Efficacy of various insecticides against gram pod borer (*Helicoverpa armigera)* HUBNER in chickpea

ABSTRACT:

The investigation sought to examine the efficacy of several pesticides on the larval population of the gram pod borer (*Helicoverpa armigera*) in chickpea plants, as well as the corresponding cost-benefit ratio. The experiment was carried out in the Entomology Research Field, Institute of Agriculture and Natural Sciences, Deeksha Bhawan, DDU Gorakhpur University, Gorakhpur in a Randomized Block Design (RBD) with seven treatments replicated three times using Pusa 362 variety in a plot size of (3 m×2 m) at a spacing of (20×10 cm). The treatments used during the observation were T1 Spinosad, T2 NSKE, T3 *Bt*, T4 *Beauveria bassiana*, T5 Neem oil, T6 Emamectin benzoate and T7 control plot (without any treatment). From the study it was noted that the highest reduction was reported in plots treated with Spinosad 0.20ml/l which proved to be superior among the rest of the treatments and the next effective treatment is Emamectin benzoate 0.4 g/l, followed by *Beauveria bassiana* 2x 10 CFU@ 5ml/l, *Bacillus thuringiensis* 1.5g/l and maximum population of pod borer was observed in untreated control plot. The data on the yield of chickpea revealed that the highest yield recorded in the treatment Spinosad (0.20ml/l) and it was superior over all the other treatment followed by Emamectin benzoate 0.4g/l with the yield was obtained in the control. The data on the increase in yield over control of chickpea revealed that the highest increase in yield over control was recorded in the treatment Spinosad (0.20ml/l) and it was superior over all the other treatments and followed by Emamectin benzoate 0.4g/l with the lowest increase in yield over control was reported in plot treated with NSKE 5% with, respectively. The maximum cost-benefit ratio was obtained in the plot treated with 0.20ml/l spinosad 45 SC next effective treatment in terms of cost-benefit ratio was Emamectin benzoate 0.4g/l and the lowest cost-benefit ratio was found in Neem oil 3%treated plot.

Keywords: Bio efficacy, gram pod borer, *Helicovera armigera*, Spinosad, Cost-benefit ratio, Eastern Uttar Pradesh

1. INTRODUCTION

Cicer arietinum L., the scientific name for chickpea, is a member of the Cicereae tribe of the Fabaceae family, more precisely the Papilionaceae subfamily (Singh and Diwakar, 1995). This traditional pulse crop is one of the most important legume crops in the world (Ladzinsky, 1975). Chickpeas, sometimes called Chana, Bengal gramme, or Gramme are an important pulse crop that are farmed in many different nations worldwide (Singh and Diwakar, 1995). They provide 20% of the world's supply of legumes. It belongs to the family Leguminaceae. The "King of Pulses," the chickpea, originates in South Western Asia. During the *Rabi* season, the plant typically grows to a height of 20 to 50 cm. It has small, fluffy leaves on both sides of the stem. Usually, it is grown in rainfed or residually damp soil environments. Chickpeas are used as food as well as for human consumption. Its seed is used as a green vegetable, in fried or roasted foods, as a snack, and to make flour and dhal (Chavan *et al*., 1987).

Globally it was grown in 149.66 lakh ha area, with a total production of 15.97 million metric tons and an average productivity of 1252 kg/ha (DES 2023, MOAF and W, GoI). Chickpea production in India was 13.75 million tonnes from an acreage of 10.91 million ha. with a productivity of 12.6 q./ha (DES 2023, MOAF and W, GoI. Chickpea solely contributes nearly 50% of the Indian pulse production. States like Maharashtra (25.97% contribution to national production), Madhya Pradesh (18.59%), Rajasthan (20.65%), Gujarat (10.10%) and Uttar Pradesh (5.64%) are major chickpea-producing states of India (Prasanna *et al.,* 2020).

Consuming chickpeas has a number of physiological benefits that could qualify them as a "functional food," in addition to their well-known ability to supply protein and fiber (Jukanti *et al.,* 2012). 80 % of the dry mass of chickpeas is made up of protein, making them a great source of both carbs and protein (Chibbar *et al.,* 2010). Because of the excellent nutritious qualities of chickpeas, humans have devoured them and still do (Jukanti *et al.,* 2012). It is prepared in a variety of ways across the globe (Ibrikci *et al.,* 2003), for example, chickpeas are used to make snacks in India (Chavan *et al.,* 1987), stews, soups, and salads in Asia and Africa (Gecit *et al.,* 1989). The variety of cooking methods for chickpeas appeals to people all across the world(Jukanti *et al.,* 2012).Per 100 grammes, chickpeas contain the following nutrients: 27.42 grammes of carbohydrates, 8.86 grammes of protein, 2.59

grammes of total fat, 7.6 grammes of dietary fibre, 172 µg of folates, 0.526 mg of niacin, 0.245 mg of pantothenic acid, 0.216 mg of pyridoxine, 0.063 mg of riboflavin, 0.200 mg of thiamine, 1.3 mg of vitamin C, 27 IU of vitamin A, 0.35 mg of vitamin E, 4.0 milligrammes of potassium, 291 mg of sodium, 49 milligrammes of calcium, 2.89 mg of iron, 48 milligrammes of magnesium, 168 milligrammes of phosphorous, and 1.53 milligrammes of zinc. (USDA, 2018).

From seedling until maturity, a variety of insect pests attack the chickpea crop (Reed *et al.,* 1980). *Helicoverpa armigera*, *Spodoptera litura*, *Agrotis ipsilon*, *Plusia orichalchea*, and *Bemisia tabaci* are the main insect pests that affect chickpea crops in the winter and summer (Mari *et al*., 2013). The polyphagous gram pod borer is a member of the Order Lepidoptera and Noctuidae family of insects (Naveen *et al.,* 2020). Other names for it include false budworm, tomato fruit borer, corn earworm, and cotton bollworm. *Helicoverpa armigera* has been identified in 181 plant species belonging to 45 families in India (Manjunath *et al*., 1989). In addition to polyphagy, the following physiological and ecological traits of H. armigera enhance its pest status: high fertility, multivoltinism, long-distance migration capacity, and diapause in adverse conditions (Fitt 1989, Zalucki *et al.* 1986). According to Kranthi *et al.* (2002), this insect has become highly resistant to a large number of regularly used insecticides. This pest feeds on leaves, delicate twigs, blossoms, and pods in order to survive. It attacks chickpea plants at every stage, from seedling to crop maturity. The larvae burrow into the pods once they have developed, feed on the seeds inside, and drastically decrease seed production (Saxena *et al.,* 2018). By puncturing the young pods and enclosing half of their bodies within, its caterpillars devour the maturing seeds. Damage from pod borer pests may reduce chickpea yield by 20–30% (Paul, 2008). The pest infestation can be diminished by the spraying of selected insecticides. (Gautam *et al*., 2018). The pod borer is a pest that is common across the tropics and subtropics, being polyphagous, electric, and global. Less gram is produced as a result of the attacks compared to the frequent outbreaks of *H. armigera*, one of the major pests of chickpea. In India, *Helicoverpa armigera* causes up to Rs 35,000 million in damages every year when left unchecked, even when multiple insecticides are used. (Meena *et al*., 2018).

In addition to polyphagy, the following physiological and ecological traits of H. armigera enhance its pest status: high fertility, multivoltinism, long-distance migration capacity, and diapause in adverse conditions (Fitt 1989, Zalucki *et al.* 1986). According to Kranthi *et al.* (2002), this insect has become highly resistant to a large number of regularly used insecticides.

2. MATERIALS AND METHODS

The present investigation was conducted during rabi season 2023 at the Entomology research field, Institute of Agriculture and Natural Science, Deen Dayal Upadhayay Gorakhpur University, Gorakhpur, India. in a Randomized Block Design (RBD) with seven treatments replicated three times using Pusa 362 variety in a plot size of (3 m × 2 m) at a spacing of (20×10 cm). Two sprays were given at fifteen days intervals using a hand-operated sprayer during morning hours to avoid photo-oxidation of chemicals. Seven treatments which include insecticide. biopesticide and an untreated control were evaluated against *H. armigera* i.e., The T1 Spinosad 45% SC, T2 NSKE, T3 *Bt,* T4 Neem oil, T5 *Beauveria bassiana,* T6 Emamectin benzoate, T7 Control. The population of gram pod borer was recorded one day before spraying and after 3, 7, and 14 days post insecticidal application. The populations of gram pod borer were recorded on 5 randomly selected and tagged plants from each plot for investigate larval population and cost-benefit ratio by following the formula.

$$Larval\ population\ coount = \frac{\text{Total number of larva}}{\text{5 randomly selected plants}}$$

$$Cost\ benefit\ ratio = \frac{\text{Net returs}}{\text{Total cost incurred}}$$

3. RESULT AND DISCUSSION

Six insecticides Spinosad, NSKE, Bt (*Bacillus thuringiensis*), Neem oil, Emamectine benzoate and *Beauveria bassiana* were tested against gram pod borer *Helicoverpa armigera* in chickpea.

The efficacy of different insecticides against *Helicoverpa armigera* was observed in the data recorded on larval population one day before the first spray is presented in Table 1 and Fig 1 showed that the population ranged between 2.31 and 2.42 larvae/5 plants. The results were statistically non-significantly indicating uniform distribution of the gram pod borer population. The data regarding to the effectiveness of various treatments at different intervals has been presented. The data presented in Table 1 and graphically represented in Fig 1 revealed that there was a significant difference among the treatments on the 3^{rd} day after the 1^{st} spray. All the treatments recorded a significant reduction in the larval population of *Helicoverpa armigera* over the untreated control. The population ranged from 1.46 to 2.46 larvae/5 plants. The most effective population recorded in treatment T1 (Spinosad 0.20ml/l) which proved to be superior among the rest of the treatments (1.46 larvae/5 plants) and the next effective treatment is T6 (Emamectin benzoate 0.4 g/l) with (1.52 larvae/ 5 plant), followed by T5 (*Beauveria bassiana* 2x 10 CFU@ 5ml/l) with (1.55 larvae/ 5 plant), T3 (*Bacillus thuringiensis* 1.5g/l) with (1.59 larvae/ 5 plants), T4 (Neem oil 5%), with (1.73 larvae/ 5 plant), T2 (NSKE 5%) were also significantly superior over control with (1.78 larvae/5 plant) respectively and were found the maximum population of pod borer was observed in untreated control i.e., 2.46 larvae/5 plant. After 7 days of the first spray, all the treatments recorded a significant reduction in the population of pod borer over the untreated control. The population ranged between 0.91 to 2.52 larvae/ 5 plants. The highest protection against *Helicoverpa armigera* is provided by T1 (Spinosad0.20ml/l) with the least population (0.91 larvae/5 plant) the next effective treatment is T6 (Emamectin benzoate 0.4 with (0.95 larvae/ 5 plant) followed by T5 (*Beauveria bassiana* 2x10 CFU@ 5ml/l) with (0.99 larvae/ 5 plant), T3 (*Bacillus thuringiensis* 1.5g/l) with (1.04 larvae/ 5 plants), next effective treatment is T4 (Neem oil 5%) (1.17), T2 (NSKE 5%) with (1.41 larvae/ 5 plant) and the maximum population of pod borer was observed in untreated control i.e., 2.52 larvae/5. After 14 days after 1^{st} spray of all insecticides was found significant and reduced the gram pod borer infestation the most effective treatment among all was T1 (Spinosad0.20ml/l) with the least population (0.99 larvae/5 plant) and the next effective treatment was T6 (Emamectin benzoate 0.4 with (1.08 larvae/ 5 plant) followed by T5 (*Beauveria bassiana* 2x10 CFU@ 5ml/l were (1.14), T3 (*Bacillus thuringiensis* 1.5g/l) with (1.24 larvae/ 5 plants), followed by treatment T4 (Neem oil 5%) with (1.39 larvae/ 5 plant), T2 (NSKE 5%) followed by with (1.41 larvae/ 5 plant), significantly superior over control respectively and the maximum population of pod borer was observed in untreated control i.e., 2.63 larvae/5 plant. From the mean data of the first spray it was noted that the highest reduction was reported in plots treated with T1 (Spinosad 0.20ml/l) which proved to be superior among the rest of the treatments (1.12 larvae/5 plants) and the next effective treatment is T6 (Emamectin benzoate 0.4 g/l) with (1.19 larvae/ 5 plant), followed by T5 (*Beauveria bassiana* 2x 10 CFU@ 5ml/l) with (1.23 larvae/ 5 plant), T3 (*Bacillus thuringiensis* 1.5g/l) with (1.29 larvae/ 5 plants), T4 (Neem oil 5%), with (1.43 larvae/ 5 plant), T2 (NSKE 5%) were also significantly superior over control with (1.47 larvae/5 plant) respectively and were found the maximum population of pod borer was observed in untreated control *i.e.,* 2.54 larvae/5 plant.

The result of the second spray is shown in (Table- 2 and Figure 2). The significant overcontrol. It was observed after 3 days after 2^{nd} spray, all insecticides significantly reduced gram pod borer infestation. The lowest population was recorded on treatment T1 (Spinosad 0.20ml/l) with the least population (1.93 larvae/5 plant) the next effective treatment is T6 (Emamectin benzoate 0.4 with (1.97 larvae/ 5 plant) followed by T3 (*Bacillus thuringiensis* 1.5g/l) with (2.17 larvae/ 5 plants), T5 (*Beauveria bassiana* 2x10 CFU@ 5ml/l) with (2.23 larvae/ 5 plant) followed by treatment T4 (Neem oil 5%) with (2.31 larvae/ 5 plant), followed by, T2 (NSKE 5%) were also significantly superior over control with (2.39 larvae/5 plant) respectively and were found the maximum population of pod borer was observed in untreated control i.e., 3.87 larvae/5 plants. After 7 days after 2^{nd} spray, all insecticides significantly reduced gram pod borer infestation. The lowest population was recorded on treatment T1 (Spinosad0.20ml/l) with the least population (1.07 larvae/5 plant) the next effective treatment is T6 (Emamectin benzoate 0.4 with (1.13 larvae/ 5 plant) followed by T5 (*Beauveria bassiana* 2x10 CFU@ 5ml/l) with (1.21 larvae/ 5 plant) T3 (*Bacillus thuringiensis* 1.5g/l) with (1.29 larvae/ 5 plants), followed by treatment T4 (Neem oil 5%) with (1.68 larvae/ 5 plant), followed by, T2 (NSKE 5%)next effective treatment with (1.75 larvae/5 plant) respectively and it was found the maximum population of pod borer was observed in untreated control i.e., 3.97 larvae/5 plants. It was observed that 14 days after 2^{nd} spray, all insecticides significantly reduced gram pod borer infestation. The lowest population was recorded on treatment T1 (Spinosad 0.20ml/l) with the least population (1.24 larvae/5 plant) the next effective treatment is T6 (Emamectin benzoate 0.4 with (1.29 larvae/ 5 plant) followed by T5 (*Beauveria bassiana* 2x10 CFU@ 5ml/l) with (1.47 larvae/ 5 plant), T3 (*Bacillus thuringiensis* 1.5g/l) with (1.57 larvae/ 5 plants), followed by treatment T4 (Neem oil 5%) (1.81 larvae/5 plant) and T2

(NSKE 5%) (1.91), and found the maximum population of pod borer was observed in untreated control i.e., 3.91 larvae/5 plants.

From the mean data of the second spray (Table 3) it was noted that the highest reduction was reported in plots treated with T1 (Spinosad 0.20ml/l) which proved to be superior among the rest of the treatments (1.42 larvae/5 plants) and the next effective treatment is T6 (Emamectin benzoate 0.4 g/l) with (1.46 larvae/ 5 plant), followed by T5 (*Beauveria bassiana* 2x 10 CFU@ 5ml/l) with (1.61 larvae/ 5 plant), T3 (*Bacillus thuringiensis* 1.5g/l) with (1.50 larvae/ 5 plants), T4 (Neem oil 5%), with (1.93 larvae/ 5 plant), T2 (NSKE 5%) were also significantly superior over control with (1.74 larvae/5 plant) respectively and were found the maximum population of pod borer was observed in untreated control i.e., 3.92 larvae/5 plant.

From the mean data of both the sprays (Table 3) it was noted that the highest reduction was reported in plots treated with T1 (Spinosad 0.20ml/l) which proved to be superior among the rest of the treatments (1.27 larvae/5 plants) and the next effective treatment is T6 (Emamectin benzoate 0.4 g/l) with (1.33 larvae/ 5 plant), followed by T5 (*Beauveria bassiana* 2x 10 CFU@ 5ml/l) with (1.42 larvae/ 5 plant), T3 (*Bacillus thuringiensis* 1.5g/l) with (1.50 larvae/ 5 plants), T4 (Neem oil 5%), with (1.68 larvae/ 5 plant), T2 (NSKE 5%) were also significantly superior over control with (1.74 larvae/5 plant) respectively and were found the maximum population of pod borer was observed in untreated control i.e., 3.23 larvae/5 plant.

As the similar reported by Yadav *et al*., (2024), Gafar *et al.,* (2024), Antony *et al.,* (2024). The lowest percentage infestation of chickpea pod borer was recorded in T4-Spinosad 45 SC (5.07%) as the similar findings were reported by Akhtar *et al*. (2022),with (6.5%), Mishra *et al.* (2014) with (3.3%), Singh *et al.(*2012), with (2.3%), Emamectin benzoate was found to be the next best treatment with a lowest per cent of infestation of pod borer (8.80%) as the similar findings was made by Akbar *et al.* (2018) with (6.61%), Sarnaik and Chiranjeevi, (2017) *Bacillus thuringiensis* was the next effective treatment with a lowest per cent of infestation (11.93%) as the similar findings was made by Bhushan *et al.* (2011) with (11.40%), Kumar *et al.* (2019) with (13.38%).

Table 1. Efficacy of different treatments against larval population of gram pod borer in chickpea 1st spray during *Rabi*, 2023-24.

S.no	Treatment	Dose	Mean larval population/ 5plants			
			Before one day of spray	**After 3days of spray**	**After 7 days of spray**	**After 14 days of spray**
T1	Spinosad 45 SC	0.20 ml/l	2.42(1.84)	1.46(1.56)	0.91(1.38)	0.99 (1.42)
T2	NSKE	5%	2.31(1.82)	1.78(1.67)	1.21(1.48)	1.41 (1.55)
T3	*Bt*	0.5g/l	2.37(1.83)	1.59(1.61)	1.04(1.43)	1.24 (1.49)
T4	Neem oil	3%	2.39(1.84)	1.73(1.65)	1.17(1.48)	1.39 (1.54)
T5	*Beauveria bassiana*	5ml/l	2.36(1.83)	1.55(1.59)	0.99(1.42)	1.14 (1.46)
T6	Emamectin benzoate	0.4g/l	2.40(1.84)	1.52(1.58)	0.95(1.40)	1.08 (1.44)
T7	Control	Water	2.34(1.82)	2.46(1.86)	2.52(1.88)	2.63 (1.90)
	SE ±		0.010	0.011	0.013	0.012
	C.D. (P=0.05)		NA	0.036	0.040	0.037

Table 2 Efficacy of different insecticides against gram pod borer in chickpea 2nd spray

S.no	Treatments	Mean larval population/ 5 plants		
		3 days after the spray	7 days after the spray	14 days after the spray
T1	Spinosad	1.93 (1.71)	1.07 (1.45)	1.24 (1.49)
T2	NSKE	2.39 (1.84)	1.75(1.66)	1.91 (1.71)
T3	*Bt*	2.23 (1.79)	1.29 (1.51)	1.57 (1.61)
T4	Neem oil	2.31 (1.82)	1.68 (1.63)	1.81 (1.67)
T5	*Beauveria bassiana*	2.17 (1.78)	1.21 (1.48)	1.47 (1.57)
T6	Emamectin benzoate	1.97 (1.72)	1.13 (1.46)	1.29 (1.52)
T7	Control	3.87 (2.207)	3.97 (2.23)	3.91 (2.21)
	SE ±	0.008	0.009	0.012
	C.D. (P=0.05)	0.024	0.028	0.038

Table 3 Efficacy of different insecticides against gram pod borer in chickpea 1st and 2nd spray:

S. No	Treatment	Dose	1st spray mean	2nd spray mean	Overall mean
T1	Spinosad 45 SC	0.20 ml/l	1.12	1.42	1.27
T2	NSKE	5%	1.47	2.02	1.74
T3	*Bt*	0.5g/l	1.29	1.70	1.50
T4	Neem oil	3%	1.43	1.93	1.68
T5	*Beauveria bassiana*	5ml/l	1.23	1.61	1.42
T6	Emamectin benzoate	0.4g/l	1.19	1.46	1.33
T7	Control	Water	2.54	3.92	3.23

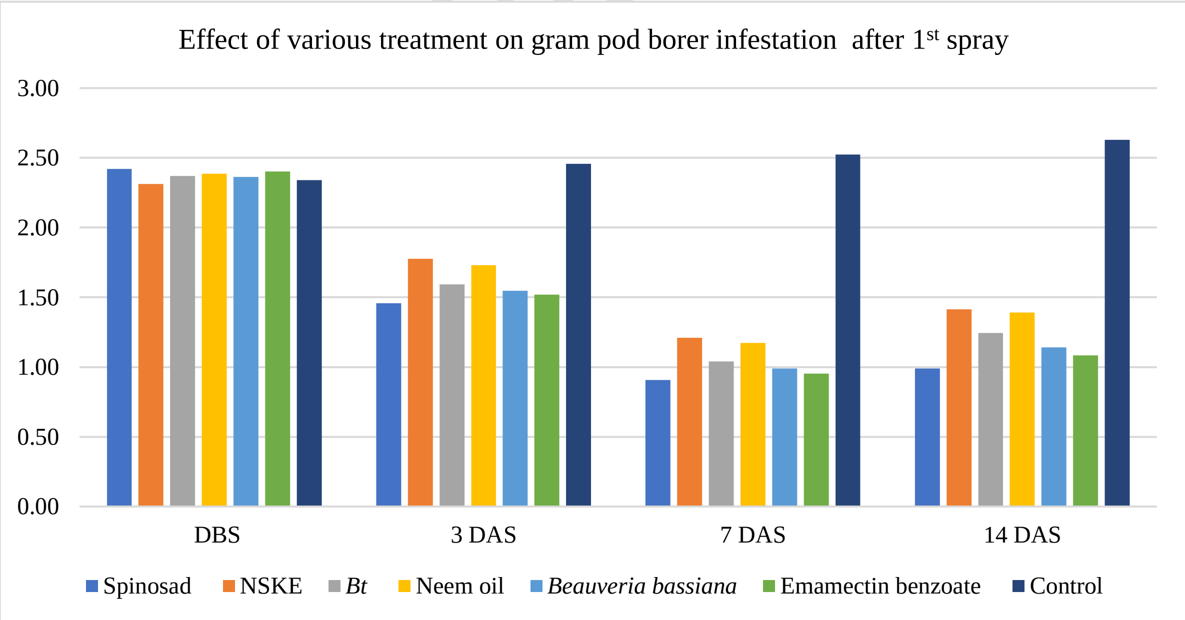

Fig 1 Effect of various treatments on gram pod borer infestation after 1st spray.

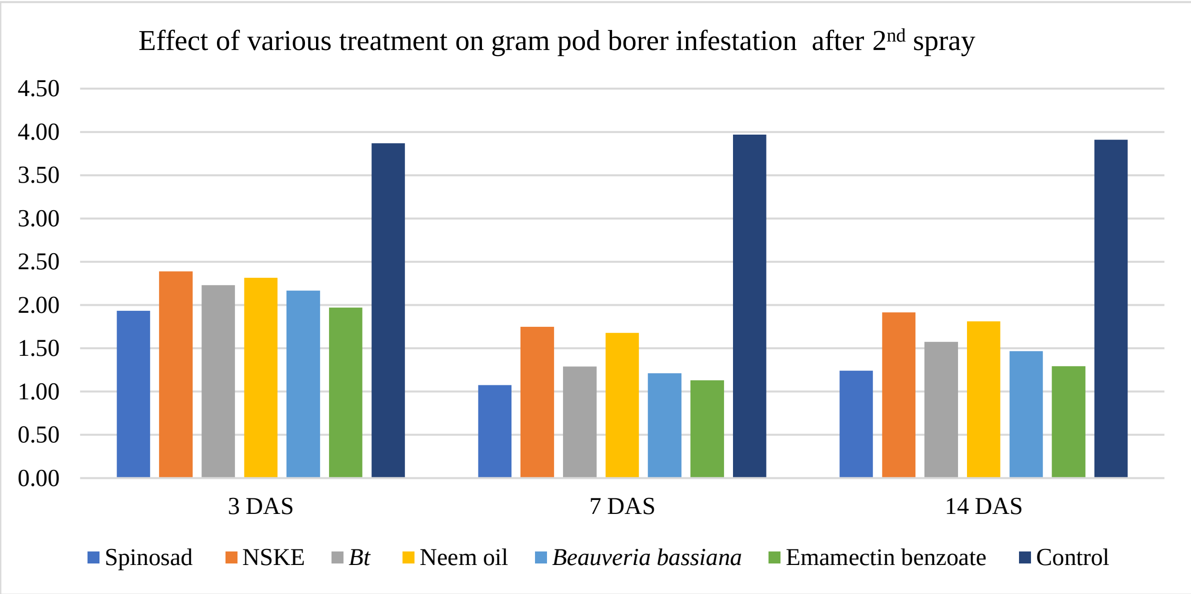

Fig 2 Effect of various treatment on gram pod borer infestation after 2nd spray

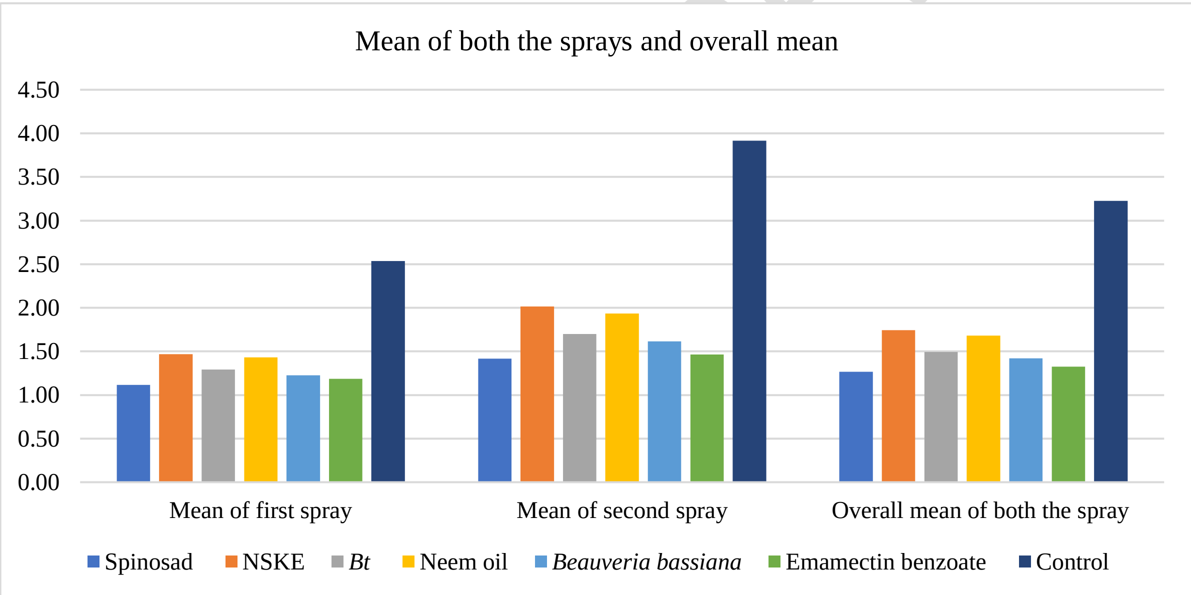

Fig 3 Mean of both the sprays and overall mean.

3.1 Effect of treatment on yield

The effectiveness of treatment determined based on chickpea grain yield obtained in different treatments during *Rabi* season 2023-24 is presented in Table .4 and Figure 4.

All the treatments yielded significantly higher results than the control. The data on the yield of chickpea revealed that the highest yield recorded in the treatment T1 Spinosad (0.20ml/l) with (24.31 q/ha) and it was superior over all the other treatments and followed by Emamectin benzoate 0.4g/l with (23.69 q/ha), *Bt* 1.5g/l with (22.91 q/ha), *Beauveria bassiana* 2x108 CFU @ 5ml/l with (22.06 q/ha), Neem oil 5% with (21.37 q/ha), NSKE 5% with (21.14 q/ha), respectively. The yield (19.47 q/ha) was obtained in the control. The present result endorses the finding of Pawar *et al* 2022, who recorded the highest grain yield in T1 Spinosad 45SC (22.90q/ha).

3.1.1 Increase in yield percentage over control

The data (Table 4 and Figure 4) on the increase in yield over control of chickpea revealed that the highest increase in yield over control was recorded in the treatment T1 Spinosad (0.20ml/l) with (24.86) and it was superior over all the other treatment and followed by Emamectin benzoate 0.4g/l with (21.67), *Bt* 1.5g/l with (17.67), *Beauveria bassiana* 2x108 CFU @ 5ml/l with (13.30), Neem oil 5% with (9.76), NSKE 5% with (8.58), respectively.

3.1.2 Cost-benefit ratio

Data is included in Table .5. The economics of treatments were determined to find out the cost-effectiveness of treatment in the terms of cost-benefit ratio. The maximum cost-benefit ratio was obtained in the plot treated with 0.20ml/l spinosad 45SC (1:9.27) next effective treatment in terms of cost-benefit ratio was Emamectin benzoate 0.4g/l with (1:9.18), *Beauveria bassiana* (1:7.48), *Bt* (1:7.28), NSKE 5% (1:3.58) the lowest cost-benefit ratio (1:2.66) was found in Neem oil 5% treated plot. The present result is in partial agreement with Upadhyay *et al*., (2020) reported that after calculating the highest cost-benefit ratio in the treatment t4 spinosad 45 SC (1:2:92) similar finding. Santhosh and Kumar, (2022) the treatment with Neem oil found to be an efficient organic treatment with a cost benefit ratio of 1:3.6. Similar findings were made by the similar finding of value 1:2.41.

Table 4: Effect of various treatments on yield and increase in yield percentage over control

S. No	Treatment	Dose	Yield q/ha	Increase in yield percentage over control
T1	Spinosad	0.20 ml/l	24.31	24.86
T2	NSKE	5%	21.14	8.58
T3	*Bt*	0.5g/l	22.91	17.67
T4	Neem oil	3%	21.37	9.76
T5	*Beauveria bassiana*	5ml/l	22.06	13.30
T6	Emamectin benzoate	0.4g/l	23.69	21.67
T7	Control	Water	19.47	0.00

Table 5. Benefit-cost ratio of different treatments used for the management of gram pod borer *Helicoverpa armigera* in chickpea during *Rabi* season year 2023-24.

S.No.	Treatment	Yield (q/ha)	Insecticide Cost	Total cost of Plant Protection	Gross Income	Net Income	Benefit over control	B:C
1	Spinosad	24.31	1440	3040	156799.5	153759.5	28178	9.27
2	NSKE	21.14	750	2350	136353	134003	8421.5	3.58
3	*Bt*	22.91	1080	2680	147769.5	145089.5	19508	7.28
4	Neem oil	21.37	1750	3350	137836.5	134486.5	8905	2.66

5	*Beauveria bassiana*	22.06	369	1969	142287	140318	14736.5	7.48
6	Emamectin benzoate	23.69	1073	2673	152800.5	150127.5	24546	9.18
7	Control	19.47			125581.5	125581.5		

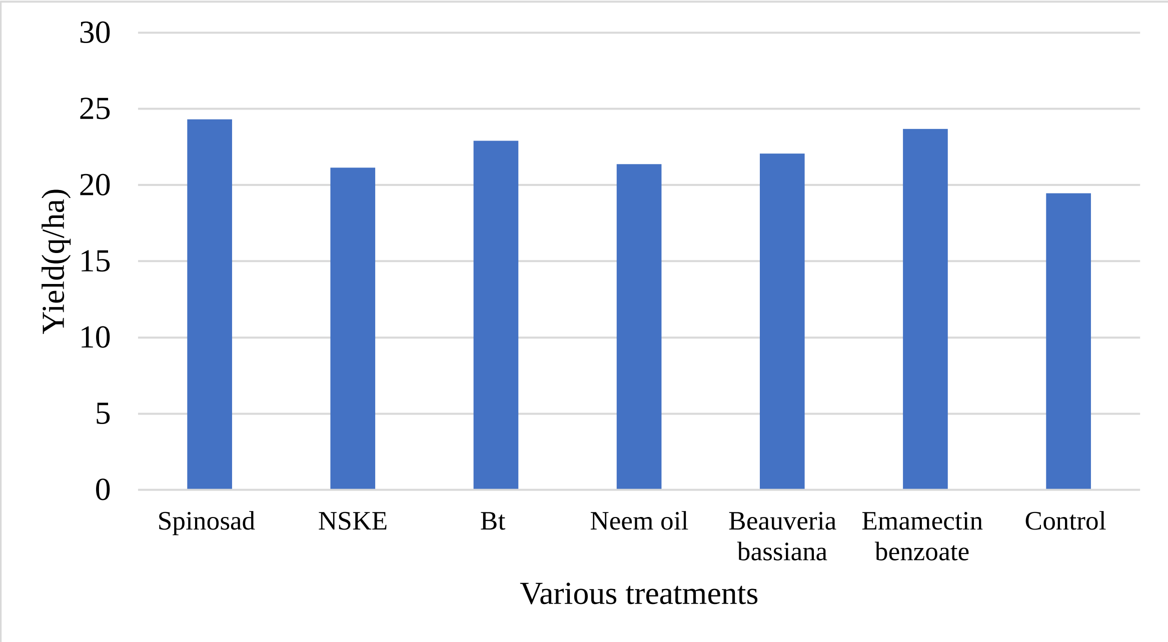

Fig 4. Graphical representation of yield of treatment.

4. CONCLUSION

From the critical analysis of the present findings, it can be concluded that among the treatments used T1 (Spinosad 0.20ml/l) proved to be superior among the rest of the treatments and the next effective treatment is T6 (Emamectin benzoate 0.4 g/l), followed by T5 (*Beauveria bassiana* 2x 10 CFU@ 5ml/l), T3 (*Bacillus thuringiensis* 1.5g/l) and the maximum population of pod borer was observed in the untreated control plot. The data on the yield of chickpea revealed that the highest yield recorded in the treatment T1 Spinosad (0.20ml/l) and it was superior over all the other treatments followed by Emamectin benzoate 0.4g/l with the yield (19.47 q/ha) was obtained in the control. The data on the increase in yield over control of chickpea revealed that the highest increase in yield over control was recorded in the treatment T1 Spinosad (0.20ml/l) and it was superior over all the other treatments and followed by Emamectin benzoate 0.4g/l with the lowest increase in yield over control was reported in plot treated with NSKE 5% with (8.58), respectively. The maximum cost-benefit ratio was obtained in the plot treated with 0.20ml/l spinosad 45SC next effective treatment in terms of cost-benefit ratio was Emamectin benzoate 0.4g/l and the lowest cost-benefit ratio (1:2.66) was found in Neem oil 3%treated plot.

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References

Akbar, W., Asif, M. U., Memon, R. M., Bux, M., & Sohail, M. (2018). Validation of some new chemistry and conventional insecticides against gram pod borer (Helicoverpa armigera) in chickpea. Pakistan Entomologist, 40(1), 45-49.

Akhtar, M., Mahmood, M. T., Khalid, M. J., Amin, A., Zafar, M. N., Aziz, A., ... & Ahmed, M. (2022). Efficacy of some new chemistry insecticides against the chickpea pod borer (Helicoverpa armigera) [Hubner]. Plant Cell Biotechnology and Molecular Biology, 23(9-10), 1-6.

Antony, A. K., & Yadav, U. (2024). Comparative efficacy of certain insecticide and bio-pesticides against gram pod borer, Helicoverpa armigera (Hubner) on chickpea, Cicer arietinum (L.). International Journal of Advanced Biochemistry Research, SP-8(5), 337-339.

Chavan, J. K., Kadam, S. S., Salunkhe, D. K., & Beuchat, L. R. (1987). Biochemistry and technology of chickpea (Cicer arietinum L.) seeds. *Critical Reviews in Food Science & Nutrition*, *25*(2), 107-158.

Chavan, J. K., Kadam, S. S., Salunkhe, D. K., & Beuchat, L. R. (1987). Biochemistry and technology of chickpea (Cicer arietinum L.) seeds. *Critical Reviews in Food Science & Nutrition*, *25*(2), 107-158.

Chibbar, R. N., Ambigaipalan, P., & Hoover, R. (2010). Molecular diversity in pulse seed starch and complex carbohydrates and its role in human nutrition and health. *Cereal chemistry*, *87*(4), 342-352.

Fitt G P. 1989. The ecology of Heliothis species in relation to agro-ecosystems. Annual Review of Entomolgy.34: 17–52.

Gafar, B. B., Yadav, U., Mushinamwar, D. R., & Chavan, S. R. (2024). Efficacy of certain biopesticides and chemicals against gram pod borer [Helicoverpa armigera (Hubner)] on chickpea (Cicer arietinum L). International Journal of Advanced Biochemistry Research, 8(5), 339-342.

Gautam, M. P., Chandra, U., Singh, S. N., Yadav, S. K., & Giri, S. K. (2018). Studies on efficacy of botanicals against Helicoverpa armigera (Hubner) on chickpea (Cicer arietinum L.). International Journal of Current Microbiological Application Sciences, 7, 612-618.

Gecit, H. H. (1989). Chickpea utilization in Turkey. *Uses of Tropical Grain Legumes*, *27*, 69.

Ibrikci, H., Knewtson, S. J., & Grusak, M. A. (2003). Chickpea leaves as a vegetable green for humans: evaluation of mineral composition. Journal of the Science of Food and Agriculture, 83(9), 945-950

Jukanti, A. K., Gaur, P. M., Gowda, C. L. L., & Chibbar, R. N. (2012). Nutritional quality and health benefits of chickpea (Cicer arietinum L.): a review. *British Journal of Nutrition*, *108*(S1), S11-S26.

Kranthi K R, Jadhav D R, Kranthi S, Wanjari R R, Ali S and Russell D A. 2002. Insecticide resistance in five major insect pests of cotton in India. Crop Protection 21: 449–60.

Kumar, A., Tripathi, M. K., Chandra, U., & Veer, R. (2019). Efficacy of botanicals and bio-pesticide against Helicoverpa armigera in chickpea. Journal of Entomology and Zoology Studies, 7(1), 54-57.

Ladzinsky, G. (1975). A new Cicer from Turkey.
Manjunath T M, Bhatnagar V S, Pawar C S and Sithanantham S. 1989. Economic importance of Heliothis spp in India and an assessment of their natural enemies and host plants. (in) Proceedings of the Workshop on Biological Control of *Heliothis*, pp 197–228. King, K G and Jackson R D (Eds), USDA
Mari, J. M., Chachar, S. D., Chachar, Q. I., & Kallar, S. A. (2013). Insect diversity in chickpea ecosystem. Journal of Agricultural Technology, Vol. 9(7):1809-1819.
Meena, R. K., Naqui, A. R., Meena, D. S., & Shubhagvan, S. (2018). Evaluation of bio-pesticides and indoxacarb against gram pod borer on chickpea. Journal of Entomology and Zoology Studies, 6, 2208-2212.

Mishra, V. K., Singh, N. N., Singh, S. K., & Kumari, R. (2014). Efficacy of insecticides against *Helicoverpa armigera* on chickpea. Annals of Plant Protection Sciences, 22(2), 424-425.

Naveen, G., & Ghosh, S. M. (2020). Studies of the occurrence of gram pod borer, Helicoverpa armigera on chickpea at new alluvial zone of West Bengal. *Journal of Entomological Research*, *44*(3), 397-402.
Pawar A H and Kumar A. (2022). Field evaluation of chemicals and bio-pesticides against chickpea pod borer [*Helicoverpa armigera* (Hubner)]. *The Pharma Innovation Journal, 11*(7): 3405-3410.

Prasanna, P. M., Badiger, B., & Shivamurthy, D. (2020). Bio-efficacy of insecticide, Cyclaniliprole 100 DC against gram pod borer, Helicoverpa armigera (Hubner). Infesting chickpea. *IJCS*, *8*(4), 3070-3073.
Reed, W., Lateef, S. S., & Sithanantham, S. (1980). Insect pest management on chickpea. In Proceedings International Workshop on Chickpea Improvement (pp. 179-183).

Santosh K and Kumar A. (2022). Comparative efficacy of selected insecticides and neem products against chickpea pod borer (*Helicoverpa armigera* Hub). *The Pharma Innovation Journal*.;11(1):1558-1562.

Sarnaik, S. V., & Chiranjeevi, B. (2017). Bioefficacy of newer insecticides against gram pod borer (Helicoverpa armigera Hub) on chickpea. An International Quarterly Journal of Sciences, 12(1), 65-69.

Saxena, H., Bandi, S., & Devindrappa, M. (2018). Pests of pulses. *Pests and Their Management*, 99-136.
Singh, F., & Diwakar, B. (1995). Chickpea botany and production practices.
Singh, P. S., Shukla, R. K., & Yadav, N. K. (2012). Bio-efficacy of some insecticides against H. armigera (Hubner) on chickpea (Cicer arietinum L.). Journal of Food Legumes, 25(4), 291-293.

Upadhyay RR, Singh PS, Singh SK. (2020). Comparative efficacy and economics of certain insecticides against gram pod borer (*Helicoverpa armigera* Hub) on chickpea, *Indian Journal of Plant Protection*.;48(4):403-410.

USDA. National Nutrient Database; 2018.

Yadav, S. K., Singh, D. R., Umrao, R. S., Yadav, A., Yadav, V., & Yadav, G. (2024). Studies on seasonal incidence of gram pod borer, *Helicoverpa armigera* (Hubner) on chickpea crop. International Journal of Environment and Climate Change, 14(3), 349-354.

Zalucki M P, Daglish G, Firempong S and Twine P. (1986). The biology and ecology of *Heliothis armigera* (Hubner) and *H. punctigera* Wallengren (Lepidoptera: Noctuidae) in Australia: What do we know? Australian Journal of Zoology 34: 779– 814.