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Economics of botanicals and biopesticides especially in reference to management of *Helicoverpa armigera* in chickpea crop

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Abstract
The field experiment was carried out at the Agriculture Farm, Department of Entomology, Tilak Dhari Post Graduate College, Jaunpur during *Rabi* 2010-11 and 2011-12 with three replications and seven treatments of Biopesticides, against *Helicoverpa armigera*. The Biopesticides like NSKE, *Bacillus thuringiensis*, Neem leaf extract, Neem oil, Nimbicidine and nuclear polyhedrosis virus in reducing the infestation of gram pod borer, *Helicoverpa armigera* and providing a higher net return per rupee invested. The higher grain yield of 24.07 Q./ha and22.65 Q/ha was recorded with the application of NSKE @ 5 per cent /ha during both years. The most favourable cost benefit ratio was obtained from the plot treated with Neem leaf Extract @ 5 per cent 31.82 and 22.22 followed by Neem leaf Extract @ 5 per cent 31.82 and 22.22, Neem oil @ 2 per cent 22.59 and 20.94, NSKE @ 5 per cent 19.68 and 15.06, Nimbecidine @ 2 per cent 16.16 and 15.04, Ha NPV @ 450 LE/ ha 9.34 and 6.28, Bt.1 kg /ha 6.40 and 4.91 during both years.

Keywords: Podborer, biopesticide, NPV and chickpea

Introduction
Chickpea (*Cicer arietinum* L.) is grown widely in the world because the seeds are a rich source of protein for the rapidly increasing population. However, the production and productivity of chickpea have been experienced drastically because of biotic and abiotic stresses. In India, chickpea crop is mainly known for protein source, grown in tropical, subtropical and temperate regions. India ranks first among the chickpea growing nations in terms of production and cultivated area.

Biopesticides based on microbial and botanical products are efficacious and promising agents. Neem, *Azadirachta indica* A. Juss. is known to affect larvae of various lepidopteran and coleopteran pests. *Bacillus thuringiensis* (Bt) is a spore-forming, gram positive bacteria which produces proteinaceous crystal at the time of sporulation. These crystals have shown potential against lepidopteran, dipteran and coleopteran pests. In India, scientists have done extensive studies on evaluation of NPVs and developed technologies for successful application of indigenous NPV preparations to combat *H. armigera infesting* chickpea. The pod borer *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae) is among the most threatening plant pests, cosmopolitan in distribution and polyphagous in herbivorous nature (Wakil *et al*., 2009a and 2009b) [9, 10]. The larvae of *H. armigera* feed on leaves and stems but, they prefer buds, inflorescences, fruits and pods, thus causing significant damage to both vegetative and reproductive plant parts (Moral Garcia, 2006) [7]. A total of 500 US million worth of soybean and cotton has been lost in Brazil by *H. armigera* where it has been introduced in the recent past (Czepak *et al*., 2013) [2]. The *H. armigera* is the key production constraints in several crops including chickpea, pigeonpea, pea, lentil chilies, Sun flower, Tomato, to bacco and cotton crops. A viable and sustainable method for this polyphagous pest using the conventional approach of relying primarily on chemical pesticides has become increasingly costly now days, and resistance in several pest species, environmental impact, safety and accumulation of residues has been the primary cause of concern. Hence, there is an urgent need for the development of environment friendly management by adopting insect

Materials and Methods
The experiment was conducted at the Agriculture Farm, Department of Entomology,

Tilak Dhari Post Graduate College, Jaunpur during *Rabi* 2010-11 and 2011-12 with the three replications and seven treatments of Biopesticides.

Results and Discussion

Data recorded on yield parameters have been presented in Table-1 All the treatments higher grain yield over control. Average yield of 24.07 Q./ha was recorded with the application of NSKE @ 5 per cent /ha. Spray of this insecticide resulted significantly higher yield of 24.07 Q./ha and 22.65 Q./ha in the first and second year, respectively followed by Bt @ 1 Kg/ ha (23.30 Q./ha in the first year and 21.86 Q. /ha in the in the second year).

Table 1: Effects of various treatments on seed yields during *Rabi* season 2010-11 and 2011-12.

Treatment	Yield (Q/ha)	
	2010-11	2011-12
T_1: NSKE @ 5%	24.07	22.65
T_2: Bt @ 1Kg	23.30	21.86
T_3: Neem Leaf Extract @ 5%	21.38	21.48
T_4: Neem Oil @ 2%	19.78	20.01
T_5: Nimbecidine @ 2%	19.65	19.32
T_6: HNPV @450 LE/ha	19.48	18.90
T_7: Control	15.90	16.40
SEm±	1.74	1.24
CD at 5%	3.52	3.32

The highest additional gross income was recorded NSKE @ 5 per cent (32680 in the first year and 25000 in the second year) with one sprays followed by Bt. @1 kg/ ha (28520 in the first year and 21840 in the second year), Neem oil @ 2 per cent (21920 in the first year and 20320 in the second year), Nimbecidine @ 2 per cent (15520 in the first year and 14440 in the second year), Ha NPV @ 450 LE/ ha (15000 in the first year and 10080 in the second year), Neem Leaf Extract @ 5 per cent (14320 in the first year and 10000 in the second year) over the control.

The most favourable cost benefit ratio was obtained from the plot which treated with the Neem leaf Extract @ 5 per cent (31.82 in the first year and 22.22 in the second year) followed by Neem leaf Extract @ 5 per cent (31.82 in the first year and 22.22 in the second year), Neem oil @ 2 per cent (22.59 in the first year and 20.94 in the second year), NSKE @ 5 per cent (19.68 in the first year and 15.06 in the second year), Nimbecidine @ 2 per cent (16.16 in the first year and 15.04 in the second year), Ha NPV @ 450 LE/ ha (9.34 in the first year and 6.28 in the second year), Bt.1 kg/ha (6.40 in the first year and 4.91 in the second year) over the control.

On the basis of cost benefit ratio the recommendation of NSKE @ 5 per cent, NSKE @ 5 per cent, Bt. 1 kg /ha and Ha NPV @ 450 LE/ha could be given to farmers for the management of gram pod borer in chickpea .

Average yield of 24.07 Q./ha was recorded with the application of NSKE @ 5 per cent /ha. Spray of this insecticide resulted significantly higher yield of 24.07 Q./ha and 22.65 Q./ in the first year and second year, respectively followed by Bt @ 1 Kg/ ha (23.30 Q./ha in the first year and 21.86 Q. /ha in the in the second year). The present findings are also in partial agreement with the findings of Anandhi *et al*. (2011) [1, 6] who reported that the pretreatment count was made a day before the first and second sprays, whereas the post treatment counts were made on third and fifth days after each spray. Results showed that the population reduction after spraying in all treatments were superior compared than the control.

Table 2: Economics of bio-pesticides against *H. armigera* Hub. On chickpea during *Rabi* 2010-11

Treatments	No. of spray	Total cost of insecticides (Rs./ha)	Yield (Q./ha)	Increased yield over the control (Q./ha)	Grass income (Rs./ha)	Additional income (Rs./ha)	B:C ratio
T_1: NSKE @ 5%	1	1660	24.07	8.17	96280	32680	19.68
T_2: Bt @ 1Kg	1	4445	23.03	7.13	92120	28520	6.40
T_3: Neem Leaf Extract @ 5%	1	970	21.38	5.48	85520	21920	22.59
T_4: Neem Oil @ 2%	1	960	19.78	3.88	79120	15520	16.16
T_5: Nimbecidine @ 2%	1	1605	19.65	3.75	78600	15000	9.34
T_6: HNPV @450 LE/ha	1	450	19.48	3.58	77920	14320	31.82
T_7: Control	1	-	15.90	-	63600	-	-

Table 3: Economics of bio-pesticides against *H. armigera* Hub. On chickpea during *Rabi* 2011-12

Treatments	No. of spray	Total cost of insecticides (Rs./ha)	Yield (Q./ha)	Increased yield over the control (Q./ha)	Grass income (Rs./ha)	Additional income (Rs./ha)	B:C ratio
T_1: NSKE @ 5%	1	1660	22.65	6.25	90600	25000	15.06
T_2: Bt @ 1Kg	1	4445	21.86	5.46	87440	21840	4.91
T_3: Neem Leaf Extract @ 5%	1	970	21.48	5.08	85920	20320	20.94
T_4: Neem Oil @ 2%	1	960	20.01	3.61	80040	14440	15.04
T_5: Nimbecidine @ 2%	1	1605	19.32	2.52	77280	10080	6.28
T_6: HNPV @450 LE/ha	1	450.	18.90	2.50	75600	10000	22.22
T_7: Control	1	-	16.40	-	65600	-	-

Among the treatments, Indoxacarb recorded the highest reduction of pod borer population in the first and second spray, followed by spinosad. Among the plant products, the best treatment with the highest reduction of pod borer population in the first and second spray was neem seed kernel extract, followed by garlic extract.

The gross income was recorded NSKE @ 5 per cent (32680 in first and 25000 in second year) with one sprays followed by Bt. @1 kg/ ha (28520 in the first year and 21840 in the second year), Neem oil @ 2 per cent (21920 in the first year and 20320 in the second year), Nimbecidine @ 2 per cent (15520 in the first year and 14440 in the second year), Ha NPV @ 450 LE/ ha (15000 in the first year and 10080 in the second year), Neem Leaf Extract @ 5 per cent (14320 in the first year and 10000 in the second year) over the control. The present findings are also in partial agreement with the findings of

Kumar (2018) [3] found that the Biopesticides, HaNPV @ 500 LE was found more effective with highest net profit.

The most favourable cost benefit ratio was obtained from the plot Wich is treated with Neem leaf Extract @ 5 per cent (31.82 in the first year and 22.22 in the second year) followed by Neem leaf Extract @ 5 per cent (31.82 in the first year and 22.22 in the second year), Neem oil @ 2 per cent (22.59 in the first year and 20.94 in the second year), NSKE @ 5 per cent (19.68 in the first and 15.06 in the second year), Nimbecidine @ 2 per cent (16.16 in the first year and 15.04 in the second year), Ha NPV @ 450 LE/ ha (9.34 in the first year and 6.28 in the second year year), Bt.1 kg /ha (6.40 in the first year and 4.91 in the second year) over the control. The present findings are also in accordance with the findings of Meena *et al.* 2018 [5] reported that the highest incremental benefit cost ratio (B:C ratio 10.28) was computed in NSKE followed by B:C ratio 9.98 in HaNPV. The minimum B:C ratio 2.64 was obtained in garlic extract followed by 3.56 in *B. thuringiensis*. The B:C ratio computed by azadirachtin and indoxacarb was 4.79 and 8.51, respectively. Present investigations are also in partial agreement with the findings of Moorthy *et al*., (2011) [6] reported that the highest cost benefit ratio with the treatment of indoxacarb and moderate B:C ratio with the application NSKE. The present results are in agreement with those of Singh *et al* (2014) [8] reported that the minimum B:C ratio with garlic extract and HaNPV, respectively and partial agreement with the findings of Mandal, *et al*., (2003) [4] reported that the highest B:C ratio with the application of *B. thuringiensis.*

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