

Original Research Article

Evaluation of some biopesticides against pod borer in garden pea (*Pisum sativum* L.) under natural conditions of Prayagraj (U.P.)

ABSTRACT

A field trial was conducted at the Central Research Farm, Department of Entomology SHUATS, Allahabad during the *Rabi* season. Eight treatments were evaluated against Pod borer, *Helicoverpa armigera* L., Neem oil 2% @ 2ml/lit, Spinosad 45% SC @ 0.2ml/lit, NSKE 5% @ 5ml/lit, *Bacillus thuringiensis* 4% WSP @ ml/lit, NSKE+*HaNPV*+*Bt*@ 1ml/lit, Emamectin Benzoate 5% SG @ 2ml/lit, *Beauveria bassiana* @ 2ml/lit and Untreated control in RBD with three replications. Results revealed that among the different treatments Emamectin benzoate 5% SG (10.57%) was found to be the most effective treatment in the reduction of *H. armigera* followed by Spinosad 45% SC (15.21%), NSKE+*HaNPV*+*Bt*(9.03%), *Beauveria bassiana* 1.5% SG (13.98%), NSKE 5% (16.41%), *Bacillus thuringiensis* 4% WSP (12.00%) and Neem oil 2% (17.32%) was found to be least effective against this pest. Among all the treatments, the cost-benefit ratio has been analyzed, in which the highest was Emamectin benzoate 5% SG (1:4.25) and marketable yield (19.20 q/ha) followed by Spinosad 45% SC (1:3.43 and 16.40 q/ha), and NSKE+*HaNPV*+*Bt* (1:3.00 and 14.60 q/ha), *Beauveria bassiana* 1.5% SG (1:2.80 and 13.25 q/ha), NSKE 5% (1:2.69 and 12.45 q/ha), *Bacillus thuringiensis* 4% WSP (1:2.55 and 11.80 q/ha) and the lowest was Neem oil 2% (1:2.48 and 11.20 q/ha) have been recorded.

Keywords: benefit cost ratio, evaluation, garden pea, *H. armigera*, pod borer.

INTRODUCTION

Garden pea (*Pisum sativum* L. var. hortense) belongs to the family Leguminosae (Fabaceae) is also called sweet pea is a choice vegetable grown for its fresh shelled green seeds rich in protein (7.2%), vitamins and minerals. Garden pea originated in the region comprising Central Asia, Mediterranean countries and Ethiopia. It is native to Syria, Iraq, Iran, Turkey, Israel, Jordan, Ethiopia, Lebanon and has been cultivated in Europe for several thousand years (Mohan *et al.*, 2013)^[30].

Comment [1]: Seven treatment with control

Comment [2]: Abstract should end with a statement of conclusion regarding suitability of the best treatments (according to this study) in the mitigation of yield loss due to pod borer.

Comment [3]: Authors should reduce the redundancy here by choosing only one of either the scientific or common name of pest.

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Comment [5]: Authors should provide reference if the statement is not theirs.

In terms of productivity, India stands as the second largest producer of green peas next to China and ranks ten among the vegetable crops. The annual global production of green pea and dry pea seeds is approximately 14.5 million tons and 22 million tons, respectively (**Kumari and Chandra2021**)^[24].

In India, it is grown in an area of 0.42 million ha with the production of 4.01 million metric tonnes and productivity is 9.5 t/ha. Garden pea is a cool season crop mainly grown during the winter season on plains and during the summer season on hills(**Mohan et al., 2013**)^[30]. The major Pea-producing states are Uttar Pradesh, Punjab, Himachal Pradesh, Orissa, Karnataka and Haryana, etc. (**Senapati et al., 2019**)^[34].

Uttar Pradesh is the leading state in the area (1.8 lakh ha) and production (18.8 lakh tonnes) followed by Madhya Pradesh (22.8 thousand ha; 5.34 lakh tonnes). Jammu and Kashmir is the leading state in productivity (20.8 t/ha) followed by Jharkhand (**Mohan et al., 2013**)^[30]. The nutritional value of dry pea seed is similar to other grain legumes and contains 18-30 % protein, 35-50% starch and 4-7 % fiber (**Ibrahim et al., 2020**)^[16].

The crop is known to suffer from a number of insect pests like pod borers (*Etiella zinckenella* Tr. and *Helicoverpa armigera* Hub.), pea stem fly (*Melanagromyza phaseoli* Tyron), pea leaf miner (*Chromatomyia horticola* Goureau), aphid (*Acyrtosiphon pisum*) and thrips (*Caliothrips indicus* Bagnall). These are serious insect pests and often cause substantial loss to the crop. Insect pests in western Uttar Pradesh, in addition to other insect pests, the pod

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borers *Etiella zinckenella* (Treitschke) and *Helicoverpa armigera* (Hübner) are most serious insect pest of vegetable pea appearing during the flowering and pod stage which seriously damages the crop and is considered to be a major limiting factor for the production of vegetable pea (Vaibhav *et al.*, 2018)^[41].

Materials and Methods

The experiment was conducted during *Rabi* 2021 at Central Research Farm, the Sam Higginbottom University of Agriculture, Technology and Sciences, Naini, Prayagraj, U.P, to evaluate the efficacy of Some Biopesticides viz., Neem oil 2%(T₁), Spinosad 45% SC (T₂), NSKE 5% (T₃), *Bacillus thuringiensis* (T₄), NSKE+HaNPV+Bt (T₅), Emamectin benzoate5%SG (T₆), *Beauveria bassiana*(T₇) and untreated Control (T₀) in RBD with three replications at a spacing of 45cm x 30cm. The experimental field was monitored for incidence of garden pea pod borer at the weekly interval to observe ETL levels of insects. Spraying was done by using a Hand compression sprayer. pod damage analysis was recorded by randomly picking 5 plants per plot from each treatment a day prior to insecticide application and seven, fourteen days after each treatment |

Comment [8]: Introduction should end with a statement on aim of the research was proposed. E.g., the present study aims to evaluate the activity of biopesticides and provide support in the management/prevention of the mentioned plant pest.

Comment [9]: If any of the biopesticides used in the study was prepared by authors, information regarding the procedures should be provided. In a case were the materials were outsourced, the source need mention as well.

Comment [10]: If there was a relation/formular used to determine this, it needs be stated with reference.

Comment [11]: How was effect of pod borer on the % yield (% pod damage) determined?

Cost-benefit ratio of treatments:

Gross returns will be calculated by multiplying the total yield with the market price of the produce. The cost of cultivation and cost of treatments will be deducted from the gross returns, to find out the returns and cost benefit of ratio by following formula,

$$B.C.R = \frac{\text{GrossReturns}}{\text{TotalCostofProtection}}$$

RESULTS AND DISCUSSION

In the experiments, eight different treatments, consisting application of were tested to compare the efficacy against *Helicoverpa armigera* and their influences on the yield of a garden pea. The results obtained are discussed in the light of available relevant literature in this chapter as before.

Comment [12]: seven treatments and control

Overall mean analysis of 7th and 14th days after 1st insecticidal application indicated that all the insecticidal treatments were significantly effective in highly reduced pod damage percentage of *H. armigera* as compared to untreated plots. Emamectin benzoate 5% SG (14.16%) was found significantly superior among all the treatments. Spinosad 45% SC (17.06%) is the next best treatment for reducing the population of pod borers. It is followed by *NSKE+HaNPV+Bt* (13.27%), *Beauveria bassiana* 1.5% SG (16.72%) and NSKE 5% (17.79%), *Bacillus thuringiensis* 4% WSP (14.98%) followed by Neem oil 2% (18.18%) which is less effective against podborer.

The data on percent pod damage of *Helicoverpa armigera* on the second spray revealed that all the treatments were significantly superior to control. Among all treatments, Emamectin benzoate 5% SG (9.03%) was found significantly superior among all the treatments which are in line with the similar findings of **Akhtar et al. (2022)**^[3]with (10.4% and 11.9%) and **Upadhyay et al. (2020)**^[40]with (7.33%) and **Dadas et al. (2019)**^[11]with (8.33%). Spinosad 45% SC (10.57%) is the next best treatment for reducing the population of pod borer which is in line with the similar findings of **Dadas et al. (2019)**^[11]with (7.33%), **Agale et al. (2019)**^[2]with pooled mean percent (6.82%), **Mihretie et al. (2020)**^[28]with (11.39%), **Akhtar et al. (2022)**^[3]with (7.8%). It is followed by

Comment [13]: Cite (Table 1).

NSKE+HaNPV+Bt (12.00%) which is in line with the similar finding of **Byrappa et al. (2012)**^[7]with (15.96%), *Beauveria bassiana* 1.5% SG (13.98%) which is in line with the similar finding of **Singh et al. (2016)**^[38]and **Khorasiya et al. (2018)**^[21]with (9.8%), and NSKE 5% (16.41%), *Bacillus thuringiensis* 4% WSP (12.00%) which is in line with the similar finding of **Khorasiya et al. (2018)**^[21]and **Meena et al. (2018)**^[27]with (13.17% and 10.50%) followed by Neem oil 2% (17.32%) which is in line with the similar finding of **Abhilasha and Shekarappa (2017)**^[1]and **Mishra et al. (2014)**^[29]with (25.68%) which is less effective against podborer.

Comment [14]: Bring the Table 1 to this place.

The yields among the treatments were found to be significant. The highest yield was recorded in Emamectin benzoate 5% SG (19.20 q/ha) which is in line with the similar findings of **Kumar and Kumar (2022)**^[25]with (1966 kg/ha), **Santhosh and Kumar (2022)**^[33]with (19.72q/ha) and **Chaukikar et al. (2017)**^[9]with (1810kg/ha) followed by Spinosad 45% SC (16.40q/ha) which is in line with the similar findings of **Mihretie et al. (2020)**^[28]with (16.68q/ha), **Mishra et al. (2014)**^[29]with (17.53q/ha) and **Upadhyay et al. (2020)**^[40]with (15.55q/ha), *NSKE+HaNPV+Bt* (14.60q/ha) which is in line with the similar finding of **Byrappa et al. (2012)**^[7]with (10.01q/ha), *Beauveria bassiana* 1.5% SG (13.25 q/ha) which is in line with the similar finding of **Khorasiya et al. (2018)**^[21]with (12.33q/ha), NSKE 5% (12.45 q/ha) which is in line with the similar finding of **Meena et al. (2018)**^[27]with (12.22q/ha) and **Hossain et al. (2010)**^[15]with (11.46q/ha), *Bacillus thuringiensis* 4% WSP (11.80 q/ha) with similar findings of **Khorasiya et al. (2018)**^[21]with (11.17q/ha), **Meena et al. (2018)**^[27]with (11.23q/ha) and **Singh et al. (2016)**^[38]with (11.4q/ha) and Neem oil 2% (11.20 q/ha) with similar findings of **Santhosh and Kumar (2022)**^[33]with (13.61q/ha) as compared to control plot(8.2q/ha).

When cost benefit ratio was worked out, interesting result was achieved. Among the treatments studied, the best and most economical treatment was Emamectin benzoate 5% SG (1:4.25) with the similar finding of **Kumar and Kumar (2022)**^[25]with (1:4.5) followed by Spinosad 45% SC (1:3.43) with the similar findings of **Kumar and Kumar (2022)**^[25]with (1:1:4.0) and **Abhilasha and Shekarappa (2017)**^[1]with (1:3.91), *NSKE+HaNPV+Bt* (1:3.00) with the similar finding of **Byrappa et al. (2012)**^[7]with (1:2.27), *Beauveria bassiana* 1.5% SG (1:2.80) with the similar finding of **Singh et al. (2016)**^[38], NSKE 5% (1:2.69) with the similar findings of **Abhilasha and Shekarappa (2017)**^[1]with (1:2.89) and

Comment [15]: Cite both (Figure 1.) and (Table 2.) here..

Comment [16]: (1:4.0) or (1:1.40)?

Hossain et al. (2010)^[15], *Bacillus thuringiensis* 4% WSP (1:2.55) with similar findings of **Khorasiya et al. (2018)**^[21]with (1:2.83) and **Meena et al. (2018)**^[27]with (1:2.29) and Neem oil 2% (1:2.48) with the similar findings of **Abhilasha and Shekarappa (2017)**^[1]with (2.73) and **Santhosh and Kumar (2022)**^[33]with (1:2.41) as compared to Control(1:1.90)

Comment [17]: Cite (Table 2.) and bring the table here

UNDER PEER REVIEW

Table 1 : List of treatments and pod damage percentage

S.No.	Treatments	Pod damage percentage									Yield(q /ha)	C:B Ratio
		Firstspray				Secondspray						
		1DBS	7DAS	14DAS	Mean	1DBS	7DAS	14DAS	Mean	Overall Mean		
T ₁	Neem oil 2%	24.04	13.31	17.18	18.18	17.18	15.02	19.76	17.32	17.18	11.20	1:2.48
T ₂	Spinosad 45% SC	24.17	7.14	11.54	14.16	11.54	8.27	12.27	10.57	11.54	16.40	1:3.43
T ₃	NSKE 5%	24.19	11.41	15.76	17.06	15.75	13.03	17.04	15.21	15.75	12.45	1:2.69
T ₄	<i>Bacillus thuringiensis</i>	24.21	12.40	16.33	17.79	16.33	14.22	18.25	16.41	16.33	11.80	1:2.55
T ₅	NSKE+HaNPV+Bt	24.07	8.54	12.32	14.98	12.32	9.57	14.09	12.00	12.32	14.60	1:3.00
T ₆	Emamectin benzoate 5% SG	24.33	6.21	9.21	13.27	9.21	7.38	10.45	9.03	9.21	19.20	1:4.25
T ₇	<i>Beauveria bassiana</i> 1.5% SG	24.88	10.63	15.75	16.72	15.76	11.01	16.25	13.98	15.76	13.25	1:2.80
T ₀	Control	24.26	27.95	29.25	27.07	29.25	27.95	28.99	28.64	29.25	8.2	1:1.90
	F-Test	NS	S	S	S	S	S	S	S	S		
	S. Ed. (±)	_____	1.65	1.55	2.37	1.55	1.54	1.52	0.49	1.55		
	C.D. (P = 0.05)	_____	3.5	3.3	5.09	3.3	3.31	3.27	1.05	3.3		

Comment [18]: Values in the table 1 could show correlations between/among treatments

Table 2. Economics of Cultivation

S.No.	Treatments	Yield of q/ha	Cost of yield / ₹/q	Total cost of yield(₹)	Common cost (₹)	Treatment cost(₹)	Net return(₹)	Total cost (₹)	C:B ratio
1	Neem oil 2%	11.20	5620	62944	24205	1160	37579	25365	1:2.48
2	Spinosad 45% SC	16.40	5620	92168	24205	2640	65323	26845	1:3.43
3	NSKE 5%	12.45	5620	69969	24205	1800	43964	26005	1:2.69
4	<i>Bacillus thuringiensis</i> 4% WSP	11.80	5620	66316	24205	1700	40411	25905	1:2.55
5	NSKE- <i>HaNPV-Bt</i> 5%-250LE-1L	14.60	5620	82052	24205	3100	54747	27305	1:3.00
6	Emamectin benzoate5%SG	19.20	5620	107904	24205	1130	82569	25335	1:4.25
7	<i>Beauveria bassiana</i> 1.5% SG	13.25	5620	74465	24205	2100	48160	26305	1:2.80
8	Control	8.2	5620	46084	24205	0	22279	24205	1:1.90

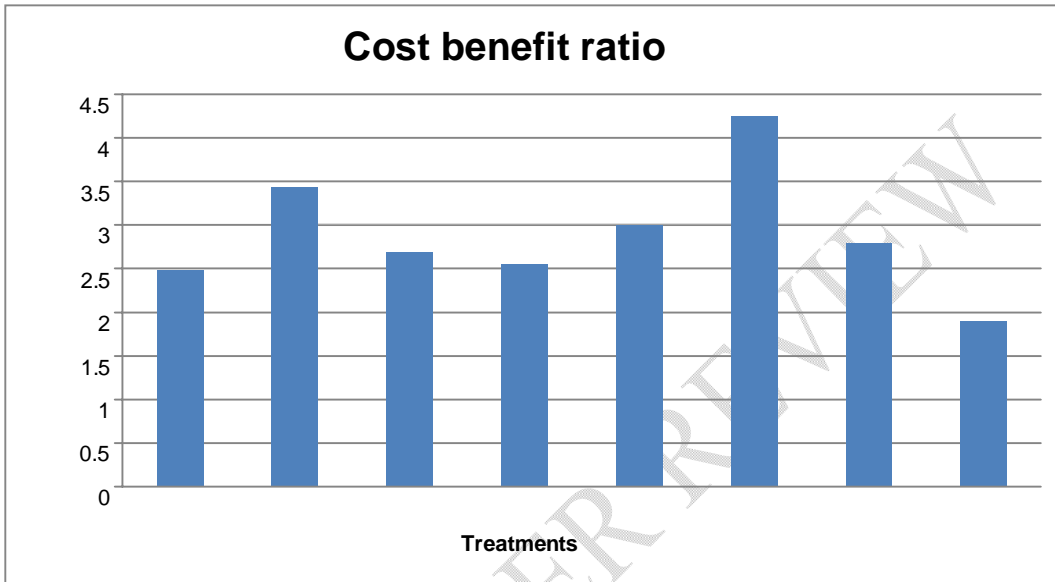


Fig1. Cost-benefit ratio of different treatments

Conclusion

The present study was conducted on the evaluation of insecticides during *rabi* season 2021-22 on garden pea pod borer, *H. armigera*. percent pod damage revealed that, Emamectin benzoate 5% SG (10.57%) was found to be the most effective treatment in the reduction of *H. armigera* followed by Spinosad 45% SC (15.21%), NSKE+HaNPV+Bt (9.03%), *Beauveria bassiana* 1.5% SG (13.98%), NSKE 5% (16.41%), *Bacillus thuringiensis* 4% WSP (12.00%) and Neem oil 2% (17.32%). Among all the treatments, the cost-benefit ratio has been analyzed, in which the highest was Emamectin benzoate 5% SG (1:4.25) and marketable yield

Comment [19]: Authors should include a legend to give brief insight of the content in figure. The bars of the 'x axis of the figure should indicate the different treatments, either with numbers or names of treatment', with the bar representing the control placed first from the left/zero.

Comment [20]: Put a fullstop at end of this to signify end of sentence and begin the p in percentage with a capital p to indicate beginning of a new one.

(19.20 q/ha) followed by Spinosad 45% SC (1:3.43 and 16.40 q/ha), and NSKE+HaNPV+Bt (1:3.00 and 14.60 q/ha), *Beauveria bassiana* 1.5% SG (1:2.80 and 13.25q/ha), NSKE 5% (1:2.69 and 12.45 q/ha), *Bacillus thuringiensis* 4% WSP (1:2.55 and 11.80 q/ha) and the lowest was Neem oil 2% (1:2.48 and 11.20 q/ha) have been recorded.

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Comment [21]: Following journal's guide, apart from the 'RESULTS AND DISCUSSION' section, numbers in parenthesis enough to reference a statement in the text citations in the body of manuscript.

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Comment [22]: Authors should look up and complete the references. The numbering of intex citations was not consistent. E.g., 1,2,3,7,9,11,15,16,21,24,25,27,28,29,30,33,34,38. Majority of the citations in text were not found in 'REFERENCE' section.

The following items were found in the 'REFERENCE' section but are not found in the manuscrip intex citations:

Babariya et al., 2010
Babu and Mallikarju 2012
Bhushan et al., 2011
Chavan et al., 2017
Chitralekha et al., 2018
Dadas et al., 2019
Dinesh et al., 2017
Gautam et al., 2018
Gomez and Gomez 1976