**Efficacy of insecticides against borers on pigeonpea in Malwa region of Madhya Pradesh**

**ABSTRACT**

Pigeonpea is second most important pulse crop in India after chickpea. But India is not self-sufficient in pulse production. In India daily availability of pulse (47 gm) is less than the per capita requirement (80 gm). There are several constraints which affect the pulse production. One of the major constraints is insects-pests. So, an experiment was carried out in pigeonpea variety RVSA 16-1 during *Kharif* season of 2022-23 at Zonal Agriculture Research Station, Rafi Ahmed Kidwai College of Agriculture, Sehore (M.P.) to find out most effective newer insecticide against one of the major insect-pest of pigeonpea *i.e* pod borers. There are eight different treatments were sprayed at 15 days interval. The lowest larval population of *H. armigera, M. vitrata and E. atomosa* were recorded in plot treated with lufenuron @ 1200 ml/ha followed by chlorfluazuron @ 500 ml/ha, emamectin benzoate @ 125 gm/ha, chlorantraniliprole @ 150 ml/ha and lambda cyhalothrin @ 500 ml/ha with maximum reduction percent over control. While maximum population recorded in control plot. The treatment with the highest yield was recorded in lufenuron @ 1200 ml/ha, which yielded an impressive 14.42 q/ha. Chlorfluazuron @ 500 ml/ha 13.27 q/ha was the next effective treatment. Based on the cost benefit ratio results chlorfluazuron @ 500 ml/ha (1:7.95) followed by lufenuron @ 600 ml/ha (1:3.84) demonstrate the highest cost benefit.

Keywords: Pigeonpea [*Cajanus cajan (*L.)]; gram pod borer (*Helicoverpa armigera*); plume moth (*Exelastis atomosa*); leaf webber (*Maruca vitrata*).

**INTRODUCTION**

Pigeonpea [*Cajanus cajan (*L.) Mill sp.] also known as red gram, Arhar or tur, is one of India's most important pulse crops. Asia is considered to be the origin of the pigeonpea. It is the second most important pulse crop in India after chickpea, accounting for about 20% of total pulse production, and is commonly grown in semi-arid and tropical regions (Sarkar *et al*., 2020). It is grown as a food and fodder crop, but it can also be used as green manure. pigeonpea is a protein-rich staple food that contributes 22 per cent of protein to the human diet, nearly three times that of cereals. It is primarily consumed in the form of split pulse as Dal, which is an important supplement to a cereal-based vegetarian diet. It is high in lysine, riboflavin, thiamine, niacin, and iron. Aside from being an important source of human food and animal feed, it also helps to maintain soil fertility by improving soil physical properties and fixing atmospheric nitrogen (Singh and Yadav, 2005). The outer covering of seeds, along with a portion of the kernel, is a valuable feed for milk cattle. The husk of pods and woody plant parts are used as fuel. Because it is drought tolerant, it is ideal for dry land farming and is commonly used as an intercrop with other crops. India is the largest producer of pigeonpea, followed by Myanmar, Malawi, Tanzania, and Haiti. The global area under pigeonpea cultivation is about 6 million hectares, with a total production of 5 million tones and an average productivity of 822 kg/ha. Within India, the major pigeonpea growing states are Maharashtra, Karnataka, Telangana, Madhya Pradesh, Andhra Pradesh and Uttar Pradesh. The area, production and productivity of pigeonpea in India are 4.54 million ha, 3.83 million tones and 842 kg/ha respectively. Madhya Pradesh has the highest productivity of pigeonpea among the Indian states, with 962 kg/ha from an area of 0.5 million ha and a production of 0.3 million tons (Anonymous, 2022).

Pigeonpea production potential is affected by several factors, including damage caused by insect pests. In India, approximately 150 species of insects’ attack pulse crops (Seetharamu *et al*., 2020). The primary biotic constraints to pigeonpea production are the pod borer complex, *Helicoverpa armigera* (Hubner), *Maruca vitrata* (Fabricius), and pod fly, *Melanagromyza obtusa* (Malloch) (Jat *et al*., 2017). The gram pod borer (*Helicoverpa armigera*), leaf webber (*Maruca vitrata*), pod fly (*Melanagromyza obtusa*), plume moth (*Exelastis atomosa*), blue butterfly (*Lampides boeticus*), and pod sucking bug (*Clavigralla* *gibbose*) all cause significant damage to pigeonpea.

The most important pest is *H. armigera*, which feeds on the reproductive structures and growing tips that are rich in nitrogen. This reduces the yield and quality of the crop (Reed and Lateef, 1990). Another pest that attacks the flowers and pods of pigeonpea is *M. vitrata*, which webs them together with leaves and frass. This pest is more severe in early maturing varieties, as it causes flower discoloration and shedding, and pod boring (Sharma *et al*., 2011). The grain yield was reduced by 60–90% by pod borer and Leaf webber caused 6-8%. *M. obtusa* which causes dark brown encrustation on the pod wall and small holes on the dry pods. The seeds inside are partially eaten and striped by this pest (Singh *et al.* 2014), causing 10 to 80% damage (Shanower *et al.*, 1999; Kumar and Nath 2003; Revathi *et al*., 2015). These pests can cause significant damage to the leaves, flowers, and pods of the crop, affecting its yield and quality of the flower damage in pigeonpea.

To protect pigeonpea from these pests, farmers often use chemical insecticides that can kill or repel the insects. Indiscriminate use of chemical pesticides, which leads to increased cost of plant protection resulting in lower profitability. However, not all insecticides are equally effective against all pests, and some may have negative effects on the environment and human health. Hence, it is necessary to assess more recent insecticides with unique modes of action in order to identify a cost-effective and efficient pesticide for the control of the major insect pests of pigeonpea, based on scientific research and field trials.

**MATERIALS AND METHODS**

The research work was carried out on pigeonpea variety RVSA 16-1 during Kharif season of 2022-23 at Zonal Agriculture Research Station, Rafi Ahmed Kidwai College of Agriculture, Sehore (M.P.). The design we used in trial was RBD with eight treatments and each treatment replicate thrice with a plot size 9.6 m2 (2.4 m × 4.0 m) and spacing was 90 cm. There are 8 different treatments applied during experiment were, T1: Lufenuron 5.4 % EC @ 600 ml/ha, T2: Lufenuron 5.4 % EC @ 1200 ml/ha, T3: Chlorfluazuron 5.4% EC @ 500 ml/ha, T4: Lambda Cyhalothrin 5 % EC @ 500 ml/ha, T5: Chlorantraniliprole 18.5 % SC @ 150 ml/ha, T6: Emamectin Benzoate 5 % SG @ 125 gm/ha, T7: Azadirachtin Neem oil 3000 ppm @ 2000 ml/ha, T8: Untreated water spray was tried. During experiment all interculture operations were done.

**SPRAY SCHEDULE**

To determine the efficacy of formulations, two sprays of insecticides on pigeonpea were done. First spray was done at initiation of insect infestation. Second spray was at fifteen days after first spray. After every treatment spray, sprayer was washed thoroughly with clean water and measures were taken to avoid contamination of spraying equipment.

**OBSERVATIONS**

Larval population count of *H. armigera*, *M. vitrata* and *E. atomosa* were recorded on five randomly selected plants in each treatment. Pre-treatment observation was recorded on one day before spraying treatment while post observations were carried out at 1, 3, 5, 7, 10 and 14 days after spray. Economics of different treatments were workout in comparison to control. Data were analyzed (√𝑥 +0.5) using ANOVA after transformation (Taylor's Power Law, 1984).

In order to compare the efficacy of the different modules/ treatments, the grain yield of net plot from each treatment were recorded after harvest of the crop. Thus, obtained yield per plot was converted into quintals per hectare and the data obtain from grain yields were used to calculate the economic viability of each treatment. The costs of each treatment and labour required for application were calculated as per market rate. Similarly, the income obtained from the sale of grains as per prevailing rates was also calculated for each treatment. The data thus obtained were used to calculate the monitory return and benefit cost ratio (B:C ratio) of various treatments.

**RESULTS AND DISCUSSION**

Result after both first and second spray the minimum larval population of *H. armigera, M. vitrata* and *E. atomosa* was recorded in plot treated with lufenuron @ 1200 ml/ha followed by chlorfluazuron @ 500 ml/ha, emamectin benzoate @ 125 gm/ha, chlorantraniliprole @ 150 ml/ha and lambda cyhalothrin @ 500 ml/ha, while maximum population recorded in control plot. The larval population obtained in eight different treatments after first and second sprays are following.

**Population of pod borer, *Helicoverpa armigera***

Overall mean larval population of all the insecticides differ significantly from control with a mean population 3.92 larvae per plant (Table- 1). The lowest larval population was recorded in lufenuron @ 1200 ml/ha (1.01 larvae per plant) followed by chlorfluazuron @ 500 ml/ha (1.11 larvae per plant), lufenuron @ 600 ml/ha (1.18 larvae per plant), emamectin benzoate @ 125 gm/ha (1.26 larvae per plant), chlorantraniliprole @ 150 ml/ha (1.35 larvae per plant) and lambda cyhalothrin @ 500 ml/ha (1.44 larvae per plant). However, compared to the rest of the insecticidal treated plots, the maximum and significantly greater population (1.93 larvae per plant) was observed in azadirachtin neem oil @ 2000 ml/ha. These current results coincide with those of Nagar (2021), who reported on the data related to the overall mean pod damage caused by *H. armigera* after both sprays showed that the treatment (chlorfluazuron 5.4% EC @ 100 ml/ha) was the most effective, with the lowest overall mean per cent of pod infestation and the highest percentage of pod damage reduction (84.72%) compared to the untreated control. Table (1).

**Population of spotted pod borer, *Maruca vitrata***

Larval population of all the insecticides differ significantly from control with a mean population 3.36 larvae per plant (Table- 2). The lowest larval population was recorded in lufenuron @ 1200 ml/ha (0.89 larvae per plant) followed by chlorfluazuron @ 500 ml/ha (0.94 larvae per plant), lufenuron @ 600 ml/ha (1.07 larvae per plant), emamectin benzoate @ 125 gm/ha (1.16 larvae per plant), chlorantraniliprole @ 150 ml/ha (1.24 larvae per plant) and lambda cyhalothrin @ 500 ml per ha (1.29 larvae per plant). However, compared to the rest of the insecticidal treated plots, the maximum and significantly greater population (1.61 larvae per plant) was observed in azadirachtin neem oil @ 2000 ml/ha. In addition, field experiments were carried out by Sreekanth *et al.* (2015) on pigeonpea to determine cost-effective control measures against the legume pod borer, *M. vitrata*. The experimental results showed that the percentage of inflorescence damage caused by *Maruca* was lowest in chlorantraniliprole 18.5% SC (2.08%). Similar findings were reported by Prakash *et al.* (2021), who found that pod damage caused by *H. armigera* and *M. vitrata* larvae was significantly reduced in the treatment group that received emamectin benzoate 5% + lufenuron 40 % WG at 70 g/ha (4.2 and 8.6%), followed by lufenuron 5.4% EC (10.6 and 10.4%). Table (2).

**Population of plume moth, *Exelastis atomosa***

After both sprays overall mean larval population of *E. atomosa* in the experimental plots ranged from 1.93 to 2.00 larvae per plant before treatments were imposed, and the population was statistically equal, showing homogeneity of the pest population in the experimental plot. All the insecticides showed significant difference from control with a mean population 3.59 larvae per plant. Minimum and significantly less (1.01) larval population was recorded in chlorfluazuron @ 500 ml/ha than rest of the treatments followed by lufenuron @ 1200 ml/ha (1.13 larvae per plant) and lufenuron @ 600 ml/ha (1.23 larvae per plant), emamectin benzoate @ 125 gm/ha (1.31 larvae per plant). The furthermore treatment chlorantraniliprole @ 150 ml/ha (1.39 larvae per plant) and lambda cyhalothrin @ 500 ml/ha (1.46 larvae per plant) were recorded which was followed by azadirachtin neem oil @ 2000 ml/ha with maximum and significantly higher population (1.85 larvae per plant). According to Nagar's (2021) report, the treatment (chlorfluazuron 5.4% EC @ 100 ml/ha) was found to be the most effective due to its minimum 2.89 overall mean per cent pod infestation and maximum (84.72%) per cent reduction in pod damage over the untreated control. The data pertaining to overall mean pod damage caused by *H. armigera* after both sprays was obtained. Table (3).

**ECONOMICS OF VARIOUS TREATMENTS**

The yield data presented in table (4) highlights the net yield obtained from different treatments, ranging from 8.50 to 14.42 q/ha. The highest yield was recorded in lufenuron @ 1200 ml/ha, which yielded an impressive 14.42 q/ha chlorfluazuron @ 500 ml/ha 13.27 q/ha was the next effective treatment followed by lufenuron @ 600 ml/ha (13.14 q/ha), lambda cyhalothrin 5 % EC (10.12 q/ha) and azadirachtin neem oil @ 2000 ml/ha (9.60 q/ha) found least effective but significant superior to control. All the treatment were found significantly superior to control (8.50 q/ha). Higher benefit cost ratio values signify a more favourable outcome, indicating that the benefits outweigh the costs. Based on the benefit cost ratio results chlorfluazuron @ 500 ml/ha (1: 7.95) followed by lufenuron @ 600 ml/ha (1:3.84) demonstrate the highest benefit cost ratio values, suggesting that these treatments offer the greatest benefits relative to their costs. The current results are consistent with those of Nagar (2021), who found that chlorfluazuron 5.4% EC @ 100 ml/ha produced the highest grain yield of 1249 kg/ha, representing a 33.86% increase over the control. Spraying chlorfluazuron 5.4 % EC at 100 ml/ha was the most cost-effective and profitable option, with a 1:17.45 C: B ratio. This was followed by chlorfluazuron 5.4% EC at 33.30 ml/ha (1:16.26) and 66.60 ml/ha (1:15.68). Similarly, Dodia *et al.* (2009) found that the highest grain yield was achieved with emamectin benzoate at 11 g/ha (1761 kg/ha), followed by spinosad at 73 g/ha (1717 kg/ha) and indoxacarb at 50 g/ha (1598 kg/ha). Furthermore, Priyadarshini *et al.* (2013) found that the treatment flubendiamide 480 SC at 60 g a.i. ha-1 yielded the highest net profit (Rs. 12,638) followed by lambda-cyhalothrin 5 EC at 25 g a.i. ha-1 (Rs. 7092). While lambda cyhalothrin 5 EC at 25 g a.i. ha-1 (1:7.5) showed the highest incremental benefit cost ratio.

**Table-1: Effect of different insecticides against pod borer, *H*. *armigera* on pigeonpea during *Kharif* season** **2022**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Dose/ha** | **1DBS** | **Population of larvae per plant** | **Overall mean** | **Per cent Reduction** |
| **After first spray** | **After second spray** |
| **1 DAS** | **3 DAS** | **5 DAS** | **7 DAS** | **10 DAS** | **14 DAS** | **1 DAS** | **3 DAS** | **5 DAS** | **7 DAS** | **10 DAS** | **14 DAS** |
| Lufenuran 5.4 % EC | 600 ml/ha | 1.83(1.53) | 1.67(1.47) | 1.50(1.41) | 1.27(1.33) | 1.20(1.3) | 1.13(1.28) | 1.20(1.3) | 1.17(1.29) | 1.13(1.28) | 1.07(1.25) | 1.03(1.24) | 0.90(1.18) | 0.87(1.17) | **1.18** | **70.07** |
| Lufenuran 5.4 % EC | 1200 ml/ha | 1.87(1.54) | 1.60(1.45) | 1.37(1.37) | 1.13(1.28) | 1.00(1.22) | 0.97(1.21) | 1.00(1.22) | 0.97(1.21) | 0.93(1.20) | 0.87(1.17) | 0.80(1.14) | 0.73(1.11) | 0.70(1.1) | **1.01** | **74.53** |
| Chlorfluazuron 5.4% EC | 500 ml/ha | 1.83(1.53) | 1.63(1.46) | 1.40(1.38) | 1.20(1.3) | 1.13(1.28) | 1.10(1.26) | 1.17(1.29) | 1.10(1.26) | 1.07(1.25) | 1.00(1.22) | 0.90(1.18) | 0.80(1.14) | 0.80(1.14) | **1.11** | **71.88** |
| Lambda Cyhalothrin 5 % EC | 500 ml/ha | 1.80(1.52) | 1.80(1.52) | 1.70(1.48) | 1.60(1.45) | 1.53(1.43) | 1.37(1.37) | 1.47(1.4) | 1.43(1.39) | 1.40(1.38) | 1.37(1.37) | 1.27(1.33) | 1.20(1.3) | 1.20(1.3) | **1.44** | **63.20** |
| Chlorantraniliprole 18.5 % SC | 150 ml/ha | 1.90(1.55) | 1.73(1.49) | 1.63(1.46) | 1.50(1.41) | 1.37(1.37) | 1.30(1.34) | 1.37(1.37) | 1.33(1.35) | 1.30(1.34) | 1.27(1.33) | 1.20(1.3) | 1.07(1.25) | 1.13(1.28) | **1.35** | **65.62** |
| Emamectin benzoate 5 % SG | 125 gm/ha | 1.87(1.54) | 1.70(1.48) | 1.60(1.45) | 1.40(1.38) | 1.30(1.34) | 1.23(1.32) | 1.33(1.35) | 1.23(1.32) | 1.17(1.29) | 1.13(1.28) | 1.10(1.26) | 0.97(1.21) | 1.00(1.22) | **1.26** | **67.89** |
| Azadirachtin 3000 ppm | 2000 ml/ha | 1.93(1.56) | 1.97(1.57) | 2.20(1.64) | 2.30(1.67) | 2.20(1.64) | 1.87(1.54) | 1.90(1.55) | 1.90(1.55) | 1.87(1.54) | 1.83(1.53) | 1.77(1.51) | 1.70(1.48) | 1.67(1.47) | **1.93** | **50.75** |
| Untreated |  | 1.93(1.56) | 2.77(1.81) | 3.90(2.1) | 4.40(2.21) | 4.63(2.27) | 4.73(2.29) | 4.80(2.3) | 4.90(2.32) | 3.83(2.08) | 3.63(2.03) | 3.47(1.99) | 3.20(1.92) | 2.77(1.81) | **3.92** | **-** |
| **S.E.m(±)** | **0.01** | **0.01** | **0.01** | **0.01** | **0.02** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.02** | **0.01** | **0.01** |  |  |
| **CD at 5%** | **NS** | **(0.03)** | **(0.02)** | **(0.03)** | **(0.05)** | **(0.03)** | **(0.03)** | **(0.04)** | **(0.03)** | **(0.04)** | **(0.05)** | **(0.03)** | **(0.03)** |  |  |

**Figures in the parentheses are transformed (√n+0.5) values, NS= Non-significant**

* **√x+0.5 transformed values are used for analysis**
* **DBS - Day before spray**
* **DAS - Day after spray**

**Table-2: Effect of different insecticides against spotted pod borer, *M. vitrarta* on pigeonpea during *Kharif* season** **2022**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Dose/ha** | **1DBS** | **Population of larvae per plant** | **Overall mean** | **Per cent Reduction** |
| **After first spray** | **After second spray** |
| **1 DAS** | **3 DAS** | **5 DAS** | **7 DAS** | **10 DAS** | **14 DAS** | **1 DAS** | **3 DAS** | **5 DAS** | **7 DAS** | **10 DAS** | **14 DAS** |
| Lufenuran 5.4 % EC | 600 ml/ha | 1.70(1.48) | 1.57(1.44) | 1.37(1.37) | 1.23(1.32) | 1.03(1.24) | 1.00(1.22) | 1.07(1.25) | 1.03(1.24) | 0.97(1.21) | 0.93(1.2) | 0.90(1.18) | 0.87(1.17) | 0.83(1.15) | **1.07** | **68.30** |
| Lufenuran 5.4 % EC | 1200 ml/ha | 1.67(1.47) | 1.50(1.41) | 1.27(1.33) | 1.13(1.28) | 0.83(1.15) | 0.80(1.14) | 0.83(1.15) | 0.80(1.14) | 0.77(1.13) | 0.73(1.11) | 0.70(1.1) | 0.67(1.08) | 0.63(1.06) | **0.89** | **73.60** |
| Chlorfluazuron 5.4% EC | 500 ml/ha | 1.63(1.46) | 1.53(1.43) | 1.33(1.35) | 1.17(1.29) | 0.87(1.17) | 0.83(1.15) | 0.90(1.18) | 0.87(1.17) | 0.83(1.15) | 0.80(1.14) | 0.77(1.13) | 0.73(1.11) | 0.70(1.1) | **0.94** | **71.95** |
| Lambda Cyhalothrin 5 % EC | 500 ml/ha | 1.73(1.49) | 1.63(1.46) | 1.57(1.44) | 1.47(1.4) | 1.30(1.34) | 1.23(1.32) | 1.33(1.35) | 1.30(1.34) | 1.27(1.33) | 1.20(1.3) | 1.13(1.28) | 1.07(1.25) | 1.00(1.22) | **1.29** | **61.60** |
| Chlorantraniliprole 18.5 % SC | 150 ml/ha | 1.67(1.47) | 1.63(1.46) | 1.53(1.43) | 1.33(1.35) | 1.23(1.32) | 1.20(1.3) | 1.27(1.33) | 1.23(1.35) | 1.20(1.3) | 1.17(1.29) | 1.07(1.25) | 1.00(1.22) | 1.03(1.24) | **1.24** | **63.09** |
| Emamectin benzoate 5 % SG | 125 gm/ha | 1.67(1.47) | 1.60(1.45) | 1.43(1.39) | 1.30(1.34) | 1.10(1.26) | 1.07(1.25) | 1.17(1.29) | 1.13(1.28) | 1.10(1.26) | 1.07(1.25) | 1.00(1.22) | 0.97(1.21) | 0.93(1.2) | **1.16** | **65.65** |
| Azadirachtin 3000 ppm | 2000 ml/ha | 1.77(1.51) | 1.80(1.52) | 1.77(1.51) | 1.73(1.49) | 1.70(1.48) | 1.63(1.46) | 1.60(1.45) | 1.63(1.46) | 1.57(1.44) | 1.53(1.43) | 1.50(1.41) | 1.47(1.40) | 1.43(1.39) | **1.61** | **52.01** |
| Untreated |  | 1.77(1.51) | 2.27(1.66) | 3.10(1.9) | 3.53(2.01) | 3.73(2.06) | 3.83(2.08) | 3.90(2.1) | 3.80(2.07) | 3.87(2.09) | 3.67(2.04) | 3.20(1.92) | 2.80(1.82) | 2.63(1.77) | **3.36** | **-** |
| **S.E.m(±)** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** | **0.01** |  |  |
| **CD at 5%** | **NS** | **(0.04)** | **(0.04)** | **(0.04)** | **(0.03)** | **(0.04)** | **(0.04)** | **(0.03)** | **(0.03)** | **(0.04)** | **(0.02)** | **(0.04)** | **(0.03)** |  |  |

**Figures in the parentheses are transformed (√n+0.5) values, NS= Non-significant**

* **√x+0.5 transformed values are used for analysis**
* **DBS - Day before spray**
* **DAS - Day after spray**

**Table-3: Effect of different insecticides against plume moth, *E. atomosa* on pigeonpea during *Kharif* season** **2022**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Dose/ha** | **1DBS** | **Population of larvae per plant** | **Overall mean** | **Per cent Reduction** |
| **After first spray** | **After second spray** |
| **1 DAS** | **3 DAS** | **5 DAS** | **7 DAS** | **10 DAS** | **14 DAS** | **1 DAS** | **3 DAS** | **5 DAS** | **7 DAS** | **10 DAS** | **14 DAS** |
| Lufenuran 5.4 % EC | 600 ml/ha | 1.97(1.57) | 1.70(1.48) | 1.57(1.44) | 1.47(1.4) | 1.20(1.3) | 1.03(1.24) | 1.10(1.26) | 1.30(1.34) | 1.27(1.33) | 1.17(1.29) | 1.00(1.22) | 0.93(1.2) | 1.07(1.25) | **1.23** | **65.21** |
| Lufenuran 5.4 % EC | 1200 ml/ha | 1.93(1.56) | 1.50(1.41) | 1.40(1.38) | 1.37(1.37) | 1.13(1.28) | 0.97(1.21) | 1.03(1.24) | 1.20(1.3) | 1.17(1.29) | 1.07(1.25) | 0.90(1.18) | 0.87(1.17) | 1.00(1.22) | **1.13** | **68.04** |
| Chlorfluazuron 5.4% EC | 500 ml/ha | 1.93(1.56) | 1.47(1.4) | 1.30(1.34) | 1.23(1.32) | 0.97(1.21) | 0.83(1.15) | 0.90(1.18) | 1.00(1.22) | 1.00(1.22) | 0.90(1.18) | 0.83(1.15) | 0.80(1.14) | 0.87(1.17) | **1.01** | **71.52** |
| Lambda Cyhalothrin 5 % EC | 500 ml/ha | 1.97(1.57) | 1.83(1.53) | 1.70(1.48) | 1.67(1.47) | 1.40(1.38) | 1.30(1.34) | 1.37(1.37) | 1.53(1.43) | 1.47(1.4) | 1.43(1.39) | 1.23(1.32) | 1.23(1.32) | 1.30(1.34) | **1.46** | **59.03** |
| Chlorantraniliprole 18.5 % SC | 150 ml/ha | 1.93(1.56) | 1.80(1.52) | 1.67(1.47) | 1.60(1.45) | 1.33(1.35) | 1.23(1.32) | 1.27(1.33) | 1.43(1.39) | 1.40(1.38) | 1.37(1.37) | 1.17(1.29) | 1.17(1.29) | 1.20(1.3) | **1.39** | **60.96** |
| Emamectin benzoate 5 % SG | 125 gm/ha | 1.97(1.57) | 1.77(1.51) | 1.63(1.46) | 1.53(1.43) | 1.23(1.32) | 1.13(1.28) | 1.23(1.32) | 1.33(1.35) | 1.30(1.34) | 1.27(1.33) | 1.10(1.26) | 1.00(1.22) | 1.17(1.29) | **1.31** | **63.11** |
| Azadirachtin 3000 ppm | 2000 ml/ha | 2.00(1.58) | 1.97(1.57) | 1.93(1.56) | 1.90(1.55) | 1.83(1.53) | 1.70(1.48) | 1.87(1.54) | 1.90(1.55) | 1.90(1.55) | 1.83(1.53) | 1.80(1.52) | 1.77(1.51) | 1.73(1.49) | **1.85** | **48.28** |
| Untreated | - | 1.93(1.56) | 2.80(1.82) | 2.97(1.86) | 3.00(1.87) | 3.60(2.02) | 3.77(2.07) | 3.80(2.07) | 3.80(2.07) | 3.73(2.06) | 3.83(2.08) | 3.90(2.1) | 3.90(2.11) | 3.97(2.11) | **3.59** | **-** |
| **S.E.m(±)** | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 |  |  |
| **CD at 5%** | **NS** | **(0.02)** | **(0.03)** | **(0.03)** | **(0.03)** | **(0.03)** | **(0.03)** | **(0.02)** | **(0.04)** | **(0.05)** | **(0.02)** | **(0.04)** | **(0.05)** |  |  |

**Figures in the parentheses are transformed (√n+0.5) values, NS= Non-significant**

* **√x+0.5 transformed values are used for analysis**
* **DBS - Day before spray**
* **DAS - Day after spray**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Dose /ha** | **Yield q/ha** | **Increase yield over control (Q)** | **Income from increased yield** | **Treatment cost** | **Net profit Rs. /ha** | **C : B** |
| Lufenuran 5.4 % EC | 600 ml/ha | 13.14 | 4.64 | 30624 | 7968 | 22656 | 1:3.84 |
| Lufenuran 5.4 % EC | 1200 ml/ha | 14.42 | 5.92 | 39072 | 11876 | 27196 | 1:3.29 |
| Chlorfluazuron 5.4% EC | 500 ml/ha | 13.27 | 4.77 | 31482 | 3960 | 27522 | 1:7.95 |
| Lambda cyhalothrin 5 % EC | 500 ml/ha | 10.12 | 1.62 | 10692 | 4140 | 6552 | 1:2.58 |
| Chlorantraniliprole 18.5 % SC | 150 ml/ha | 12.86 | 4.36 | 28776 | 8544 | 20232 | 1:3.37 |
| Emamectin Benzoate 5 % SG | 125 gm/ha | 10.80 | 2.30 | 15180 | 5000 | 10180 | 1:3.04 |
| Azadirachtin 3000 ppm | 2000 ml/ha | 9.60 | 1.10 | 7260 | 4700 | 2560 | 1:1.54 |
| Untreated | - | 8.50 | - | - | - | - | - |

**Table - 4: Economics of various treatments**

* Pigeonpea Rs. 6600/quintal
* Labour charge= Rs. 500/labour, (2 labour/hectare/spray)
* Chlorfluazuron 5.4% EC = Rs. 980/500 ml,
* Lambda- cyhalothrin 5% EC= Rs. 1070/ 500 ml,
* Lufenuron 5.4 % EC= Rs. 2984/ 600 ml,
* Chlorantraniliprole 18.5% SC= Rs. 3272/150 ml,
* Emamectin benzoate 5% SG= Rs.1500/125 gm
* Azadiractin 3000 ppm 1350/lit.

**CONCLUSION:**

All insecticidal treatments significantly reduced the larval population of Helicoverpa armigera, Maruca vitrata and Exelastis atomosa compared to the untreated control. Among the tested insecticides **lufenuron @ 1200 ml/ha** and **chlorfluazuron @ 500 ml/ha** were the most effective across all three pests recording the lowest larval populations and highest yields. Chlorfluazuron also exhibited the highest cost-benefit ratio (1:7.95), indicating superior economic viability. Therefore, lufenuron and chlorfluazuron can be recommended as effective and economical options for managing pod borers in black gram under the agro-climatic conditions of the Gird region.

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