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Comparative Efficacy and Economics of Certain Chemicals and Biopesticides against Podborer, *Helicoverpa armigera* (Hubner) in Chickpea at Naini, Prayagraj, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted at the research plot of the Department of Agricultural Entomology at Central Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during the *rabi* season of 2021.The field was laid in randomised block design (RBD) with seven treatments and one controlled plot. The Mean larval population plant was taken day before and 3, 7 and 14 days after each spray. All the insecticides tested significally reduced the pest infestation compared to control. The results obtained based on pest population, grain yield and B: C ratio are as follows, T_4 Spinosad 45% SC is most effective treatment against gram pod borer of Mean larval population producing maximum yield and recorded highest Cost-Benefit ratio compared to other treatments. While T_1 Chlorantraniliprole 18.5% sc, T_2 Spinetoram 11.7EC, T_3 Flubendamide 39.35% SC, T_4 Spinosad 45% SC,T_5 *Bacillus thuringiensis* has shown average results has proved to be least effective chemicals. T_6 *Beauveria bassiana* and T_7 *Metarhizium anisopilae* found to be least effective in managing *Helicoverpa armigera*. When cost benefit ratio was worked out, interesting result was achieved. Among the treatment studied, the best and most economical treatment was Spinosad 45% SC (1:3.98), Spinetoram 11.7EC (1:3.95), followed by

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Chlorantraniliprole 18.5% sc (1:3.82), Flubendamide 39.35% SC (1:3.73), *Bacillus thuringiensis* (1:3.21), and *Beauveria bassiana* (1:2.96), The lowest cost benefit ratio was recorded in *Metarhiziun anisopilae* (1:2.80) when compared to Control (1:1.95).

Keywords: Biopesticides; chemicals; chickpea; effect; Helicoverpa armigera; pod borer.

1. INTRODUCTION

Chickpea, *Cicer arietinum*, is a member of the legume, pea, or pulse, family "Fabaceae". Chickpea is the common name for an annual plant, Cicer arietinum, of the Fabaceae (or Leguminosae) family that is widely cultivated for its typically yellow-brown, pea like seeds. Legumes are multipurpose crops and are consumed either directly as food or in various processed forms or as feed in many farming systems [1] In India it is also known as “King of pulses”.

Madhya Pradesh ranked first contributing an area of 30.76 lakh ha, production 33.98 lakh tonnes and productivity 1105 kg/ha (34.46% and 40.62% of total area and production of country). Maharashtra is one of the second rank for area 15.41 lakh ha (17.26%) and third for production 11.98 lakh tones (14.32%). Where as, Rajasthan stood second in production (14.47%) and third in area (15.37%). The highest yield was recorded in the state of Telangana (1459 kg/ha) followed by Gujarat (1201 kg/ha) and West Bengal (1163 kg/ha). The lowest yield was recorded in Karnataka (578 kg/ha). (Annual Report DPD 2017).

The crop has multiple uses in rural as well as urban India [2,3]. Chickpea is a good source of protein (20 mg/ 100 g), carbohydrate and minerals, also its posses a high nutritional value. 100 g of gram seed provides 358 calories which is more than that of any other legume, except groundnut and lupine seeds (Kanwar, 1979). It is good source of amino acid. The amino acid content per gram of chickpea is 0.44 mg lysine, 0.30 mg thiamine, 0.51 mg riboflavin and 2.1 mg niacin. Chickpea seeds are good source of Vitamin A [I.U.]-(316 mg), vitamin C-(3 mg), vitamin K-(0.29 mg) and minerals (12 mg) along with the Folic-acid (125g/100g). Germinated seeds are recommended against scurvy disease. Chickpea also contains 56.5 per cent carbohydrate, besides ash, calcium and iron etc.

Among biotic factors chickpea is infested by nearly 60 insect’s species in which cutworm, *Agrotisipsilon* (Ratt.), gram pod borer, *Helicoverpa armigera* (Hubner), semilooper, *Autographa nigrisigna* (Walk.), and aphid, *Aphis craccivora* (Koch.) are the pests of major importance [4]. Among these, the major damage is caused by gram pod borer which is polyphagous in nature; *Helicoverpa armigera* is one of the serious pests of chickpea, which feeds more than 150 crops throughout the world [5]. Gram pod borer is widely distributed and a serious pest of chickpea causing heavy crop losses (20- 60%) throughout the India. Thus, we need to use integrated approaches for the control of gram pod borer in order to avoid indiscriminate use of pesticides [6-8].

2. MATERIALS AND METHODS

The experiment was conducted during *rabi* season 2021 at the Central Research Farm (CRF) of Sam Higginbottom University of Agriculture, Technology and Sciences, Naini, Prayagraj, Uttar Pradesh, India, in a randomized block design with eight treatments replicated three times using Ankur-chirag (local variety) in a plot size of 2m×2m at a spacing of 30×10cm with a recommended package of practices excluding plant protection. Seven treatments of chemicals and biopesticides were evaluated against, *Helicoverpa armigera* i.e., T_1 Chlorantraniliprole 18.5% sc, T_2 Spinetoram 11.7EC, T_3 Flubendamide 39.35% SC, T_4 Spinosad 45% SC,T_5 *Bacillus thuringiensis,*T_6 *Beauveria bassiana,*T_7 *Metarhizium anisopilae* and T_0 control plot. The population of chickpea pod borer was recorded before 1-day spraying and on 3rd day, 7th day and 14th day after insecticidal application and were subjected to statistical analysis. The populations of chickpea pod borer was recorded on 5 randomly selected and tagged plants from each plot for investigating larval population and cost benefit ratio.

2.1 Cost Benefit Ratio

Based on the yield data, the gross returns and net returns were calculated for each treatment. The benefit cost ratio (BCR) was determined by dividing the additional returns with the additional cost of imposing the respective treatment on hectare basis.

$$B.C.R = \frac{Gross\ Returns}{Total\ Cost\ of\ Protection}$$

3. RESULTS AND DISCUSSION

The results of the experiment Evaluation of different insecticides chickpea pod borer *Helicoverpa armigera* (Hubner) to study cost benefit ratio during *rabi* season of 2021-2022. The data so obtained through observation on various aspects were subjected to statistical analysis wherever necessary and the compiled mean data are tabulated in the following pages. Results obtained are presented aspect wise here under.

Perusal of the data (Table 1) revealed that population of *Helicoverpa armigera* over control on mean (3, 7 and 14 DAS) 1st spray revealed that all the treatments were significantly superior over control (3.28). Among all the treatments minimum larval population was recorded in T_4 Spinosad 45% SC (1.44), followed by T_1 Chlorantraniliprole 18.5% SC (1.6) T_2 Spinetoram 11.7% SC(1.8),T_3 Flubendamide 39.35% SC (2.00), T_5 *Bacillus thuringiensis* 1x10^8 CFU/ml (2.2), T_6 *Beauveria bassiana* 1x10^8 CFU/ml (2.33).In this the maximum larval population was recorded in T_7 *Metarhizium anisopliae* 1x10^8 CFU/ml (2.46).In this (T_7 T_6), (T_6 T_5), (T_5T_3), (T_3T_2), (T_2T_1) and (T_1T_4) they are found statistically at par with each other.

Perusal of the data (Table 2) revealed that population of *Helicoverpa armigera* over control on mean (3, 7 and 14 DAS) 2nd spray revealed that all the treatments were significantly superior over control (3.82). Among all the treatments minimum larval population was recorded in T_4 Spinosad 45% SC (0.73), followed by T_1 Chlorantraniliprole 18.5% SC (0.86), T_2 Spinetoram 11.7% SC (1.06), T_3 Flubendamide 39.35% SC (1.26), T_5 Bacillus thuringiensis 1x108 CFU/ml (1.46), T_6 Beauveria bassiana 1x108 CFU/ml (1.6).In this the maximum larval population was recorded in T_7 Metarhizium anisopliae 1x108 CFU/ml (1.73). In this ($T_7T_6T_5$), (T_5T_3), (T_3T_2), (T_2T_1) and (T_1T_4) they are found statistically at par with each other.

Perusal of the data (Table 3) revealed that population of *Helicoverpa armigera* over control on Overall mean revealed that all the treatments were significantly superior over control (3.55). Among all the treatments minimum larval population was recorded in T_4 Spinosad 45% SC (1.08), followed by T1 Chlorantraniliprole 18.5% SC (1.23) T2 Spinetoram 11.7% SC(1.43), T_3 Flubendamide 39.35% SC (1.63), T5 Bacillus thuringiensis 1x108 CFU/ml (1.83), T_6 Beauveria bassiana 1x108 CFU/ml (1.96). In this the maximum larval population was recorded in T_7 Metarhizium anisopliae 1x108 CFU/ml (2.1).

The yields among the treatment were significant. The highest yield was recorded in T_4 Spinosad 45% SC (23.52q/ha), followed by T_1 Chlorantraniliprole 18.5% SC (22.75q/ha), T_2 Spinetoram 11.7% SC (20.50q/ha),T_3 Flubendamide 39.35% SC (18.00q/ha), T_5 *Bacillus thuringiensis* 1x10^8 CFU/ml (16.24 q/ha), T_6 *Beauveria bassiana* 1x10^8 CFU/ml (16.24 q/ha) and T_7 *Metarhizium annisopliae* 1x10^8 CFU/ml (14.00 q/ha) and T_0 control (9.02 q/ha).

Table 1. Efficacy of certain chemicals and biopesticides on the population of pod borer, *H. armigera* on chickpea during *rabi* season of 2021-22 (1st Spray)

	Treatment	Average number of Larvae/5 Plants(1st spray)				
		1DBS	3DAS	7DAS	14DAS	Mean
T_4	Spinosad 45% SC	2.8	1.66	1.53	1.13	1.44
T_1	Chlorantraniliprole18.5 SC	2.86	1.86	1.66	1.26	1.6
T_2	Spinoterum 11.7% SC	2.8	2.06	1.86	1.46	1.8
T_3	Flubendamide 39.35% SC	3.00	2.26	2.06	1.66	2.00
T_5	*Bacillus thuringiensis* 1x10^8 CFU/ml	2.93	2.46	2.26	1.86	2.2
T_6	*Beauveria bassiana* 1x10^8 CFU/ml	3.06	2.6	2.4	2.00	2.33
T_7	*Metarhizium anisiopilae* 1x10^8 CFU/ml	2.93	2.73	2.53	2.13	2.46
T_0	Control	3.00	3.13	3.46	3.26	3.28
	F-test	NS	S	S	S	S
	C.D. at 0.5%	---	0.111	0.173	0.130	0.231
	S.EdA (±)	0.161	0.050	0.077	0.054	0.104

Table 2. Efficacy of certain chemicals and biopesticides on the population of pod borer, *H. armigera* on chickpea during *rabi* season of 2021-22 - (2nd Spray)

	Treatment	Average number of Larvae/5Plants (2nd spray)				
		1DBS	3DAS	7DAS	14DAS	Mean
T_4	Spinosad 45% SC	1.26	0.93	0.73	0.53	0.73
T_1	Chlorantraniliprole 18.5% SC	1.46	1.06	0.86	0.66	0.86
T_2	Spinoterum 11.7% SC	1.66	1.26	1.06	0.86	1.06
T_3	Flubendamide 39.35% SC	1.13	1.46	1.26	1.06	1.26
T_5	*Bacillus thuringiensis* $1x10^8$ CFU/ml	1.86	1.66	1.46	1.26	1.46
T_6	*Beauveria bassiana* $1x10^8$ CFU/ml	2.00	1.8	1.6	1.4	1.6
T_7	*Metarhizium anisiopilae* $1x10^8$ CFU/ml	2.13	1.93	1.73	1.53	1.73
T_0	Control	3.26	3.6	3.73	4.13	3.82
	F-test	S	S	S	S	S
	C.D. at 0.5%	0.130	0.185	0.282	0.221	0.292
	S.EdA (±)	0.054	0.083	0.130	0.1	0.134

Table 3. Efficacy of certain chemicals and biopesticides on the population of pod borer, *H. armigera* on chickpea during *rabi* season of 2021-22 - (1st and2nd Spray)

Sr. No.	Treatments	Over all mean population		
		1st Spray	2nd Spray	Mean
T_4	Spinosad 45% SC	1.44	0.73	1.08
T_1	Chlorantraniliprole 18.5% SC	1.6	0.86	1.23
T_2	Spinoterum 11.7% SC	1.8	1.06	1.43
T_3	Flubendamide 39.35% SC	2.00	1.26	1.63
T_5	*Bacillus thuringiensis* $1x10^8$ CFU/ml	2.2	1.46	1.83
T_6	*Beauveria bassiana* $1x10^8$ CFU/ml	2.33	1.6	1.96
T_7	*Metarhizium anisiopilae* $1x10^8$ CFU/ml	2.46	1.73	2.1
T_0	Control	3.28	3.82	3.55

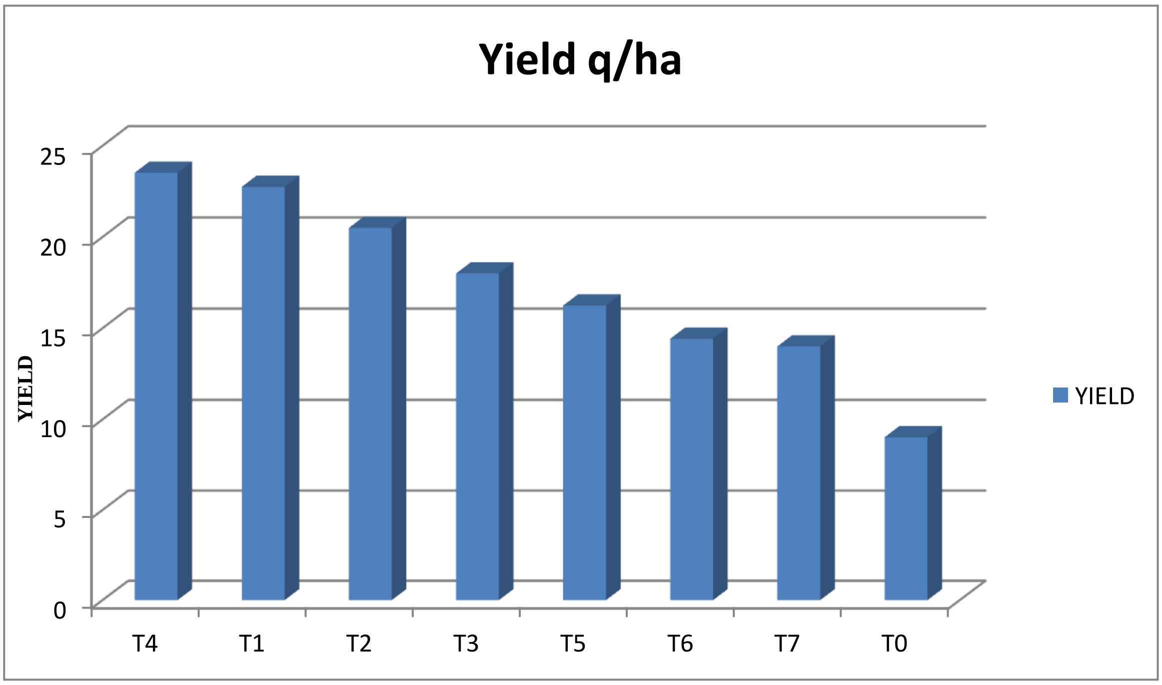

Fig. 1. Graphical representation of yield

Table 4. Economics of cultivation

Sr. No.	Treatment	Yield q/ha	Cost of yield q/₹	Total cost of yield in ₹	Common cost	Treatment cost	Total Treatment cost	C:B Ratio
T_4	Spinosad 45% SC	23.52	5500	129630	25365	7195	32560	1:3.98
T_1	Chlorantraniliprole 18.5 SC	22.75	5500	125125	25365	7390	32755	1:3.82
T_2	Spinetoram 11.7 SC	20.50	5500	112750	25365	3135	28500	1:3.95
T_3	Flubendamide 39.35% SC	18.00	5500	99000	25365	1144	26509	1:3.73
T_5	*Bacillus thuringiensis* $1x10^8$ CFU/ml	16.24	5500	89320	25365	2440	27805	1:3.21
T_6	*Beauveria bassiana* $1x10^8$ CFU/ml	14.42	5500	79310	25365	1420	26785	1:2.96
T_7	*Metarhizium anisiopilae* $1x10^8$ CFU/ml	14	5500	77000	25365	2050	27415	1:2.80
T_0	Control	9.02	5500	49610	25365	----	25365	1:1.95

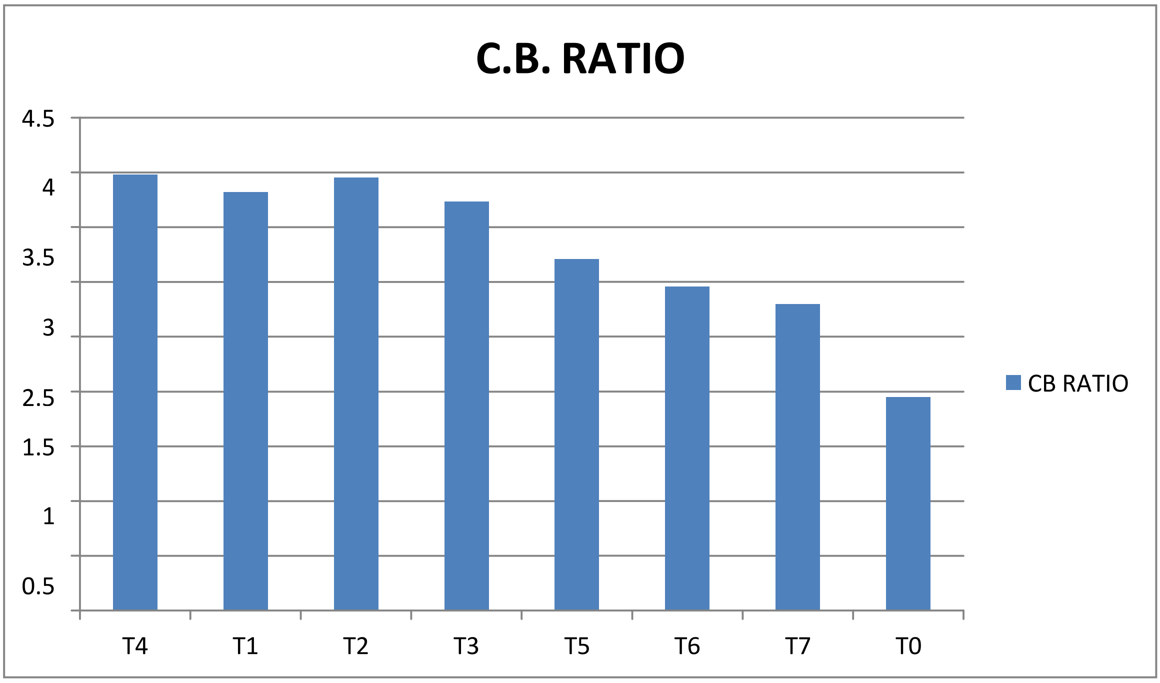

Fig. 2. Graphical representation of cost benefit ratio

When cost benefit ratio worked out, interesting result was achieved, among the treatment studied, the best and most economical treatment T_4 Spinosad 45% SC 45% SC (1:3.98), followed by T_2 Spinetoram 11.7% SC(1:3.95), T_1 Chlorantraniliprole 18.5% sc 18.5% SC (1:3.82), T_3 Flubendamide 39.35% SC (1:3.73), T_5 *Bacillus thuringiensis* 1x10^8 CFU/ml (1:3.21), T_6 *Beauveria bassiana* 1x10^8 CFU/ml (1:2.96) and T_7 *Metarhizium annisopliae* 1x10^8 CFU/ml (1:2.80) and T_0 control (1:1.95).

3.1 Discussion

Perusal of the data revealed that population of *Helicoverpa armigera* over control on Overall mean revealed that all the treatments were significantly superior over control (3.55). Among all the treatments minimum larval population was recorded in T_4 Spinosad 45% SC (1.08), followed by T_1 Chlorantraniliprole 18.5% SC (1.23) is similar to the findings of Chitralekha et al. [9], T_2 Spinetoram 11.7% SC (1.43),T_3 Flubendamide 39.35% SC (1.63), T_5 *Bacillus thuringiensis* 1x10^8 CFU/ml(1.83) is similar to the findings of Chitralekha et al. [9], T_6 Beauveria *bassiana* 1x10^8 CFU/ml (1.96).In this the maximum larval population was recorded in T_7 *Metarhizium anisopliae* 1x10^8 CFU/ml (2.1).

All the insecticides were found very effective and significantly superior over control. The minimum larval population was recorded in T4 Spinosad 45% SC yield(23.52q/ha) these results are similar to the findings of Kumar et al. [10], T_1 Chlorantraniliprole 18.5% SC and maximum yield (22.75q/ha) these results are similar to the findings of Kapulai Santhosh and Ashwani Kumar [11] followed by T_2 Spinetoram 11.7%SC yield (20.50q/ha) these results are similar to the findings of Akbar et al. [12] followed by T3 Flubendamide 39.35% SC yield (18.00 q/ha) these results are similar to the findings of Kapulai Santhosh and Ashwani Kumar [11], T5 *Bacillus thuringiensis* yield (16.24 q/ha) these results are similar to the findings of S. Bhushan et al. [13]. T_6 *Beauveria bassiana* yield (14.42q/ha),in this the maximum larval population was recorded in T_7 *Metarhizium anisopliae* with minimum yield (14.00q/ha) and control(9.02q/ha).

The cost benefit ratio among the treatment were significant. The highest cost benefit ratio in T_4 Spinosad 45% SC with (1:3.98). These results are similar to the findings of Chandel et al. [14]. T_2 Spinetoram 11.7% SC with cost benefit ratio (1:3.95). These results are similar to the findings of Dadas et al. [15], followed by T_1 Chlorantraniliprole 18.5% SC with cost benefit ratio (1:3.82). These results are similar to the findings of Shahiduzzaman et al. [16], followed by T_3 Flubendamide 39.35% SC with cost benefit ratio (1:3.73), as similar to the findings of Deshmukh et al. [17], followed by T_5 *Bacillus* *thuringiensis* these results are similar to the findings of S. Bhushan et al. [8] with cost benefit ratio (1:3.21), and T_6 *Beauveria bassiana* with cost benefit ratio (1:2.96), The lowest cost benefit ratio was recorded in T_7 *Metarhizium anisopliae* was (1:2.80) when compared to T_0 Control with cost benefit ratio (1:1.95).

4. CONCLUSION

From the present study, the results it showed that T_4 Spinosad 45% SC most effective treatment against gram pod borer of Mean larval population and producing maximum yield and recorded highest Cost-Benefit ratio compared to other treatments. While T_1 Chlorantraniliprole 18.5% SC, T_2 Spinetoram 11.7EC, T_3 Flubendamide, has shown average results has proved to be least effective chemicals. *Bacillus thuringiensis, Beauveria bassiana*, and *Metarhizium annisopliae* found to be least effective in managing *Helicoverpa armigera*. Botanicals are the part of integrated pest management in order to avoid indiscriminate use of pesticides causing pollution in the environment and not much harmful to beneficial insects.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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