International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452
Maths 2023; SP-8(5): 325-329

https://www.mathsjournal.com
Received: 18-06-2023
Accepted: 26-07-2023

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Grain yield and incremental cost benefit ratio (ICBR) biorational insecticides against *Helicoverpa armigera* in chickpea

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DOI: https://doi.org/10.22271/maths.2023.v8.i5Se.1212

Abstract
The investigations on "Grain yield and incremental cost benefit ratio (ICBR) biorational insecticides against *Helicoverpa armigera* in chickpea" were carried out at the Student's Instructional Farm, C. S. Azad University of Agriculture and Technology, Kanpur during *Rabi* season 2021-22 and 2022-23 with three replications and eight treatments of biorational insecticides, against *Helicoverpa armigera*. The biorational insecticides like HaNPV, Nimbecidine, *Bacillus thuringiensis*, *Beauveria bassiana*, Dhatura leaf extract, Spinosad and Indoxacarb, in reducing the infestation of pod borer, *Helicoverpa armigera* and providing a higher net return per rupee invested. The higher grain yield of 20.10 q/ha and 19.70 q/ha was recorded with the application of spinosad 45% SC (Tracer) @ 84.375 g/ha during both years. The most favourable cost benefit ratio was obtained from the plot treated with spinosad 45% SC (Tracer) @ 84.375 g/ha 1:13.98 and 1:14.80 followed by indoxacarb 14.5% SC @ 75g/ha 1:8.51and 1:8.79, *Bacillus thuringiensis* @ 1.5 kg/ha 1:7.62 and 1:7.50, nimbecidine @ 2% 1:6.38 and 1:6.53, HaNPV @ 300LE/ha. 1:5.23 and 1:5.38, *Beauveria bassiana* @ 3kg/ha. 1:4.57 and 1:4.52 and dhatura leaf extract @ 5% 1:3.23 and 1:2.57 during both years.

Keywords: Chickpea, *H. armigera*, biorational insecticides, yield

Introduction
Chickpea (*Cicer arietinum* L.), a member of Fabaceae, belongs to family "Leguminosae", subfamily "Papilonidae" having diploid number of chromosomes 2n=16 is an important pulse crop. It is a self-pollinated crop and is second most important food legume crop after common bean which has been considered as 'King of Pulses'. It is generally grown under rainfed or residual soil moisture conditions in Rabi season and the plant grows to 20-50 cm height and has small, feathery leaves on either side of the stem. (Spoorthi *et al*., 2017) [13].

There are two types of chickpea based upon seed size, color and shape known as Desi and Kabuli. Desi type contributes about 85% of world annual chickpea production while kabuli type contributes 15%. (Abbas *et al*., 2021) [1]. It contains an excellent source of the essential nutrients *viz*., 21 per cent protein, 2.2 per cent fat and 62 per cent carbohydrates. It also contains calcium of about 190 mg/100g, Iron 90.5 mg/100g and Phosphorus 280 mg/100 g. Chickpea is a very important component of cropping systems of the dry and rainfed areas because it can fix 80 to 120 kg nitrogen per hectare through symbiotic nitrogen fixation. The per cent chickpea crop area covered in major states India is Madhya Pradesh (32.97%), Maharashtra (18.36%), Rajasthan (16.70%), Andra Pradesh (8.55%), Karnataka (8.21%), Uttar Pradesh (6.85%) and Gujarat (2.92%). In India, the area under chickpea was 7.37 million hectares with a production of 5.89 million tonnes with productivity of 799 kg/ha. In Karnataka, the crop is grown in an area of 6.05 lakh hectares with a productivity of 937 kg/ha (Anonymous, 2022) [15].

Among biotic factors chickpea is infested by nearly 60 insects' species in which cutworm, *Agrotis ipsilon* (Ratt.), gram pod borer, *Helicoverpa armigera* (Hubner), semilooper, *Autographa nigrisigna* (Walk.), and aphid, *Aphis craccivora* (Koch.) are the pests of major importance. Among these, the major damage is caused by gram pod borer which is polyphagous in nature; *H. armigera* is one of the serious pests of chickpea, which feeds more than 150 crops throughout the world.

Materials and Methods

The investigations on "Grain yield and incremental cost benefit ratio (ICBR) biorational insecticides against *Helicoverpa armigera* in chickpea" were carried out at the Student's Instructional Farm, C. S. Azad University of Agriculture and Technology, Kanpur during *Rabi* season 2021-22 and 2022-23 in Randomized Block Design (RBD) having three replications and eight treatments of biorational insecticides, against *Helicoverpa armigera*. Grain yield for different treatments was recorded to measure the effect of individual treatments on the yield. Cost benefit ratio was calculated on the basis of net income gain obtained from additional yield over control.

$$\text{Incremental cost benefit ratio} = \frac{\text{Net monetary return}}{\text{Cost due to treatments}}$$

Results and Discussion

The effectiveness of treatment was determined in the term of grain yield obtained in different treatments revealed that the spinosad 45% SC @ 84.375 g/ha, indoxacarb 14.5% SC @ 75 g/ha and *Bacillus thuringiensis* @ 1.5 kg/ha were found statistically at par to each other but significantly superior over untreated control for increase the chickpea grain yield, respectively both year. nimbecidine @ 2% and HaNPV @ 300 LE/ha was at par then for compared to each other. The plots treated with spinosad 45% SC@ 84.375 g/ha gave maximum grain yield as compared to other treatments in managing the infestation of *H. armigera* as it realized the highest grain yield of chickpea. indoxacarb 14.5% SC @ 75 g/ha and *Bacillus thuringiensis* @ 1.5 kg/ha were found the second and third most effective insecticides, respectively as compared to nimbecidine @ 2%, HaNPV @ 300 LE/ha, *Beauveria bassiana* @ 3 kg/ha and dhatura leaf extract @ 5%. These findings are in accordance with the results of earlier workers (Aminu *et al*., 2023, Bohria *et al*., 2012, Das *et al*., 2022, Kambrekar *et al*., 2012 and Singh *et al*., 2022) [2, 3, 4, 8, 11]. (Tabe- 1 & Fig- 1).

Table 1: Effect of various treatments on grain yield caused by *H. armigera* in chickpea

Treatments	2021-22	2022-23
	Q/ha	Q/ha
T_1: HaNPV @ 300 LE/ha.	17.50	16.90
T_2: Nimbecidine @ 2%	18.20	17.60
T_3: *Bacillus thuringiensis*@ 1.5 kg/ha.	18.90	18.10
T_4: *Beauveria bassiana* @ 3kg/ha.	17.10	16.40
T_5: Dhatura leaf extract @ 5%	16.30	15.20
T_6: Spinosad 45% SC @ 84.375 g/ha.	20.10	19.70
T_7: Indoxacarb 14.5% SC @ 75 g/ha.	19.37	18.80
T_8: Control	14.10	13.50
SEm ±	0.76	0.79
CD at 5%	2.48	2.57

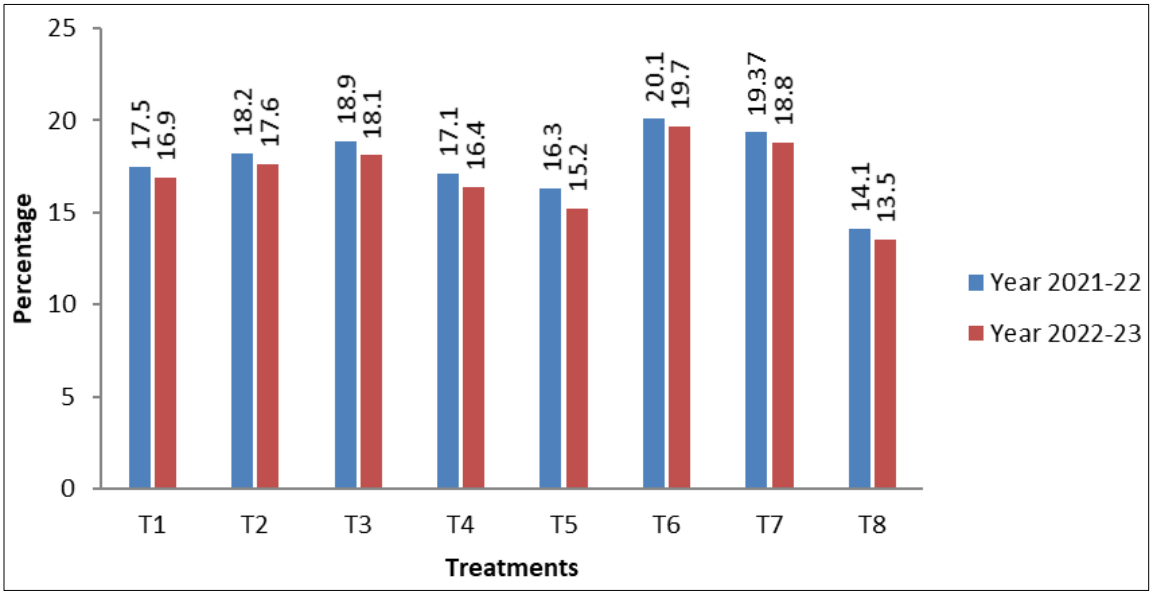

Fig 1: Effect of various treatments on grain yield caused by *H. armigera* in chickpea

The economics of the treatments was determined to find out the cost effectiveness of various treatments in terms of cost benefit ratio. The highest net income and cost benefit ratio (1:13.98, Rs 30600 ha^{-1} and 1:14.80 Rs. 32426 ha^{-1} both year, respectively) was found in spinosad 45% SC @ 84.375 g/ha treated plot followed by indoxacarb 14.5% SC @ 75 g/ha (1:8.51, Rs 26877 ha^{-1} and 1:8.79 Rs. 27719 ha^{-1} both year, respectively) and *Bacillus thuringiensis* @ 1.5 kg/ha (1:7.62, Rs 24480 $ha^{-1}$and 1:7.50 Rs. 24058 ha^{-1}). nimbecidine @ 2%, HaNPV @ 300 LE/ha, *Beauveria bassiana* @ 3 kg/ha and dhatura leaf extract @ 5%. Was also found effective as well as economical with average cost benefit ratio. The findings of the present studies are in conformity of the result of Deshmukh *et al*., 2010, Gautam *et al*., 2018, Jagtap *et al*., 2020, Meena *et al*., 2018, Murray *et al*., 2005 and Tripathi and Kumar, 2018 [5, 6, 7, 9, 10, 14]. (Table- 2&3, Fig-2&3).

Table 2: Cost Benefit ratio of different treatments during 2021-22

Treatments	Cost of insecticides (Rs/ha.)	Grain yield (q/ha.)	Additional yield over control (q/ha.)	Additional income (Rs/ha.)	B:C ratio
T_1: HaNPV @ 300 LE/ha.	3310	17.50	3.40	17340	1:5.23
T_2: Nimbecidine @ 2%	3280	18.20	4.10	20910	1:6.38
T_3: *Bacillus thuringiensis*@ 1.5 kg/ha.	3210	18.90	4.80	24480	1:7.62
T_4: *Beauveria bassiana* @ 3kg/ha.	3350	17.10	3.00	15300	1:4.57
T_5: Dhatura leaf extract @ 5%	3470	16.30	2.20	11220	1:3.23
T_6: Spinosad 45% SC @ 84.375 g/ha.	2190	20.10	6.00	30600	1:13.98
T_7: Indoxacarb 14.5% SC @ 75 g/ha.	3155	19.37	5.27	26877	1:8.51
T_8: Control	-	14.10	-	-	-

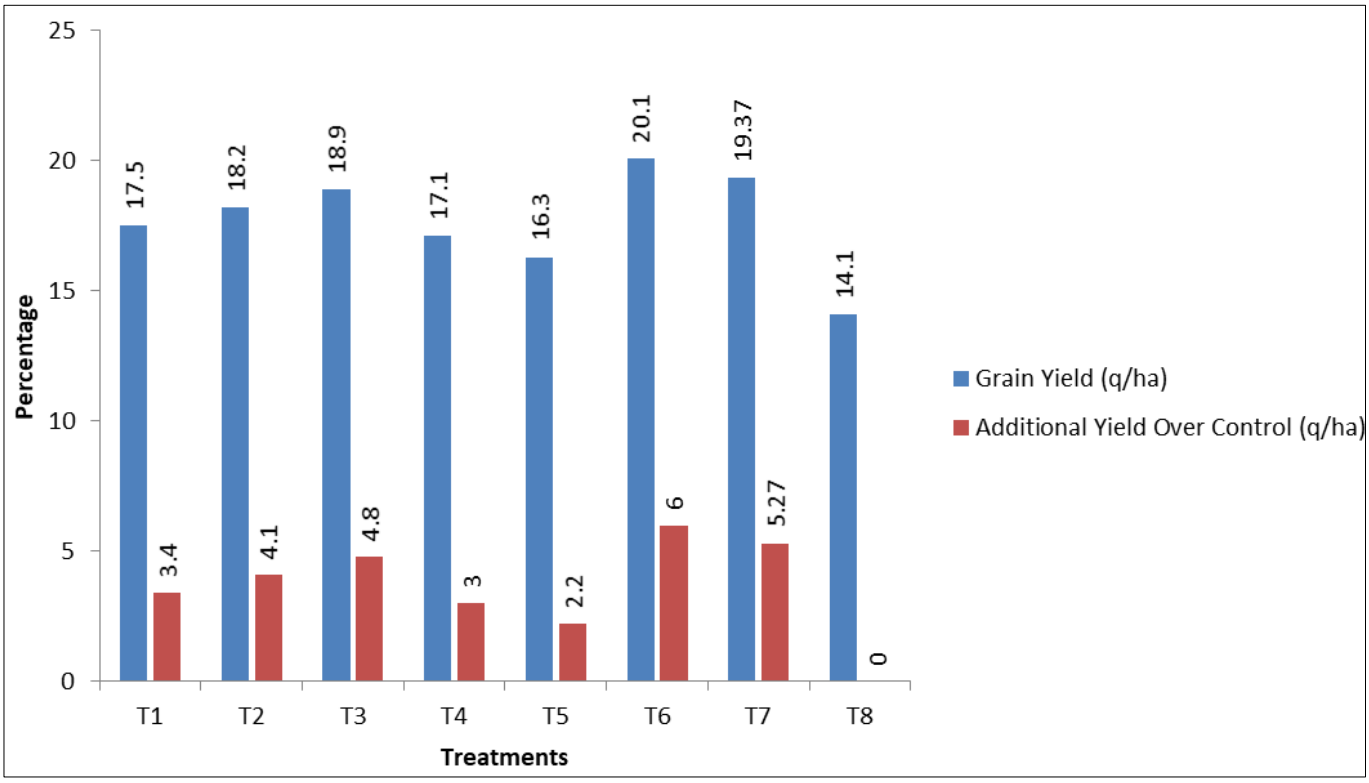

Fig 2: Cost Benefit ratio of different treatments during 2021-22

Table 3: Cost Benefit ratio of different treatments during 2022-23

Treatments	Cost of insecticides (Rs/ha.)	Grain yield (q/ha.)	Additional yield over control (q/ha.)	Additional income (Rs/ha.)	B:C ratio
T_1: HaNPV @ 300LE/ha.	3310	16.90	3.40	17782	1:5.38
T_2: Nimbecidine @ 2%	3280	17.60	4.10	21443	1:6.53
T_3: *Bacillus thuringiensis*@ 1.5 kg/ha.	3210	18.10	4.60	24058	1:7.50
T_4: *Beauveria bassiana* @ 3kg/ha.	3350	16.40	2.90	15167	1:4.52
T_5: Dhatura leaf extract @ 5%	3470	15.20	1.70	8891	1:2.57
T_6: Spinosad 45% SC @ 84.375 g/ha.	2190	19.70	6.20	32426	1:14.80
T_7: Indoxacarb 14.5% SC @ 75 g/ha.	3155	18.80	5.30	27719	1:8.79
T_8: Control	-	13.50	-	-	-

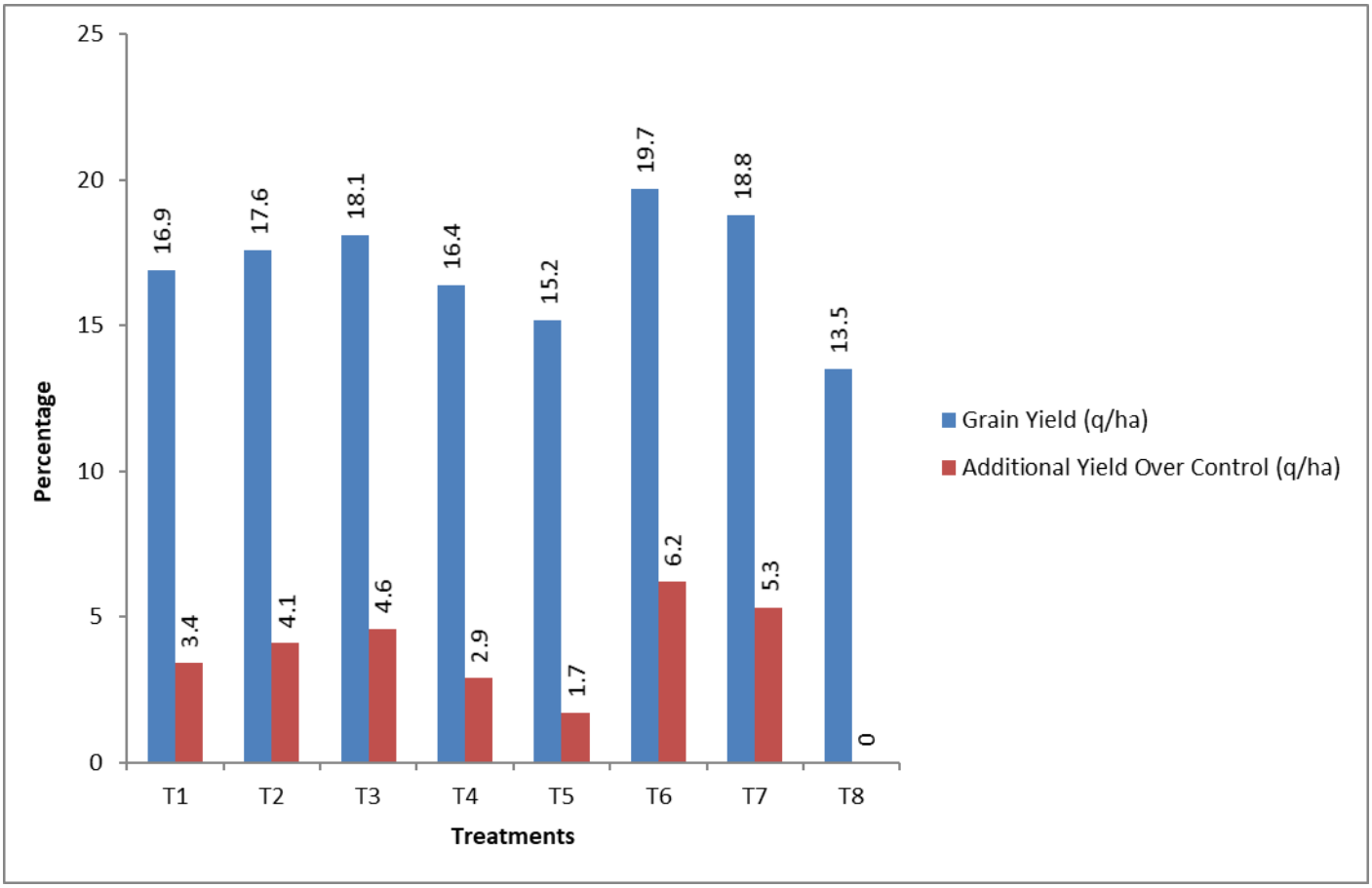

Fig 3: Cost Benefit ratio of different treatments during 2022-23

Conclusion

The grain yield data in different treatments, that spinosad 45% SC @ 84.375 g/ha treated plot highest grain yield (20.10 q/ha and 19.70 q/ha, respectively, both year) followed by indoxacarb 14.5% SC @ 75 g/ha and *Bacillus thuringiensis* @ 1.5 kg/ha. By and large, all the treatments were found effective in increase the chickpea grain yield over the untreated control. Based on the economics of the treatments, the highest net income and cost benefit ratio (1:13.98, Rs. 30600 ha^{-1} and 1:14.80, Rs. 32426 ha^{-1}, respectively, both year) was observed by spinosad 45% SC followed by indoxacarb 14.5% SC (1:8.51, Rs. 26877 ha^{-1} and 1:8.79, Rs. 27719 ha^{-1} both year, respectively) and *Bacillus thuringiensis* (1:7.62, Rs. 24480 ha^{-1} and 1:7.50 Rs. 24058 ha^{-1} both year, respectively). All the treatments were also found economic over untreated control. Based on present study it is concluded that spinosad 45% SC was the best insecticide in increasing the reduction of gram pod borer infestation, achieved the higher grain yield and was the best from view point of economic feasibility.

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