrata* on pigeonpea during *Kharif* 2014

T. No	Treatment details	Dosage L^{-1}	No. of *M. vitrata* larvae / plant#							Pod damage (%)	Reduction over control (%)	Grain damage (%)	Reduction over control (%)
			Pre count	5 DAS	Reduction over control (%)	7 DAS	Reduction over control (%)	Over all efficacy	Overall reduction over control (%)				
T_1	NSKE 5 %	50 g	5.4 (2.52)*	1.87 (1.69)*	75.6	1.97 (1.72)*	75.4	1.9 (1.70)*	76.0	19.8 (26.52)**	27.5	14.2 (22.11)**	30.2
T_2	*Bacillus thuringiensis* var. *kurstaki* @ 1.5 kg/ ha	3 g	5.0 (2.44)	1.27 (1.50)	83.4	0.83 (1.35)	89.6	1.1 (1.44)	86.1	11.9 (20.20)	56.3	8.8 (17.29)	56.5

T_3	*Metarrhizium anisopliae* @ 1.5 kg/ha	3 g	5.2 (2.48)	1.97 (1.70)	74.3	1.37 (1.54)	82.9	1.7 (1.64)	78.5	17.3 (24.60)	36.5	9.8 (18.28)	51.6
T_4	*Beauveria bassiana* @ 1.5 kg/ ha	3g	4.6 (2.36)	1.50 (1.58)	80.4	1.03 (1.43)	87.1	1.3 (1.51)	83.8	15.4 (23.21)	43.1	9.0 (17.46)	55.7
T_5	Spinosad 45 % SC @ 73 g a.i/ ha	0.3ml	4.2 (2.28)	0.03 (1.00)	99.6	0.03 (1.02)	99.6	0.1 (1.04)	98.7	6.4 (14.70)	76.4	4.0 (11.49)	80.5
T_6	Chlorpyriphos 20 EC @ 250 g a.i/ ha + DDVP 76 EC @ 380 g a.i/ha	2.5 ml + 1 ml	5.0 (2.44)	0.63 (1.27)	91.8	0.5 (1.23)	93.8	0.5 (1.22)	93.7	7.5 (15.93)	72.4	4.4 (12.06)	78.5
T_7	Control	--	5.4 (2.52)	7.67 (2.95)	--	8 (3.0)	--	7.9 (2.98)	--	27.3 (31.47)	--	20.3 (26.80)	--
F-test		--	N S	Sig.	--	Sig.	--	Sig	--	Sig.	--	Sig.	--
SEm±		--	0.06	0.07	--	0.06	--	0.04	--	0.81	--	1.36	--
CD (P=0.05)		--	0.17	0.24	--	0.20	--	0.11	--	2.49	--	4.20	--
C.V (%)		--	3.94	7.56	--	6.79	--	3.74	--	6.45	--	13.26	--

* Figures in () are SQRT (n+1) transformed values; ** Figures in ( ) are arc sin transformed values; # Mean of 3 sprays; Sig.- Significant; NS - Non Significant; DAS: Days after spraying

Table 4: Economics of different bio-pesticides evaluated against pod borers on pigeonpea during *Kharif* 2014

T. No.	**Treatment details**	**Dosage L^{-1}**	**Cost of the product (Rs.)**	**Yield (kg ha^{-1})**	**Additional yield over control (kg ha^{-1})**	**Value of additional yield ha^{-1} (Rs.) (A)**	***Plant protection cost ha^{-1} for 3 sprays (Rs.) (B)**	**Net returns (Rs.) (A-B)**	**ICBR (A-B)/B**
T_1	NSKE 5 %	5 ml	10 /kg	1134	65	3250	2250	1000	0.44
T_2	*Bacillus thuringiensis* var. *kurstaki* @ 1.5 kg/ ha	3 g	300 /kg	1236	167	8350	2850	5500	1.93
T_3	*Metarrhizium anisopliae* @ 1.5 kg/ha	3 g	320 /kg	1210	141	7050	2940	4110	1.40
T_4	*Beauveria bassiana* @ 1.5 kg/ ha	3g	280 /kg	1205	136	6800	2760	4040	1.46
T_5	Spinosad 45 % SC @ 73 g a.i/ ha	0.3ml	1200/75 ml	1672	603	30150	8700	21450	2.47
T_6	Chlorpyriphos 20 EC@ 250 g a.i/ ha + DDVP 76 EC @ 380 g a.i/ha	2.5 ml + 1 ml	350/L + 450/L	1303	234	11700	3489	8211	2.35
T_7	Control	-	--	1069	--	--	--	--	--

*Quantity of spray fluid used – 500 L per ha; Price of redgam seed – Rs. 50.00 / kg; *Plant protection cost includes spray boy charges

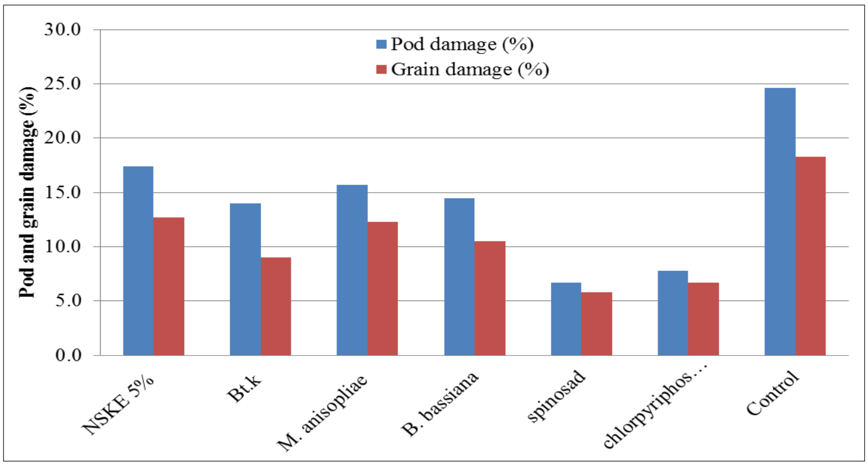

Fig 1: Efficacy of bio-pescticides on pod and grain damage (%) due to *H. armigera* during *kharif* 2014

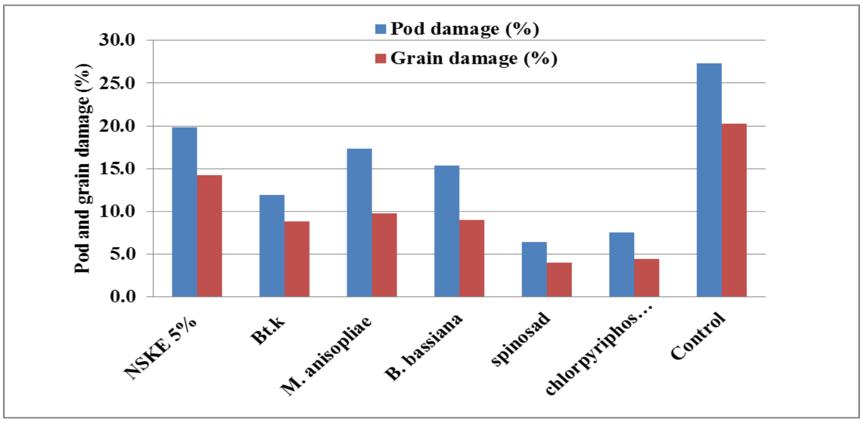

Fig 2: Efficacy of bio-pesticides on pod and grain damage (%) due to M. vitrata during kharif 2014

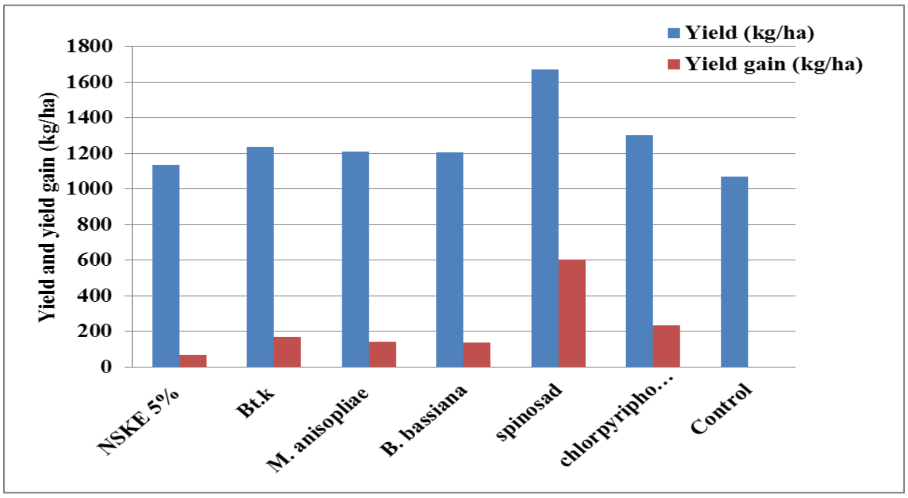

Fig. 3: Effect of bio-pesticides on yield and yield gain of pigeonpea during *kharif* 2014

References

1. Agarwal R, Choudharya A, Tripathi N, Patil N, Agnihotri S, Bharti D. Bio-pesticides formulation of *Metarrhizium anisopliae* against larvae of *Helicoverpa armigera*. International Journal of Agriculture and Food Sciences. 2014; 2 (2):32-36.
2. AICRP Report. All India Co-ordinated Research Project on Pigeonpea. Project Coprdinator's Report (2016-17). Annual group meeting. 2017; 23-24.
3. Ankali SM, Jadhav YT, Jadhav KA, Barkade DP. Study of relative toxicity of Sysnthesis insectide and Bio-pesticides to *Maruca vitrata* on pigeonpea. International Journal of Plant Protection. 2011; 4 (1):156-157.
4. Bajya DR, Ranjith M, Raza SK. Evaluation of *Beauveria bassiana* against chickpea pod borer, *Helicoverpa armigera* and its safety to natural enemies. Indian Journal of Agriculture Science. 2015; 8(3):378-381.
5. Chaitanya T, Sreedevi K, Krishna TM, Prasanthi L. Efficacy of newer molecules of insecticides against legume pod borer, *Maruca vitrata* (Geyer) in pigeonpea. Pesticide Research Journal. 2013; 25 (2):181-184.
6. Choudhary AK, Raje RS, Datta S, Sultana R, Ontagodi T. Conventional and molecular approaches towards genetic improvement in pigeonpea for insect resistance. American Journal of Plant Sciences. 2013; 4:372-385.
7. Ghosh A, Chatterjee M, Roy A. Bioefficacy of spinosad against tomato fruit borer (*Helicoverpa armigera*, Hubner) (Lepidoptera: Noctuidae) and its natural enemies. Journal of Horticulture and Forestry. 2010; 2(5):108-110.
8. Gomez KA, Gomez AA. Statistical procedures for Agricultural Research. Wiley International Publications, John wiley and sons, New York, 1984; 207-215.
9. ICRISAT. The medium term plan. International Crops Research Institute for the Semi-Arid Tropics. Patancheru. 502 324. Telangana. 2007; Vol-3.
10. Jagadish J, Agnihotri M, Sharma R. Evaluation of some Bio-pesticides against some important Lepidopteron Pests of pigeonpea at Pamtnagar, Uttrakhand, India. Greener Journal of Agriculture Sciences. 2014; 4(6):232-237.
11. Kpindou OKD, Diegui DA, Githo IA, Tamo M. Sensitivity of *Helicoverpa armigera* to the Entamopathogenic fungi, *Maruca vitrata* and *Beauveria bassiana* in laboratory. Asian Research publishing Network (ARPN). 2012; 7(12):1007-1015.
12. Mehinto JT, Atachi P, Kpindou OKD, Dannon EAD, Tamo M. Mortality of *Maruca vitrata* larval stages induced by different doses of entamopathogenic fungia *Metarhizium anisopliae* and *Beauveria bassiana*. International Journal of Advanced Research. 2014; 2(4):273-285.
13. Narasimhamurthy GM, Keval R. Field evaluation of some instecides and Bio- pesticides against tur pod bug *Clavigralla gibbosa* in long duration pigeonpea. African Journal of Agriculture Research. 2013; 8(38):4876-4881.
14. Prasad A, Syed Nand Purohit S. *Beauveria bassiana* (balsamo) vuillemin: a successful biopesticide against key pest *Helicoverpa armigera* (Hubner). International Journal of Pharma and Bio Sciences. 2010; 1(2):1-7.
15. Rao GD, Nagsh M, Chalan MSV, Rao VS. Efficacy of different Insecticides against spotted pod borer, *Maruca vitrata* in rice fallow Blackgram. The Andhra Agriculture Journal.2014; 61(1):151-156.
16. Rathod NP, Vala GS, Dudhat AS, Kachhadiya NM. Field efficacy of Biopesticides alone in combination with Newer insectides against *Helicoverpa armigera* of pigeonpea. International Journal plant protection. 2014; 7(1):128-131.
17. Sahoo G, Sahoo BK, Behera SS. Efficacy of safer insecticide and plant production against gram pod borer larva in pigeonpea. Journal of Plant Protection and Environment. 2014; 11(2):102-106.
18. Saxena KB, Chandrasena GDSN, Hettiarachchi K, Iqbal YB, Fonseka HHD, Jayasekara SJBA. Evaluation of pigeonpea accessions and selected lines for reaction to *Maruca*. Crop Science. 2002; 42:615-618.
19. Sreekanth M, Seshamahalakshmi M. Studies on relative toxicity of biopesticides to *Helicoverpa armigera* (Hubner) and *Maruca vitrata* (Geyer) on Pigeonpea (*Cajanuscajan* L.). Journal of Biopesticides. 2012; 5(2):191-195.
20. Vinayaka T, Babu CSJ, Cheton T, Murali S, Reddy GN. Evaluation of different botanical and chemical insecticides against pigeonpea pod borer. Environment and Ecology. 2013; 31 (2):1169-1173.
21. Vishakantaiah M, Jagadeesh Babu CC. Bionomics of the tur web worm, *Maruca testulalis* (Lepidoptera: Pyralidae). Mysore Journal of Agricultural Sciences. 1980; 14:52-53.