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

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**ARTICLE INFO**  
**ABSTRACT**

Received : 24 December 2021  
Revised : 10 March 2022  
Accepted : 20 March 2022  
Available online: 29 May 2022  

**Key Words:**  
Bioefficacy  
Chickpea  
Gram pod borer  
*Helicoverpa armigera*  
Insecticides

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 30g a.i./ha (7.86:1) 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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**Doi:** https://doi.org/10.36953/ECJ.10332235  
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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         | Flubendiamide  | Fame        | 39.35% SC              | 60g a.i.                                               | Bayer Crop Science Limited, Mumbai |
| T5         | Cytraniliprole | 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                                                  | -                     |

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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 T2-Chlorantraniliprole 25g a.i./ha (3.00 larvae/mrl) followed by the treatment T5- Cyantraniliprole 60g a.i./ha (3.33 larvae/mrl) and highest in treatment T9- Lambda Chylothrin 30g a.i./ha (4.67 larvae/mrl). The observation recorded at 7 DAS revealed that the minimum population was found in T2-Chlorantraniliprole 25g a.i./ha (3.00 larvae/mrl) followed by T5- Cyantraniliprole 25g a.i./ha (0.89 larvae/mrl), and maximum in the treatment T9-Fipronil 50g a.i./ha (2.44 larvae/mrl). The data noted at 15 DAS depicted that all the treatments were significantly superior to control. The overall population after second spraying indicated that treatment T2-Chlorantraniliprole 25g a.i./ha (1.96 larvae/mrl) was superior to the remaining treatments followed by T5- Cyantraniliprole 60g a.i./ha (1.15 larvae/mrl), whereas treatment T9-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. 1 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. armigera.
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 | First Spray |         |         |         |         |         |         | **Pod damage (%)** |
|---------|---------------------|---------|-------------|---------|---------|---------|---------|---------|---------|-------------------|
|         |                     |         | DBS         | 5 DAS   | 7 DAS   | 15 DAS  | Mean    | DBS     | 3 DAS   | 7 DAS   | 15 DAS  | Mean    |                     |
| T1      | Spinosad            | 60 g 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) |
| T2      | Chlorantraniliprole | 25 g 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) |
| T3      | Emamectin benzoate  | 12 g 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) |
| T4      | Flubendiamide       | 60 g 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) |
| T5      | Cyantraniliprole    | 60 g 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) |
| T6      | Indoxacarb          | 60 g 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) |
| T7      | Lambda Cyhalothrin  | 30 g 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) |
| T8      | Novaluron           | 75 g 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) |
| T9      | Fipronil            | 50 g 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) |
| T10     | 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 |
|---------|-----------------------|---------|----------------------------------------|--------------------------------------------------|---------------|--------------------------|-------------|--------------------------------------|-----------------|-------------|----------|------|
| T1      | Spinosad 60g a.i.     | 133mL   | 4454                                   | 2                                                 | 8908          | 12.80                    | 5.50        | 28050                               | 19142           | 2.14        | VII      |
| T2      | Chlorantraniliprole   | 25g a.i. | 135mL                                  | 2                                                 | 6450          | 14.00                    | 6.70        | 34170                               | 27720           | 4.29        | III      |
| T3      | Emamectin benzoate    | 12g a.i. | 240g                                   | 2                                                 | 3580          | 13.10                    | 5.80        | 29580                               | 26000           | 6.75        | II       |
| T4      | Flubendiamide 60g a.i.| 152mL   | 3907                                   | 2                                                 | 7814          | 13.30                    | 6.00        | 30600                               | 22786           | 2.91        | V        |
| T5      | Cyantraniliprole      | 60g a.i. | 584mL                                  | 2                                                 | 12380         | 13.73                    | 6.43        | 32793                               | 20413           | 1.64        | VIII     |
| T6      | Indoxacarb 60g a.i.   | 413mL   | 2498                                   | 2                                                 | 4996          | 12.10                    | 4.80        | 24480                               | 19484           | 3.89        | IV       |
| T7      | Lambda Cyhalothrin    | 30g a.i. | 600mL                                  | 2                                                 | 1708          | 10.27                    | 2.97        | 15147                               | 13439           | 7.86        | I        |
| T8      | Novaluron 75g a.i.    | 750mL   | 2810                                   | 2                                                 | 5620          | 10.15                    | 2.85        | 14535                               | 8915            | 1.58        | IX       |
| T9      | Fipronil 50 a.i.      | 1000mL  | 2450                                   | 2                                                 | 4900          | 10.80                    | 3.50        | 17850                               | 12950           | 2.64        | VI       |
| T10     | 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
Similarly, Upadhyay et al. (2020) also reported that the highest efficacy of insecticide after the spray was found in T3-Chlorantiniprole 18.5 SC 92g a.i. ha\(^{-1}\) (63.05%) and the lowest overall % efficacy was registered in T8-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 T2-Chlorantraniliprole 25g a.i./ha (2.00%) followed by T5-Cyantraniliprole 60g a.i./ha (4.67%) whereas maximum pod damage was recorded from T9-Fipronil 50g a.i./ha (18.00%) and T7-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 T5-Flubendiamide 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 T2-Chlorantraniliprole 25g a.i./ha. The succeeding best treatment was T5-Cyantraniliprole 60g a.i./ha 13.73 q/ha yield and next best treatment was T4-Flubendiamide 60g a.i./ha with 13.30 q/ha yield. Among all the treatments T8- 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 Flubendiamide 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 T2-Chlorantraniliprole 25g a.i./ha (Rs. 27720) and the minimum in T8-Novaluron 75g a.i./ha (Rs. 8915). The benefit: cost ratio of different insecticides revealed that T7-Lambda Cyhalothrin 30g a.i./ha (7.86:1) was the most economical treatment followed by T3-Emamectin benzoate 12g a.i./ha (6.75:1), T2-Chlorantraniliprole 25g a.i./ha (4.29:1), T6-Indoxacarb 60g a.i./ha (3.89:1), T4-Flubendiamide 12g a.i./ha (2.91:1), T9-Fipronil 50g a.i./ha (2.64:1), T1-Spinosad 60g a.i./ha (2.14:1), T5-Cyantraniliprole 60g a.i./ha (1.64:1) and treatment T8-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.

**Acknowledgement**

The authors are highly thankful to Head, Department of Entomology, Acharya Narendra Deva University of Agriculture & Technology,
Kumarganj, Ayodhya (U.P.) India for providing essential facilities and support during the experiment.

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

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