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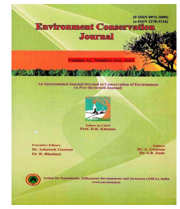

Bioefficacy and economics of certain new molecule of insecticides against Gram pod borer, *Helicoverpa armigera* (Hübner) in chickpea

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ABSTRACT

Gram pod borer (*Helicoverpa armigera*) is a major insect pest of chickpea. The gram pod borer begins to infest at vegetative stage and later feeds on flowers and developing pods. A field investigation was conducted to evaluate the bioefficacy of certain new molecule insecticides against *Helicoverpa armigera* (Hübner) on chickpea during *Rabi* 2020-21 in randomized block design with three replications. The outcomes revealed that the application of Chlorantraniliprole 18.5% SC @ 25g a.i./ha and Cyantraniliprole 10.26% OD @ 60g a.i./ha were established to be most effective treatments and application of Fipronil 5% SC @ 50g a.i./ha was least effective in respect of reduction of *H. armigera* larval population. The maximum yield was recorded in Chlorantraniliprole 18.5% SC @ 25g a.i./ha (14.00 q/ha) followed by Cyantraniliprole 10.26% OD @ 60g a.i./ha (13.73 q/ha) and lowest yield was recorded from Novaluron 75g a.i./ha (10.15 q/ha) treated plot. The economics of different new molecule insecticides indicated that higher benefit cost ratio (BCR) was observed from Lambda Cyhalothrin 30g a.i./ha (7.86:1) followed by Emamectin benzoate 12g a.i/ha (6.75:1) and the lower BCR was recorded from Cyantraniliprole 60g a.i./ha (1.64:1) and Novaluron 75g a.i./ha (1.58:1). Chlorantraniliprole and Cyantraniliprole are newer group of insecticides, which are relatively safer and more effective against gram pod borer as comparison to conventional insecticides and can be used in successful management of this key pest of chickpea.

Introduction

Pulses are dry seeds of plants which belongs to Leguminosae family. Pulses are source of protein, amino acids and have other medicinal properties. Production and consumption of higher amount of pulses are the best way to overcome spread of protein malnutrition in world. In 2016, United Nations General Assembly (UNGA) celebrated as International Year of Pulses (IYP) to generate awareness in food security and several benefits of protein and also about sustainable foods production for small holder farmers (Anonymous, 2016). In India over dozens of pulse crops grown, however Chickpea (*Cicer arietinum* L.) is the third most important pulses crop after dry beans and field pea. It is commonly known as Bengal gram, chana or gram, originated from South Western Asia. It is an important *Rabi* pulse crop of India, and considered as 'King of Pulses' due to its nutritional values and high demand (Bhatt and Patel, 2001). Chickpea highly fix more than 80 per cent of atmospheric nitrogen in association with *Rhizobium* spp. India leads top rank in area and production of chickpea. In India, chickpea occupies 107.21 lakh hectare area and producing 9.02 million tons with 895

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kg/ha productivity (Anonymous, 2020). Madhya Pradesh ranks highest in chickpea production (32.37%) followed by Rajasthan (19.46%), Maharashtra (15.82%), Andhra Pradesh (8.76%) and Uttar Pradesh (6.45%) and these states contributing 82% of total production of country (Naik *et al.,* 2018). Insect pests are one of the major limiting factors for production of chickpea. In India, gram pod borer (*Helicoverpa armigera* Hübner) (Noctuidae, Lepidoptera) is a major pest of chickpea. The gram pod borer begins to infest at vegetative stage and later feeds on flowers and developing pods until crop maturity, where pod borer caused 60 to >90 per cent losses in seeds/grains yield under favourable conditions throughout the India (Anonymous, 2013; Patil *et al*., 2017). Due to the feeding preference of the *H. armigera* larvae on the plant parts that are rich in protein content and reproductive parts of growing plants, e.g. flowers, pods, cotton bales and buds results in a reduction in the crop yield. The Indian farmers mostly rely on insecticides for the management of insect pests' infestation because; agrochemicals are considered as the last recline for management due to their quick knockdown effect. Over dependence on a particular group of chemicals is one of the important reasons for the rapid development of resistance and hazards to the environment and human health, among the several avenues to overcome the insecticidal resistance and environmental problems, replacement with the new molecules of insecticide is one of the important considerations (Gill and Garg, 2014). Keeping these facts in mind the present investigation was planned and conducted to find out the reliable and cost effective source for the management of gram pod borer in chickpea.

Material and Methods

The present experiment was conducted under field conditions at Students' Instructional Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during *Rabi* 2020-21 on chickpea cultivar of PUSA-262 in Randomized Block Design (RBD) with 10 treatments and 3 replications. The unit plot size kept 1.50×2.50m of each with line to line 30 cm spacing and plant to plant spacing 10cm. The observation on *H. armigera* larval population was taken on mean larval population per metre row length basis. The larval population of *H. armigera* was recorded at a day before spraying and 3, 7 and 15 days after application of treatments at each spraying. The Benefit-Cost Ratio worked out for each treatment on the basis of additional return over control in terms rupees and cost of insecticidal spray in each treatment The data obtained were analyzed statistically to compare the treatment effects for randomized block design (Panse and Sukhatme, 1961).

Table 1: Details of different insecticides and their source used in the present investigation

Treatments	Chemical name	Trade name	Strength of pesticide	Dose of Insecticides (g/ml) or Concentration (%) dose/ha	Source of availability
T1	Spinosad	Tracer	45% SC	60g a.i	Dow Agro Science
T2	Chlorantraniliprole	Coragen	18.5% SC	25g a.i.	FMC India Private Limited
T3	Emamectin benzoate	Emagold	5% SG	12g a.i	Alfa Crop Science, Raipur (C.G.)
T4	Flubendaimide	Fame	39.35% SC	60g a.i	Bayer Crop Science Limited, Mumbai
T5	Cyantraniliprole	Benevia	10.26% w/w OD	60g a.i	FMC India Private Limited
T6	Indoxacarb	Isacarb	14.5% SC	60g a.i	Isagro Agrochemicals Private Limited
T7	Lambda Cyhalothrin	Karate	5% SC	30g a.i.	Syngenta Agrochemicals Limited
T8	Novaluron	Rimone	10% EC	75g a.i.	Indofil Industries Limited
T9	Fipronil	Regent	5% SC	50g a.i.	Bayer Crop Science Limited, Mumbai
T10	Control (Water spray)	-	-	500 L	-

Results and Discussion

Bioefficacy of certain new molecule of insecticides against larval population *H. armigera*

The initial count of *H. armigera* larvae revealed that the pest population was distributed homogenously throughout the experimental field a day before application of treatments on the crop during the *Rabi* 2020-21 (Table 1 and Figure 1 & 2).

First spray

Pre-treatment observation was recorded a day before the application of insecticides, which revealed the uniform distribution of pod borer in the field. The data pertaining efficacy of the first spray was obtained and presented in Table 1 and Figure 1 indicates that the population a day before was ranged from 5.11 to 6.00 larvae/mrl. The data obtained from 3 DAS (Days after spray) revealed that reduction in larval population was recorded in all treated plots in comparison to the untreated plot. However, among all the treatments the minimum larval population was found in treatment T_2- Chlorantraniliprole 25g a.i./ha (3.00 larvae/mrl) followed by the treatment T_5- Cyantraniliprole 60g a.i./ha (3.33 larvae/mrl) and highest in treatment T_7- Lambda Chylothrin 30g a.i./ha (4.67 larvae/mrl). The observation recorded at 7 DAS revealed that the minimum population was found in T_2- Chlorantraniliprole 25g a.i./ha (0.78 larvae/mrl) followed by T_5- Cyantraniliprole 25g a.i./ha (0.89 larvae/mrl), and maximum in the treatment T_9- Fipronil 50g a.i./ha (2.44 larvae/mrl). The data noted at 15 DAS depicted that all the treatments were significantly superior to over control and treatment T_2- Chlorantraniliprole 25g a.i./ha (1.11 larvae/mrl) was the most effective treatment recorded the lowest population over control followed by T_5-Cyantraniliprole 60g a.i./ha (1.22 larvae/mrl) and treatment T_9- Fipronil 50g a.i./ha (3.22 larvae/mrl) least effective treatment recorded the highest population over control. The overall mean population of 3, 7 and 15 DAS indicate that all treated plots were significantly outperformed over control. However, among the all treatments minimum larval population was found in T_2- Chlorantraniliprole 25g a.i./ha (1.63 larvae/mrl) and T_5- Cyantraniliprole 60g a.i./ha (1.81 larvae/mrl), which were most effective treatments in reducing the larval populations and T_9- Fipronil 50 a.i./ha (3.22 larvae/mrl) had maximum population.

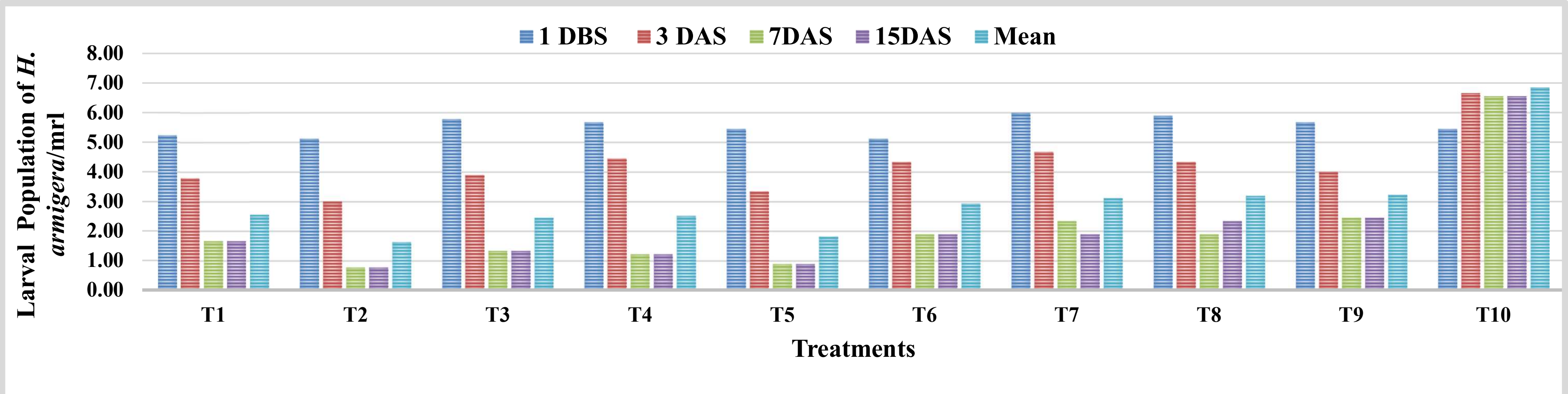
Second spray

The data pertaining population recorded a day before second spray varied in the range of 5.67 to 6.00 larvae mrl^{-1} (Table 1 and Figure 2). The data recorded at 3 DAS revealed that minimum larval population was recorded in T_2-Chlorantraniliprole 25g a.i./ha (3.33 larvae/ mrl) followed by T_5- Cyantraniliprole 60g a.i./ha (3.67 larvae/mrl) and minimum population was found in T_6-Indoxacarb 60g a.i./ha (5.11 larvae/mrl).The data noted at 7 DAS depicted that the lowest population was found in T_2-Chlorantraniliprole 25g a.i./ha (1.33 larvae/mrl) followed by T_5-Cyantraniliprole 60g a.i./ha (1.44 larvae/mrl) and highest population was found in T_9-Fipronil 50g a.i./ha (3.44 larvae/mrl). At 15 DAS that the minimum population was recorded in T_2-Chlorantraniliprole 25g a.i./ha (1.44 larvae/mrl) followed by T_5-Cyantraniliprole 60g a.i./ha (1.56 larvae/mrl) and minimum population was found in T_9-Fipronil 50g a.i./ha (3.56 larvae/mrl). The records on overall insecticidal efficacy revealed that the treatments were statistically superior to control. The overall population after second spraying indicated that treatment T_2-Chlorantraniliprole 25g a.i./ha (1.96 larvae/mrl) was superior to the remaining treatments followed by T_5-Cyantraniliprole 60g a.i./ha (1.15 larvae/mrl), whereas treatment T_9- Fipronil 50g a.i./ha (3.56 larvae/mrl) was least effective treatment after second insecticidal spray. The results are in conformity with the Chitralekha *et al.* (2018) who tested Novaluron 10 % EC @ 375 ml/ha, quinalphos 25 % EC @ 1000 ml/ha, Chlorantraniliprole 18.5 % SC @ 135 ml/ha, Lambda- Cyhalothrin 5 % EC @ 500 ml/ha, and emamectin benzoate 5 % SG @ 220 g/ha against gram pod borer at the population of larvae reached at economic threshold, *i.e.* l larvae/mrl on chickpea. All the treatments had resulted significantly better than untreated control; Chlorantraniliprole (18.5% SC) had the highest per cent larvae reduction compared to control (85.68%). The similar results also reported by Rani *et al.* (2018) who found that Emamectin benzoate 5% SG, Flubendamide 20% WG, Chlorantraniliprole 20% SC, Thiodicarb 75% WP, Indoxacarb 14.5% SC, Novaluron 10% EC were effective against the larval population of *H.*

Table 1: Efficacy of certain new molecule of insecticides against gram pod borer, *H. armigera* infesting chickpea during *Rabi* 2020-21

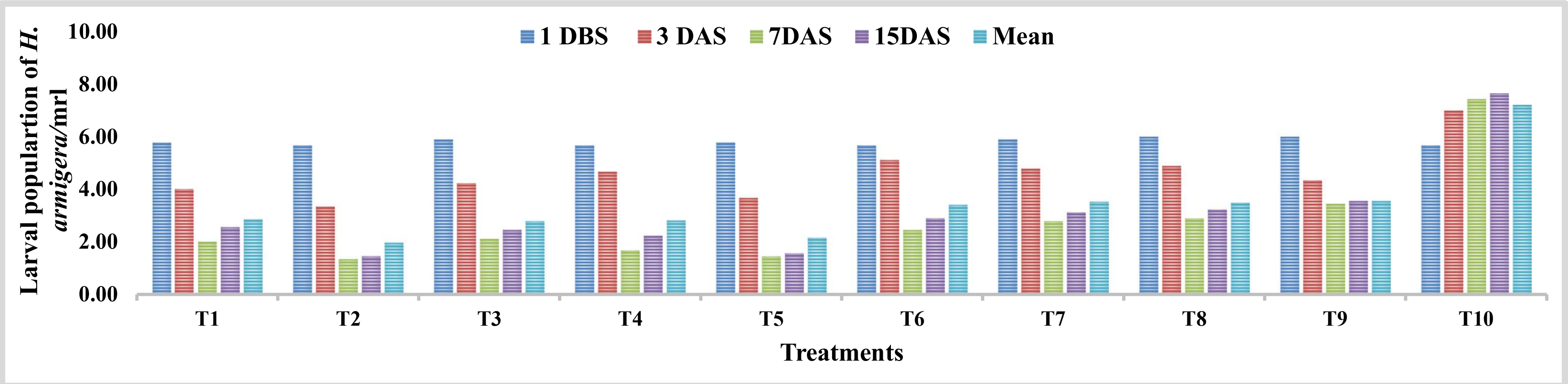
Tr. No.	Treatments	Dose/ha	*Mean larval population of *H. armigera* per metre row length										**Pod damage (%)
			First Spray					Second Spray					
			DBS	3 DAS	7 DAS	15 DAS	Mean	DBS	3 DAS	7 DAS	15 DAS	Mean	
T_1	Spinosad	60g a.i	5.22 (2.39)	3.78 (2.07)	1.67 (1.47)	2.22 (1.65)	**2.56 (1.75)**	5.78 (2.51)	4.00 (2.12)	2.00 (1.58)	2.56 (1.75)	**2.85 (1.83)**	12.00 (20.77)
T_2	Chlorantraniliprole	25g a.i.	5.11 (2.37)	3.00 (1.87)	0.78 (1.13)	1.11 (1.27)	**1.63 (1.46)**	5.67 (2.48)	3.33 (1.96)	1.33 (1.35)	1.44 (1.39)	**1.96 (1.57)**	2.00 (8.13)
T_3	Emamectin benzoate	12g a.i.	5.78 (2.51)	3.89 (2.09)	1.33 (1.35)	2.11 (1.62)	**2.44 (1.72)**	5.89 (2.53)	4.22 (2.17)	2.11 (1.62)	2.44 (1.72)	**2.78 (1.81)**	9.33 (17.79
T_4	Flubendiamide	60g a.i.	5.67 (2.48)	4.44 (2.22)	1.22 (1.31)	1.89 (1.55)	**2.52 (1.74)**	5.67 (2.48)	4.67 (2.27)	1.67 (1.47)	2.22 (1.65)	**2.81 (1.82)**	7.33 (15.21)
T_5	Cyantraniliprole	60g a.i	5.44 (2.44)	3.33 (1.96)	0.89 (1.18)	1.22 (1.31)	**1.81 (1.52)**	5.78 (2.51)	3.67 (2.04)	1.44 (1.39)	1.56 (1.43)	**2.15 (1.63)**	4.67 (12.48)
T_6	Indoxacarb	60g a.i.	5.11 (2.37)	4.33 (2.20)	1.89 (1.55)	2.56 (1.75)	**2.93 (1.85)**	5.67 (2.48)	5.11 (2.37)	2.44 (1.72)	2.89 (1.84)	**3.41 (1.98)**	12.00 (20.27)
T_7	Lambda Cyhalothrin	30g a.i	6.00 (2.55)	4.67 (2.27)	1.89 (1.55)	2.78 (1.81)	**3.11 (1.90)**	5.89 (2.53)	4.78 (2.30)	2.78 (1.81)	3.11 (1.90)	**3.52 (2.00)**	15.33 (23.05)
T_8	Novaluron	75g a.i	5.89 (2.53)	4.33 (2.20)	2.33 (1.68)	2.89 (1.84)	**3.19 (1.92)**	6.00 (2.55)	4.89 (2.32)	2.89 (1.84)	3.22 (1.96)	**3.48 (2.00)**	14.67 (22.52
T_9	Fipronil	50g a.i	5.67 (2.48)	4.00 (2.12)	2.44 (1.72)	3.22 (1.93)	**3.22 (1.93)**	6.00 (2.55)	4.33 (2.20)	3.44 (1.99)	3.56 (2.01)	**3.56 (2.01)**	18.00 (25.10)
T_{10}	Control (Water Spray)	500 L	5.44 (2.44)	6.67 (2.68)	6.56 (2.66)	7.33 (2.80)	**6.85 (2.71)**	5.67 (2.48)	7.00 (2.74)	7.44 (2.82)	7.67 (2.86)	**7.22 (2.78)**	24.67 (29.78)
S. Em±			**0.04**	**0.07**	**0.03**	**0.04**	**0.08**	**0.03**	**0.08**	**0.06**	**0.03**	**0.04**	**(0.63)**
CD at 5%			**-**	**0.22**	**0.11**	**0.12**	**0.24**	**-**	**0.25**	**0.20**	**0.11**	**0.13**	**(1.89)**

Figures in the parenthesis are $\sqrt{x+0.5}$ transformed values, **Figures in the parenthesis are Arcsine transformed values, DBS= Day before spray, DAS= Days after spray, *Mean of three replications



First Spray

Figure 1: Effect of certain new molecule of insecticides on gram pod borer, *H. armigera* during *Rabi* 2020-21.



Second Spray

Figure 2: Effect of certain new molecule of insecticides on gram pod borer, *H. armigera* during *Rabi* 2020-21.

Table 2: Economics of certain new molecule of insecticides during *Rabi* 2020-21

Tr. No.	Treatments	Dose/ha	Quantity of insecticide formulation/ha	Cost of one Spray (labour+ Sprayer+ insecticide)/ha)	No. of sprays	Total cost of spraying /ha	Yield (q/ha)	Additional yield over control (q/ha)	Total return /ha)	Net return /ha	B:C ratio	Rank
T_1	Spinosad	60g a.i.	133mL	4454	2	8908	12.80	5.50	28050	19142	2.14	**VII**
T_2	Chlorantraniliprole	25g a.i.	135mL	3225	2	6450	14.00	6.70	34170	27720	4.29	**III**
T_3	Emamectin benzoate	12g a.i.	240g	1790	2	3580	13.10	5.80	29580	26000	6.75	**II**
T_4	Flubendiamide	60g a.i.	152mL	3907	2	7814	13.30	6.00	30600	22786	2.91	**V**
T_5	Cyantraniliprole	60g a.i.	584mL	6190	2	12380	13.73	6.43	32793	20413	1.64	**VIII**
T_6	Indoxacarb	60g a.i.	413mL	2498	2	4996	12.10	4.80	24480	19484	3.89	**IV**
T_7	Lambda Cyhalothrin	30g a.i.	600mL	854	2	1708	10.27	2.97	15147	13439	7.86	**I**
T_8	Novaluron	75g a.i.	750mL	2810	2	5620	10.15	2.85	14535	8915	1.58	**IX**
T_9	Fipronil	50 a.i.	1000mL	2450	2	4900	10.80	3.50	17850	12950	2.64	**VI**
T_{10}	Control (Water Spray)	500 L	-	-	-	-	7.30	-	-	-		

BCR= Benefit Cost Ratio, Minimum support price of chickpea during 2020-21 = Rs. 51/kg, Labour charge = Rs. 300/day/labour, Sprayer charge: 50/day

armigera. Similarly, Upadhyay *et al*. (2020) also reported that the highest efficacy of insecticide after the spray was found in T_3-Chlorantiniprole 18.5 SC 92g a.i. ha^{-1} (63.05%) and the lowest overall % efficacy was registered in T_8-Acephate 75 WP 750 g a.i. ha^{-1} (30.04%).

Effect of certain new molecule of insecticides on pod damage

The efficacy of insecticides was tested in terms of pod damage in the field trial for the *Rabi* 2020-21 (Table 1). The respective results show that each of the individual treatments was significantly efficient than the control. The best result in terms of minimum pod damage was shown by treatment T_2-Chlorantraniliprole 25g a.i./ha (2.00%) followed by T_5- Cyantraniliprole 60g a.i./ha (4.67%) whereas maximum pod damage was recorded from T_9-Fipronil 50g a.i./ha (18.00%) and T_7-Lambda Chylothrin 30g a.i./ha (15.33%). The results are in conformity with the Upadhyay *et al.* (2020) who found that the lowest pod damage was recorded in the treatment (4.67%) followed by T_6-Flubendamide 39.35 EC 49g a.i./ha (5.33%). Rani *et al.* (2018) reported that application of Chlorantraniliprole in red gram had lowest pod damage caused by gram pod borer.

Effect of certain new molecule of insecticides on yield chickpea

The study made on the effect of insecticidal treatments on yield is shown in Table 2. All treatments showed superior with less pod damage compared to untreated control. Among all treatments the minimum pod damage was 2 per cent with highest yield of chickpea pods (14.00 q/ha) was recorded in T_2-Chlorantraniliprole 25g a.i./ha. The succeeding best treatment was T_5-Cyantraniliprole 60g a.i./ha 13.73 q/ha yield and next best treatment was T_4-Flubendiamide 60g a.i./ha with 13.30 q/ha yield. Among all the treatments T_8- Novaluron 75g a.i./ha produced minimum yield (10.15 q/ha). The results are in conformity with the Upadhyay *et al*. (2020) who found that the highest yield was recorded in the treatment Chlorantiniprole 18.5 SC 92g a.i./ha (17.33 q/ha) followed by Flubendamide 39.35 EC 49g a.i./ha (16.44 q/ha) and Spinosad 45 SC 74g a.i./ha (15.55 q/ha). Rani *et al.* (2018) found that use of Chlorantraniliprole in red gram produced higher yield against gram pod borer.

Economics of new molecule of insecticides in Chickpea

The data pertaining to economics of various treatments are presented in Table 2. The highest net return was recorded from T_2-Chlorantraniliprole 25g a.i./ha (Rs. 27720) and the minimum in T_8-Novaluron 75g a.i./ha (Rs. 8915). The benefit: cost ratio of different insecticides revealed that T_7-Lambda Cyhalothrin 30g a.i./ha (7.86:1) was the most economical treatment followed by T_3-Emamectin benzoate 12g a.i./ha (6.75:1), T_2-Chlorantraniliprole 25g a.i./ha (4.29:1), T_6-Indoxacarb 60g a.i./ha (3.89:1), T_4-Flubendiamide 12g a.i./ha (2.91:1), T_9-Fipronil 50g a.i./ha (2.64:1), T_1-Spinosad 60g a.i./ha (2.14:1), T_5-Cyantraniliprole 60g a.i./ha (1.64:1) and treatment T_8-Novaluron 75g a.i./ha (1.58:1) was least economical treatment. The present findings are in agreement with Upadhyay *et al*. (2020) who reported that Lambda Cyhalothrin was second most economical treatment after Indoxacarb. Meena *et al*. (2018) also found treatment with Indoxacarb (1:9.52) was highly cost effective treatment in chickpea against gram pod borer.

Conclusion

Application of insecticides for the management of insect pests in agriculture ecosystem is one of the most common activities as insecticides provide good control of insect pests in very short span of time. Foliar spray of Chlorantraniliprole 25g a.i./ha and Cyantraniliprole 60g a.i./ha were the most effective insecticides against *Helicoverpa armigera* with minimum larval population, lowest pod damage and highest yield per hectare. Chlorantraniliprole 25g a.i./ha had highest net return while Lambda Cyhalothrin 30g a.i./ha was most cost effective treatment with highest benefit cost ratio. These insecticides belong to newer group, relatively safer and more effective at lower doses against gram pod borer as comparison to conventional insecticides for management of this key pest of chickpea. The information generated in present study can be suitably incorporated in the management strategies.

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Conflict of interest
The authors declare that they have no conflict of interest.

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