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Evaluation of some biopesticides and new chemical insecticides against lepidopteran pod borers in vegetable pigeonpea

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Abstract
Pigeonpea (*Cajanus cajan* L.) as a vegetable crop has gained importance due to rich dietary proteins. In this context, production of quality green pods is the need of the hour. Among the various insect pests, lepidopteran pod borers including blue butterfly, *Lampides boeticus* (Linnaeus) and Pod borer, *Helicoverpa armigera* (Hubner) has become real threat in vegetable pigeonpea production. Keeping this point in view, the field experiments was undertaken to evaluate some biopesticides and new chemical insecticides against lepidopteran pod borers during *Kharif* season of 2018-19 and 2019-20 at college of Horticulture, Bagalkot, Karnataka. The pooled data indicated that treatment application of chlorantraniliprole 18.5 SC at 0.2 ml per liter and cyantraniliprole 10 OD at 1.2 ml per litre showed the least larval population, lowest pod damage with higher green pod yield followed by sequential application of *B. bassiana* (2×10^8 cfu/ml) at 2.0 ml per litre + azadirachtin (1000 ppm) at 1.0 ml per litre. However, the highest B: C ratio was obtained in the treatment chlorantraniliprole 18.5 SC suggesting that two sprays of chlorantraniliprole 18.5 SC at 0.2 ml per litre in 10 days interval after 50 per cent flowering is environmentally safe, economically viable to manage lepidopteran pod borers in vegetable pigeonpea along with obtaining residue free green seeds at the time of harvest.

Keywords: pod borers, *Lampides boeticus*, *Helicoverpa armigera*, vegetable pigeonpea, pest management

Introduction
Pulses have become part of the human diet since agriculture has begun. Pigeonpea stands 6th in the global pulse production after *Phaseolus* beans, peas, chickpeas, broad beans and lentils [1]. In India, pigeonpea is the second most economically important pulse crop next to chickpea accounting for about 20 per cent of total pulse production [2].
In several states of India, including Karnataka, immature seeds of pigeonpea are used as a fresh vegetable because of its well known nutritional benefits. Green seeds are a good source of protein, vitamins (A, C, B complex), minerals (Ca, Fe, Zn, and Cu), carbohydrates, and dietary fibre [3]. Despite superior edible quality of vegetable pigeonpea, the production has not been enhancing for several reasons such as poor knowledge regarding the suitable varieties among the farmers, biotic and abiotic constraints widespread across the vegetable pigeonpea growing areas.
Among the biotic constraints, damage caused by insect pests is one of the main reasons for low production and productivity. More than 200 species of insects have been found feeding on pigeonpea while, only a few of these causes considerable damage to pigeonpea [4]. Out of which, lepidopteran pod borer complex causes substantial yield loss in pigeonpea production [5]. Pod borer, *Helicoverpa armigera* (Hubner) is one of the most destructive and widespread insect pests. It is polyphagous and attacks more than 182 plant species including pigeonpea. The larva feeds on flowers, tender pods and green seeds and cause higher yield losses in unprotected condition. A single larva has a potential to feed on 30 to 40 pods before it reaches maturity [6]. Another lepidopteran pod borer *i.e.*, blue butterfly, *Lampides boeticus* (Linnaeus) observed as minor pest of pigeonpea however, under favorable climatic condition it attains pest status [7]. The greenish larva of blue butterfly cause yield loss by feeding on flower buds and green pods.

Improper usage of insecticides to manage these pests resulted in resistance, resurgence, and residue on the crop. Hence, it is important to emphasize more on the selection of proper as well as safer insecticides to manage these pod borers in vegetable pigeonpea as the green seeds are consumed raw. Hence, an attempt was made to evaluate the efficacy of biopesticides and new molecules against the major lepidopteran pod borers of vegetable pigeonpea at College of Horticulture, Bagalkot, Karnataka.

Materials and methods

Eco-friendly management practices comprising of biopesticides and newer molecules against pod borer and blue butterfly was conducted during *Kharif* from June to January of 2018-19 and 2019-20 at vegetable science research block, College of Horticulture, Bagalkot. Popular, high yielding pigeonpea variety ICP 7035 which is exclusively meant for the vegetable purpose was raised according to the package of practice followed by UAS, Dharwad except for plant protection measures. The experiment was laid out in a randomized block design (RBD) in an area of 235 sq. m., with ten treatments and the treatments were replicated thrice (Table 1). Each treatment plot measured 4.8 × 4.8 sq. m. and a spacing of 120 cm and 60 cm was maintained between rows and plants, respectively.

(a) Spraying schedule

All the treatments were imposed after 50 per cent flowering and two sprays were given at 10 days interval using knapsack power sprayer. Afterwards, two common sprays of acephate 75 SP at 1.0 g per litre was imposed to manage pod fly and pod bugs.

(b) Determination of amount of insecticide

The required amount of insecticides were calculated by using the following formula

$$\text{Amount of insecticide required} = \frac{\text{Volume of water (l/ha)} \times \text{Desired concentration of spray fluid (\%)}}{\text{Concentration of commercial formulation required}}$$

(c) Observations on blue butterfly and pod borer population

Observations on the larval population of blue butterfly and pod borer were recorded from 10 randomly selected and tagged plants in each plot, leaving the border rows. Pre treatment counts were taken one day before the application of treatments and afterward the larval population was recorded at three, seven and ten days.

(d) Yield (q/ha) and cost economics (Rs/ha)

Green pod damage due to lepidopteran pod borer complex (pod borer and blue butterfly) was assessed by considering 200 randomly selected pods from each treatment during the time of each picking and the mean per cent pod damage was computed as mentioned below.

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

Further, green pod yield was also recorded from each treatment at each picking and the total yield was computed to quintal per hectare basis. Cost economics was calculated based on total yield in quintal per hectare, cost of insecticide, other costs of cultivation and gross return based on the market price of Rs. 40 per kg. The benefit cost ratio and net returns of different treatments were calculated using the following formulae.

Gross return= Yield × Market price of vegetable pigeonpea

Net return = Gross return – Total cost

$$\text{B: C ratio} = \frac{\text{Gross income}}{\text{Total cost of cultivation (including cost of treatment)}}$$

Results and Discussion

(a) Blue butterfly

The pretreatment population of blue butterfly larvae was ranged from 2.48 to 2.70 larvae per plant. All the treatments were non-significant at one day before spraying indicated the uniformity in the pest density. After ten days of first spray, significant lowest larval population of blue butterfly (0.75 larvae/plant) was observed in chlorantraniliprole 18.5 SC at 0.2 ml per litre treated plot followed by cyantraniliprole 10 OD at 1.2 ml per litre (0.92 larvae/plant). Rest of the treatments was moderate in reducing the larval population. Among them, combination of *B. bassiana* (2 × 10^8 cfu/ml) at 2.0 ml per litre + azadirachtin (10000 ppm) at 1.0 ml per litre showed better results as compared to rest of the biopesticides. However, individual application of *B. bassiana* (2 × 10^8 cfu/ml) at 2.0 ml per litre and azadirachtin (10000 ppm) at 1.0 ml per litre failed to suppress the larval population. After ten days of second spray, the larval population was nil in chlorantraniliprole 18.5 SC at 0.2 ml per litre and cyantraniliprole 10 OD at 1.2 ml per litre treated plots while *B. bassiana* (2 × 10^8 cfu/ml) at 2.0 ml per litre + azadirachtin (10000 ppm) at 1.0 ml per litre was significantly superior over other biopesticides and statistically on par with *B. thuringiensis* (2 × 10^8 cfu/ml) at 5.0 ml per litre + azadirachtin (10000 ppm) at 1.0 ml per litre with (Table 1).

(b) Pod borer

The pre treatment count of pod borer larval population was uniform across the various treatments and it gradually increased during the course of study and it was revealed from the larval population in the untreated check. The results pertaining to efficacy of various biopesticides and new molecules against pod borer larvae is presented in the Table 2. The mean larval population before imposition of treatment varied from 2.50 to 2.65 larvae per plant among different treatments and they were statistically on par with each other. Three days after first spray with new molecules and biopesticides did not bring down the larval population below ETL but reduced the larval population compared to pretreatment count. After seventh and tenth day after first spray, chlorantraniliprole 18.5 SC at 0.2 ml per liter reduced the larval population below ETL (0.85 and 0.75 larvae/plant) and statistically superior over rest of the treatments. Among the biopesticides tested, a non significant difference was noticed between the treatments with combination of *B.*

bassiana (2×10^8 cfu/ml) at 2.0 ml per litre + azadirachtin (1000 ppm) at 1.0 ml per litre and *Ha*NPV (1×10^9 POB/ml) at 1.0 ml per litre + azadirachtin (1000 ppm) at 1.0 ml per litre after seventh and 15th days of first spray. However, the individual treatment of *B. bassiana* (2×10^8 cfu/ml) at 2.0 ml per litre, azadirachtin (1000 ppm) at 1.0 ml per litre and *Ha*NPV (1×10^9 POB/ml) at 1.0 ml per litre failed to reduce the larval population of pod borer. Fourteen days after second spray, larval population was nil in chlorantraniliprole 18.5 SC at 0.2 ml per litre and cyantraniliprole 10 OD at 1.2 ml per litre while *B. bassiana* (2×10^8 cfu/ml) at 2.0 ml per litre + azadirachtin (1000 ppm) at 1.0 ml per litre recorded significantly minimum (0.90 larvae/plant) larval population among biopesticides followed by *Ha*NPV (1×10^9 POB/ml) at 1.0 ml per litre + azadirachtin (1000 ppm) at 1.0 ml per litre (1.0 larvae/plant) and *B. thuringiensis* (1×10^8 cfu/ml) at 5.0 ml per litre (1.05 larvae/plant).

The efficacy of chlorantraniliprole 18.5 SC and cyantraniliprole 10 OD may be attributed in reducing the larval population of blue butterfly and pod borer attributed to their unique mode of action against lepidopteran insects as they belong to a new chemical class, the anthranilic diamides and has a novel mode of action as an activator of insect ryanodine receptors, causing rapid muscle dysfunction and paralysis of larva (Hannig *et al*., 2010) [8]. The present finding is in conformity with Patel *et al*. (2015), who reported the effectiveness of chlorantraniliprole 18.5 SC against blue butterfly [9]. Concurrently, Sreekanth *et al*. (2014) reported that spraying of chlorantraniliprole 18.5 SC gave higher larval mortality of pod borer at Guntur in Andra Pradesh. However, Rachappa *et al*. (2014) concluded that cyantraniliprole 10.26 OD (60 g a.i./ha) was highly effective in controlling *H. armigera* by registering lowest mean larval population (0.17 larvae/five plants) compared to chlorantraniliprole 18.5 SC [10].

Table 1: Evaluation of biopesticides and new molecules against blue butterfly, *Lampides boeticus* in vegetable pigeonpea var. ICP 7035 (Pooled data of 2017-18and 2019-20)

	Treatments	Dosage (ml/l)	Mean larval population/plant						
			First spray				Second spray		
			1 DBS	3 DAS	7 DAS	10 DAS	1 DAS	7 DAS	10 DAS
T_1	*Bacillus thuringiensis* var *krustaki* (2×10^8 cfu/ml)	5.0	2.48^{a}	2.13 (1.46)^{d}	1.92 (1.38)^{d}	2.50 (1.43)^{cd}	1.93 (1.39)^{c}	1.80 (1.34)^{c}	1.80 (1.52)^{c}
T_2	*Beauveria bessiana* (2×10^8 cfu/ml)	2.0	2.7^{a}	2.32 (1.52)^{c}	2.12 (1.45)^{c}	1.93 (1.39)^{cd}	1.67 (1.29)^{de}	1.47 (1.21)^{d}	1.37 (1.37)^{c}
T_3	*Ha*NPV (1×10^9 POB/ml)	1.0	2.55^{a}	2.82 (1.68)^{b}	3.22 (1.79)^{b}	4.18 (2.04)^{b}	4.48 (2.12)^{b}	4.90 (2.21)^{b}	2.98 (1.87)^{b}
T_4	Azadirachtin 10000 ppm	1.0	2.52^{a}	2.03 (1.42)^{de}	1.87 (1.36)^{d}	2.02 (1.42)^{cd}	1.60 (1.26)^{e}	1.43 (1.19)^{d}	1.32 (1.35)^{c}
T_5	T_1+ Azadirachtin 10000 ppm	5.0 + 1.0	2.68^{a}	1.93 (1.39)^{ef}	1.67 (1.29)^{e}	1.90 (1.37)^{d}	1.52 (1.23)^{e}	1.30 (1.14)^{d}	1.18 (1.30)^{cd}
T_6	T_2+ Azadirachtin 10000 ppm	2.0 + 1.0	2.55^{a}	1.85 (1.36)^{f}	1.43 (1.19)^{f}	1.35 (1.16)^{e}	1.12 (1.06)^{f}	1.00 (1.00)^{e}	0.93 (1.20)^{d}
T_7	T_3+Azadirachtin 10000 ppm	1.0 + 1.0	2.55^{a}	2.13 (1.46)^{d}	1.87 (1.36)^{d}	2.08 (1.44)^{c}	1.75 (1.32)^{d}	1.68 (1.29)^{c}	1.4 (1.38)^{c}
T_8	Chlorantraniliprole 18.5 SC	0.20	2.63^{a}	0.98 (0.98)^{h}	0.82 (0.90)^{f}	0.75 (0.86)^{g}	0.40 (0.63)^{h}	0.18 (0.42)^{f}	0.00 (0.71)^{e}
T_9	Cyantraniliprole 10 OD	1.20	2.58^{a}	1.15 (1.07)^{g}	1.05 (1.02)e	0.92 (0.95)^{f}	0.53 (0.73)^{g}	0.25 (0.50)^{f}	0.17 (0.72)^{e}
T_{10}	Untreated check	-	2.65^{a}	3.15 (1.77)^{a}	3.60 (1.90)^{a}	4.60 (2.14)^{a}	4.98 (2.23)^{a}	5.63 (2.37)^{a}	3.38 (1.97)^{a}
S.Em±			0.05	0.02	0.02	0.02	0.02	0.03	0.03
CD at 5%			NS	0.04	0.05	0.05	0.06	0.08	0.10

DBS: Day before spray DAS: Day after spray Figures in parentheses are square root transformed values
In a column, means followed by same alphabet(s) do not differ significantly by DMRT (P=0.05)

Table 2: Evaluation of biopesticides and new molecules against pod borer, *Helicoverpa armigera* in vegetable pigeonpea var. ICP 7035 (Pooled data of 2018-19 and 2019-20)

	Treatments	Dosage(ml/l)	Mean larval population/plant						
			First spray				Second spray		
			1 DBS	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS
T_1	*Bacillus thuringiensis* var *krustaki* (2×10^8 cfu/ml)	5.0	2.63^{a}	2.42 (1.55)^{b}	2.22 (1.49)^{b}	2.33 (1.53)^{b}	2.05 (1.43)^{b}	2.05 (1.43)^{b}	1.85 (1.52)^{b}
T_2	*Beauveria bessiana* (2×10^8 cfu/ml)	2.0	2.62^{a}	2.20 (1.48)^{cd}	1.90 (1.38)^{cd}	1.82 (1.34)^{d}	1.60 (1.26)^{cd}	1.60 (1.26)^{c}	1.33 (1.35)^{c}
T_3	*Ha*NPV (1×10^9 POB/ml)	1.0	2.63^{a}	2.30 (1.52)^{bc}	2.03 (1.43)^{c}	1.92 (1.38)^{cd}	1.70 (1.30)^{c}	1.70 (1.30)^{c}	1.38 (1.37)^{c}
T_4	Azadirachtin 10000 ppm	1.0	2.52^{a}	2.07 (1.44)^{d}	1.83 (1.35)^{d}	1.98 (1.41)^{c}	1.55 (1.24)^{cd}	1.55 (1.24)^{cd}	1.35 (1.35)^{c}
T_5	T_1+ Azadirachtin 10000 ppm	5.0 + 1.0	2.62^{a}	1.90 (1.38)^{e}	1.65 (1.28)^{e}	1.78 (1.34)^{d}	1.42 (1.19)^{de}	1.18 (1.19)^{de}	1.05 (1.24)^{d}
T_6	T_2+ Azadirachtin 10000 ppm	2.0 + 1.0	2.50^{a}	1.70 (1.30)^{f}	1.43 (1.20)^{f}	1.48 (1.22)^{e}	1.18 (1.08)^{f}	1.18 (1.08)^{f}	0.90 (1.18)^{d}
T_7	T_3+Azadirachtin 10000 ppm	1.0 + 1.0	2.58^{a}	1.80	1.55	1.48	1.30	1.30	1.00

				(1.34)^{ef}	(1.24)^{ef}	(1.22)^{e}	(1.14)^{ef}	(1.14)^{ef}	(1.22)^{d}
T_8	Chlorantraniliprole 18.5 SC	0.20	2.55^{a}	1.05 (1.02)^{h}	0.85 (0.92)^{h}	0.75 (0.93)^{g}	0.53 (0.73)^{h}	0.47 (0.68)^{h}	0.00 (0.71)^{e}
T_9	Cyantraniliprole 10 OD	1.20	2.65^{a}	1.22 (1.10)^{g}	1.03 (1.02)^{g}	0.88 (0.99)^{f}	0.72 (0.85)^{g}	0.65 (0.80)^{g}	0.00 (0.71)^{e}
T_{10}	Untreated check	-	2.60^{a}	3.73 (1.93)^{a}	4.52 (2.12)^{a}	5.08 (2.25)^{a}	6.57 (2.56)^{a}	6.50 (2.56)^{a}	5.52 (2.45)^{a}
S.Em±			0.03	0.02	0.2	0.02	0.03	0.02	0.04
CD at 5%			NS	0.06	0.06	0.05	0.08	0.07	0.11

DBS: Day before spray DAS: Day after spray Figures in parentheses are square root transformed values
In a column, means followed by same alphabet(s) do not differ significantly by DMRT (P=0.05)

(c) Pod damage

Significantly lower pod damage due to lepidopteran pod borer complex was recorded in chlorantraniliprole 18.5 SC (0.2 ml/l) and cyantraniliprole 10 OD (1.2 ml/l) with pod damage of 5.68 and 6.90 per cent, respectively. However, among the biopesticides, *Ha*NPV (1 × 10^9 POB/ml) at 1.0 ml per litre + azadirachtin (1000 ppm) at 1.0 ml per litre recorded lesser pod damage and the treatment was significantly at par with *B. bassiana* (2 × 10^8 cfu/ml) at 2.0 ml per litre + azadirachtin (1000 ppm) at 1.0 ml per litre. While, significantly higher pod damage was recorded in untreated check (26.02%) (Table 3). Lesser pod damage in chlorantraniliprole 18.5 SC (0.2 ml/l) and cyantraniliprole 10 OD (1.2 ml/l) is mainly because of their efficacy in reducing larval population of blue butterfly and pod borer which in turn resulted in lesser pod damage of green pods.

(d) Green pod yield (q/ha) and Cost economics (Rs/ha)

A significant variation was observed with respect to green pod yield among the biopesticides and new molecules tested. Chlorantraniliprole 18.5 SC at 0.2 ml per litre (66.96 q/ha) treated plot recorded the highest green pod yield which was significantly on par with the plots treated with cyantraniliprole 10 OD at 1.2 ml per litre (63.32 q/ha) meanwhile, the lowest green pod yield was recorded in untreated check (11.18 q/ha) (Table 3). However, cost effectiveness of different treatments indicated that chlorantraniliprole 18.5 SC at 0.2 ml per litre had obtained maximum net returns (Rs. 227204/ha) with highest B:C ratio (6.59) as compared to rest of the treatments suggesting that chlorantraniliprole 18.5 SC at 0.2 ml per litre is profitable (Table 4). The higher green pod yields due to lepidopteran pod borers in both the treatments was attributed to their efficacy in reducing the green pod damage as compared to rest of the treatments. Though cyantraniliprole 10 OD at 1.2 ml per litre was superior in producing green pod yield, the lower B: C ration of cyantraniliprole 10 OD was due to higher chemical cost as compared to chlorantraniliprole 18.5 SC. The present results are in confirmation with Sreekanth *et al*. (2014) and Sharma *et al*. (2016) who reported the lowest pod damage, higher grain yield and B: C ratio in chlorantraniliprole 18.5 SC treated plots in dal pigeonpea [11] [12]. Hence, two sprays of chlorantraniliprole 18.5 SC at 0.2 ml per litre in 10 days interval after 50 per cent flowering is environmentally safe, economically viable to manage lepidopteran pod borers in vegetable pigeonpea along with obtaining residue free green seeds at the time of harvest.

Table 3: Effect of biopesticides and new molecules on green pod damage and green pod yield due to *L. boeticus* and *H. armigera* in vegetable pigeonpea var. ICP 7035 (Pooled data of 2018-19 and 2019-20)

Treatments		Dosage (ml/l)	Per cent green pod damage	Green pod yield (q/ha)
T_1	*Bacillus thuringiensis* var *krustaki* (2 × 10^8 cfu/ml)	5.0	20.13 (26.66)^{b}	34.95^{e}
T_2	*Beauveria bessiana* (2 × 10^8 cfu/ml)	2.0	19.43 (26.15)^{bc}	36.58^{de}
T_3	*Ha*NPV (1 × 10^9 POB/ml)	1.0	18.22 (25.26)^{bcd}	37.77^{cde}
T_4	Azadirachtin 10000 ppm	1.0	17.08 (24.41)^{cd}	39.14^{cd}
T_5	T_1+ Azadirachtin 10000 ppm	5.0 + 1.0	16.03 (23.60)^{de}	41.60^{c}
T_6	T_2+ Azadirachtin 10000 ppm	2.0 + 1.0	14.33 (22.17)^{ef}	45.89^{b}
T_7	T_3+Azadirachtin 10000 ppm	1.0 + 1.0	12.43 (20.32)^{f}	48.24^{b}
T_8	Chlorantraniliprole 18.5 SC	0.20	5.68 (13.76)^{g}	66.96^{a}
T_9	Cyantraniliprole 10 OD	1.20	6.90 (13.58)^{g}	63.32^{a}
T_{10}	Untreated check	-	26.02 (30.65)^{a}	11.18^{f}
S.Em±			0.64	1.30
CD at 5%			1.91	3.99

In a column, means followed by same alphabet(s) do not differ significantly by DMRT (p=0.05)
Values in parentheses are arc sine transformed values

Table 4: Economics of biopesticides and new molecules against blue butterfly, *L. boeticus* and pod borer, *H. armigera* in vegetable pigeonpea var. ICP 7035

Treatments	Dosage (ml/l)	Yield (q/ha)	Cost of production (Rs/ha)	Cost of plant protection (Rs/ha)	Total cost (Rs/ha)	Gross return* (Rs/ha)	Net return (Rs/ha)	B:C ratio
Bacillus thuringiensis var *krustaki* (2 × 10^8 cfu/ml)	5.0	34.95	34566	5190	39756	135800	96044	1: 3.42
Beauveria bessiana (2 × 10^8 cfu/ml)	2.0	36.58	34566	2340	36906	146320	109414	1: 3.96
*Ha*NPV (1 × 10^9 POB/ml)	1.0	37.77	34566	3840	38406	151080	112674	1: 3.93
Azadirachtin 10000 ppm	1.0	39.14	34566	2940	37506	156560	119054	1: 4.17
T_1+ Azadirachtin 10000 ppm	5.0 + 1.0	41.60	34566	7440	42006	166640	124634	1: 3.97

T_2+ Azadirachtin 10000 ppm	2.0 + 1.0	45.89	34566	4590	39156	183560	144404	1: 4.69
T_3+Azadirachtin 10000 ppm	1.0 + 1.0	48.24	34566	6090	40656	193000	152344	1: 4.75
Chlorantraniliprole 18.5 SC	0.20	66.96	34566	6110	40676	267880	227204	1: 6.59
Cyantraniliprole10 OD	1.20	63.32	34566	16065	49941	253280	203339	1: 5.07
Untreated check	-	11.18	34566	-	34566	44720	10154	1:1.29

* Market value of vegetable pigeonpea = 40 Rs/kg

Gross return = Yield x Market price of vegetable pigeonpea Net returns = Gross return – Total cost B:C ratio = Gross return/ Total cos

References

1. Anonymous. Production Yearbook for 1995, Rome, Italy. Food Agric. Organ 1996;49:235.
2. Sharma OP, Gopali JB, Yelshetty S, Bambawale OM, Garg DK, Bhosle BB. Pests of pigeonpea and their management. NCIPM, LBS building, IARI Campus, New Delhi, India 2010.
3. Saxena KB, Ravishankar K, Vijayakumar R, Sreejith KP, Srivastava RK. Vegetable pigeonpea – a high protein food for all ages. Information Bulletin No. 83. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics 2010, 124.
4. Lateef SS, Pimbert MP. The search for host plant resistance of *Helicoverpa armigera* in chickpea and pigeonpea at ICRISAT. In: Proceedings of the consultative group meeting on the host selection behavior of *Helicoverpa armigera*, 5–7 March Patancheru, India: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), 1990, 14-18.
5. Satpute NS, Barkhade UP. Evaluation of rynaxypyr 20 SC against pigeonpea pod borer complex. J. Food Legumes 2012;25(2):162-163.
6. Singh SP. Fifteen years of AICRP on biological control. Project Directorate of Biological Control, Bangalore 1994, 102-109.
7. Singh R, Mahal MS, Singh B. Assessment of losses caused by borer complex in arhar [*Cajanus cajan* (L) Millsp.]. J. Insect Sci. 1998;1:168 -172.
8. Hannig GT, Ziegler M, Marcon PG. Feeding cessation effects of chlorantraniliprole, a new anthranilic diamide insecticide, in comparison with several insecticides in distinct chemical classes and mode of action groups. Pest Manage. Sci 2010;65:969-974.
9. Patel SA, Patel BC, Patel PS, Trivedi JB. Evaluation of newer molecules against pod borer complex of pigeonpea (*Cajanus cajan* (L.) Millspaugh). Int. J. Agric. Sci 2015;7(7):587-590.
10. Rachappa V, Yelshetty S, Shekaran C, Pampapathi G. Management of insect pests of pigeonpea using a novel anthranilic diamide molecule. J. Exp. Zool. India 2014;17(2):621-626.
11. Sreekanth M, Lakshmi MSM, Rao YK. Bio efficacy and economics of certain new insecticides against gram pod borer, *Helicoverpa armigera* (Hubner) infesting pigeonpea (*Cajanus cajan* L.). Int. J. Plant Animal Environ. Sci 2014;4(1):11-15.
12. Sharma SR, Singh J, Singh DP, Bain R. Bio-efficacy of insecticides for management of *Helicoverpa armigera* in chickpea and their economics. Ann. Plant. Protec. Sci 2016;24(1):71-73.