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Evaluation of bio-pesticides and indoxacarb against gram pod borer on chickpea

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Abstract
An experiment conducted during *rabi*, 2015-16 to evaluate the efficacy of bio-pesticides and indoxacarb against gram pod borer on chickpea from six treatments *viz.,* Indoxacarb, *Bacillus thuringiensis,* Nuclear Polyhedrosis Virus, NSKE, *Azadirachtin* and Garlic extract. The indoxacarb 14.5 SC (1.0 ml/lit.) was found most effective in crop protection. NSKE (5.0 ml/ha), azadirachtin 0.3 EC (5.0 ml/lit.), HaNPV (250 LE/ha) and *B. thuringiensis* (1000 ml/ha) were found moderately effective in reducing pod borer population, while garlic extract (10 ml/lit.) was found least effective. The minimum pod damage (4.69%) was recorded in treatment of indoxacarb followed by NSKE (10.41%) and azadirachtin (10.84%). The maximum pod damage (14.27%) was found in garlic extract treatment, while it was 20.95% in control. The maximum seed yield was obtained in the treatment of indoxacarb 14.5 SC (16.49 q/ha) whereas it was minimum in garlic extract (10.10 q/ha) treatment. Maximum B:C ratio was obtained in the treatment indoxacarb (9.52), while minimum in garlic extract (0.17).

Keywords: Bio-pesticides, chickpea, indoxacarb, *H. armigera,* evaluation

1. 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. It is vulnerable to a broad range of pathogens and the mainly severe pest being gram pod borer, *Helicoverpa armigera* (Hübner). *H. armigera* is a cosmopolitan and widely distributed insect pest in the world. It is a serious pest of all legumes. In India, it has been observed to feed on 181 cultivated and uncultivated species belonging to 45 families. *H. armigera* is found in the Palearctic, Oriental, Ethiopian and Australian provinces, south of a line at approximately 52°N. This range occupied by the species includes tropical, dry and temperate climates [2].
Helicoverpa armigera (Hubner) (Lepidoptera: Noctuidae) is a cosmopolitan, polyphagous and notorious pest which attacks numerous crops of agricultural importance and widely distributed in the tropics and sub-tropics. The low yield of chickpea is attributed to the regular outbreaks of pod borer, *H. armigera* which is considered as one of the major pests of chickpea. It alone is responsible for losses over Rs 35, 000 million annually in India despite heavy pesticide inputs [11]. Pesticides probably continued to be the most effective control strategy to date. However, their detrimental effects are a cause for public concern, which calls for rationalized use of insecticides and reorientation of protection strategies towards ecologically sound pest management. 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 [5]. 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. Keeping in view, the present study was undertaken to evaluate the bio efficacy of certain biopesticides against the pod borer in chickpea ecosystem.

2. Materials and Methods
The experiment was laid out in simple Randomized Block Design (RBD) with seven treatments including untreated control, using three replications. The plot size was 3.0 × 2.0 m^2 keeping row to row and plant to plant distance of 30 cm and 10 cm, respectively on evaluation

of bio-pesticides and indoxacarb against gram pod borer on chickpea during 2015-16 at Research farm of College of Agriculture, SKRAU, Bikaner (Rajasthan). The seeds of variety GNG-469 were sown on November 5th, 2015. There were seven treatments including control. All the six insecticidal treatments were applied as foliar spray. The untreated (control) plot was also maintained for the comparison with water spray. The first spray was given on economic threshold level of the pod borer, whereas, the second spray was given after one fortnight of the first spray. The detailed information regarding insecticides used has been presented in Table 1.

Table 1: Details of insecticides/bio-pesticides used

S. No	Common name	Trade name	Formulation	Conc./Dose
1	Indoxacarb	King doxa	14.5 SC	1.0 ml/l
2	*Bacillus thuringiensis*	Dipel	8 L	1000 ml/ha
3	Nuclear Polyhedrosis Virus	Helilure (HaNPV)	-	250 LE/ha
4	NSKE	Self preparation	-	5.0 ml/l
5	Azadirachtin	Nimbecidine	0.3 EC	5.0 ml/l
6	Garlic extract	Self preparation	-	10 ml/l
7	Control	-	-	-

2.1 Preparation of neem seed kernel extract
Fifty gram of neem seed kernel was taken and crushed into fine powder and then soaked overnight in a little quantity of water. Later the mixture was squeezed through the muslin cloth and the volume was made up to one liter so as to obtain 5 per cent neem seed kernel extract. Soap solution was added at 0.1 per cent as a spreader [16].

2.2 Preparation of garlic extract
100 gram of garlic bulb was taken and cut into small pieces with the help of knife and then crushed them in the grinder and mixer. The paste of garlic is removed from mixer and was squeezed through the muslin cloth and the volume was made up to one litter so as to obtain 10 per cent garlic extract. Soap solution was added at 0.1 per cent as a spreader.

2.3 Method of Observations
The pre and post-treatment observations on larval population was taken just before and 1, 3, 7 and 15 days after application, respectively, on five randomly selected and tagged plants in each plot. Observations as the above described manner were taken again after the second spray of insecticides. The results were drawn on the basis of larval reduction per five plants from each plot. The pod damage was also recorded at harvest on the same five plants in each plot and grain yield was recorded on plot basis at harvest.

2.4 Statistical analysis
The percentage reduction in population was calculated using formula given by [7].

$$\text{Population Reduction (\%)} = 100 \left\{ 1 - \frac{Ta \, . \, Cb}{Tb \, . \, Ca} \right\}$$

Where,
Ta = numbers of insects in the treatments after application
Tb = numbers of insects in the treatments before application
Ca = numbers of insects in the control after application
Cb = numbers of insects in the control before application

To determine the most effective and economical treatment, the net profit and benefit-cost ratio was worked out by taking the expenditure on the individual insecticidal treatment and the corresponding yield into account.

3. Results
3.1 Effect of insecticidal treatments on percent reduction of larval population
Efficacy of various bio-pesticides/insecticides applied as foliar spray against *H. armigera* in field was assessed on the basis of percent reduction in larval population at different intervals after application and the results are presented in table 2.

Table 2: Efficacy of different bio-pesticides/insecticides against *H. armigera* (Hub.) on chickpea during *Rabi*, 2015-16 (First spray)

Treatments	Percent reduction in larval population days after treatment									
	First spray					Second spray				
	PTP*	1	3	7	15	PTP	1	3	7	15
Indoxacarb	3.00 (1.99)**	60.26 (50.96)	86.26 (68.64)	80.60 (64.09)	69.87 (56.73)	1.00 (1.41)	68.89 (56.10)	86.67 (69.24)	78.45 (62.39)	69.78 (57.04)
Bacillus thuringiensis	3.33 (2.08)	18.28 (25.29)	28.28 (32.12)	42.20 (40.51)	38.45 (38.29)	2.10 (1.75)	17.69 (24.78)	39.44 (38.89)	61.85 (51.87)	43.61 (41.32)
HaNPV	2.67 (1.91)	18.37 (25.38)	29.77 (32.99)	59.45 (50.46)	38.46 (38.32)	1.70 (1.63)	17.35 (24.60)	42.22 (40.52)	67.04 (54.97)	45.92 (42.65)
NSKE	3.33 (2.08)	18.58 (25.54)	38.53 (38.35)	49.12 (44.50)	30.73 (33.52)	2.04 (1.74)	32.41 (34.62)	52.78 (46.59)	49.44 (44.68)	46.11 (42.77)
Azadirachtin	2.33 (1.82)	18.84 (25.72)	36.51 (37.08)	50.38 (45.22)	28.71 (32.33)	1.66 (1.62)	29.07 (32.58)	50.55 (45.32)	47.22 (43.41)	43.15 (41.02)
Garlic Extract	3.33 (2.08)	18.37 (25.38)	34.65 (36.01)	48.52 (44.15)	27.52 (31.58)	2.41 (1.84)	28.10 (32.01)	49.52 (44.72)	45.95 (42.66)	41.19 (39.92)
Control	2.67 (1.91)	0.00	0.00	0.00	0.00	2.90 (1.97)	0.00	0.00	0.00	0.00
S. Em. ±	0.10	0.93	1.98	1.84	1.97	0.07	1.18	1.92	1.78	2.35
CD (P=0.05)	NS	2.85	6.10	5.68	6.08	0.24	3.65	5.92	5.49	7.24

*PTP Pre treatment population, **Figures in parentheses are angular transformed values

3.1.1 First spray

The incidence of pod borer larvae given in Table 2, reveal that the pre-treatment population varied from 1.82 to 2.08 mean5/plant. All the insecticidal treatments at one, three, seven and fifteen day interval proved significantly superior over control in reducing the larval population of pod borer. One, three, seven and fifteen days after spray, the maximum larval population reduction was 50.96, 68.64, 64.09 and 56.73 per cent during 2015-16, respectively, as recorded for indoxacarb (1.0 ml/lit.), that was significantly superior over the bio-pesticides; whereas, the minimum larval population reduction of 25.29, 32.12 and 40.51 per cent was recorded in the treatment with *Bacillus thuringiensis* (1000 ml/ha) at one, three and seven days after spray, respectively, but at fifteen days after sprays 31.58 per cent reduction was recorded in the treatment with garlic extract (10 ml/l).

3.1.2 Second spray

The incidence of pod borer larvae given in Table 2, reveal that the pre-treatment population varied from 1.41 to 1.97 mean5/plant. All the insecticidal treatments at one, three, seven and fifteen day interval proved significantly superior over control in reducing the larval population of pod borer. One, three, seven and fifteen days after spray, the maximum larval population reduction was 56.10, 69.24, 62.39 and 57.04 per cent during 2015-16, respectively, as recorded for indoxacarb (1.0 ml/lit.), that was significantly superior over the bio-pesticides; whereas, the minimum larval population reduction of 24.60 per cent in HaNPV (250 LE/ha) at one, 38.89 per cent in *Bacillus thuringiensis* (1000 ml/ha) at three and 42.66 and 39.92 per cent was recorded in the treatment with garlic extract (10 ml/l) at seven and fifteen days after spray, respectively. The overall efficacy of insecticides evaluated against *H. armigera* in respect to population reduction over control revealed that indoxacarb (1.0 ml/lit.) was found most effective followed by NSKE (5.0 ml/lit.) and azadirachtin (5.0 ml/lit.). The insecticides HaNPV (250 LE/ha) and *B. thuringiensis* (1000 ml/ha) ranked in middle order of efficacy. The botanical pesticides garlic extract (10 ml/lit.) was found least effective. The descending order of overall efficacy of insecticides at all the intervals was: Indoxacarb > NSKE > Azadirachtin > HaNPV >*B. thuringiensis*> Garlic extract.

3.2 Effect of insecticides on pod borer damage at harvest

The data presented in table 3, revealed that all the insecticides proved significantly better in lowering the pod damage in comparison to control. The treatment of indoxacarb recorded lowest pod damage (12.32%).The treatment of NSKE, azadirachtin, HaNPV, *B. thuringiensis* and garlic extract recorded 18.78, 19.19, 20.04, 20.29 and 22.14 percent pod damage, respectively and were at par to each other and significantly inferior than indoxacarb.

3.3 Impact of insecticidal treatments on yield of chickpea

It is evident from Table 3, that all the insecticides brought higher yield of chickpea as compared to control (8.67 q/ha). The maximum yield was obtained in the treatment of indoxacarb (14.83 q/ha) followed by NSKE (12.22 q/ha). However, the yield obtained from NSKE was comparable to all other treatments but superior to control. The yield obtained with the application of garlic extract, *B. thuringiensis*, HaNPV and azadirachtin ranged from 10.00 to 11.86 q per ha which are comparable to each other in respect to yield produced.

The increase in yield ranged from 1.33 to 6.16 q per ha. The data presented in Table 4, indicated that maximum increase in yield was recorded in indoxacarb (6.16 q/ha) followed by *B. thuringiensis* (3.55 q/ha) and HaNPV (3.19 q/ha). The minimum increase in chickpea yield was found in garlic extract followed by azadirachtin (2.56 q/ha) and NSKE (2.74 q/ha).

Table 3: Effectiveness of different bio-pesticides/insecticides on the pod damage and yield of chickpea during *Rabi*, 2015-16

Treatments	Pod damage (%)	Yield (q ha^{-1})
Indoxacarb	4.69 (12.32)	14.83
Bacillus thuringiensis	12.10 (20.25)	11.23
HaNPV	11.83 (20.04)	11.41
NSKE	10.41 (18.78)	12.22
Azadirachtin	10.84 (19.19)	11.86
Garlic Extract	14.27 (22.14)	10.00
CONTROL	20.95 (27.20)	8.67
S. Em. ±	1.37	0.80
CD (P=0.05)	4.22	2.45

3.4 Economics of different insecticides

The data presented in Table 4, indicated that maximum net profit of Rs. 35910 was calculated in indoxacarb (1.0 ml/lit.) followed by Rs. 18891 per ha in HaNPV and Rs. 18056 per ha in *B. thuringiensis*. The minimum net profit of 6283 per ha was recorded in garlic extract (10 ml/lit.) followed by Rs. 13796 per ha in azadirachtin (5.0 ml/lit.) and Rs. 16269 per ha in NSKE (5.0 ml/lit.). 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.

Table 4: Comparative economics and incremental B:C ratio of different treatments during *Rabi*, 2015-16

Treatments	Formulation	Conc. /Dose	Mean yield (q ha^{-1})	Total increase in yield over control (q ha^{-1})	Income of increased yield (Rs.*)	Total cost of protection (Rs. ha^{-1})**	Increase net profit	Incremental B:C ratio
Indoxacarb	14.5 SC	1.0 ml/l	14.83	6.16	40132	4222	35910	8.51
Bacillus thuringiensis	8 L	1000 ml/ha	11.23	2.56	16678	5072	11606	2.29
HaNPV	-	250 LE/ha	11.41	2.74	17851	1892	15959	8.44
NSKE	-	5.0 ml/l	12.22	3.55	23128	1582	21546	13.62
Azadirachtin	0.3 EC	5.0 ml/l	11.86	3.19	20783	2882	17901	6.21
Garlic Extract	-	10 ml/l	10.00	1.33	8665	2382	6283	2.64
CONTROL	-	-	8.67	-	-	-	-	-

*Price of seed grains of chickpea at current season was Rs. = 6515 per quintal; **Includes cost of insecticides and labour involved in spraying; Number of man days/ha/spray= 3; Total number of man days/ha for two spray= 6 Labour charges @ Rs. 197/man

4. Discussion

Investigations on the bio efficacy of six biopesticides/insecticides against *H. armigera* in chickpea were carried out. Meager work is available on some of the biopesticides against *H. armigera* in chickpea; however, the available literature pertaining to the efficacy of biopesticides/insecticides against *H. armigera* is being compared and discussed.

The overall efficacy of insecticides at different time intervals evaluated against *H. armigera* in respect to population reduction and pod damage over control revealed that indoxacarb (1.0 ml/lit.) was found most effective followed by NSKE (5.0 ml/lit.) and azadirachtin (5.0 ml/lit.). The present results are in agreement with those of [21, 10, 3, 4, and 15] who reported two sprays of indoxacarb at different doses most effective against *H. armigera*.

The insecticides NSKE (5.0 ml/lit.) and azadirachtin (5.0 ml/lit.) stood second in order of efficacy against *H. armigera* in the present investigation. The spray of 5 percent NSKE was reported moderately effective [15] partially corroborate the present findings Onkar, 2006, Chandra, 2010 and Singh, *et al.*, 2012 [17, 3, 20] reported NSKE and azadirachtin as the least effective in reducing larval population of *H. armigera* contradicts the present results.

Two spray of HaNPV (250 LE/ha) and *B. thuringiensis* (1000 ml/ha) ranked in middle order of efficacy with respect to larval population reduction of *H. armigera* in chickpea. [18] reported as most effective and [21] as moderately effective in reducing the larval population of *H. armigera* partially corroborate the present results. Contrary to this [17, 10, 3] reported these biopesticides as least effective against *H. armigera*.

The botanical pesticide garlic extract (10 ml/lit.) proved least effective in the present study. The present findings are not in agreement with that of [15] who reported two sprays of garlic extract as most effective in reduction of pod borer population on chickpea.

4.1 Impact of insecticidal treatments on yield of chickpea

The data revealed that all the insecticides increased the yield of chickpea significantly over the control. The maximum yield (16.49 q/ha) was recorded in the plots treated with indoxacarb (1.0 ml/lit.) followed by NSKE @ 5.0 ml/lit. (12.22 q/ha). However, the yield obtained from NSKE was comparable to all other treatments but superior than control. The yield ranging from 14.22 to 18.50 q/ha in indoxacarb [6, 21, 10, 1, 4, 14] have been reported earlier superior the present finding Verma, *et al.*, 2015 [22] reported higher yield of chickpea with the spray of NSKE as compared to farmer's practice also confirm the present results.

The minimum yield of 10.10 q/ha was recorded in garlic extract (100 ml/lit.) followed by *B. thuringiensis* (1000 ml/ha), HaNPV (250 LE/ha) and azadirachtin (5.0 ml/lit.) as 11.23, 11.41 and 11.86 q/ha, respectively. The present results are not in arrangement with those of Kumar and Prasad, 2002, Mandal, *et al.*, 2003, Jadhav, *et al.*, 2004, Hossain, 2007 and Singh and Yadav, 2007 [12, 13, 9, 8, and 21] as who reported maximum quantity of grain yield of chickpea by *B. thuringiensis*, HaNPV and azadirachtin as compared to other treatments.

Singh, *et al.*, 2012 and Kulhari, *et al.*, 2009 [20, 10] reported minimum yield of chickpea with application of azadirachtin corroborates the present findings.

4.2 Economics of different insecticides

In the present finding the highest incremental cost benefit ratio (B:C ratio 9.52) was computed in indoxacarb followed by B:C ratio 9.50 in NSKE. [1, 3, 15, 19] reported highest cost benefit ratio with the treatment of indoxacarb and moderate B:C ratio with the application NSKE (Moorthy, *et al.*, 2011) [15] corroborate the present findings. Contrary to the present results Singh and Yadav, 2007 and Singh, *et al.*, 2012 [21, 20] reported moderate and lowest B:C ratio with the application indoxacarb.

Minimum B:C ratio of 0.17 was recorded in garlic extract followed by 1.0 in *B. thuringiensis*. The B:C ratio computed by azadirachtin and HaNPV was 3.95 and 4.99, respectively and ranked in middle order.

The present results are in agreement with those of [15, 19] who reported minimum B:C ratio with garlic extract and HaNPV, respectively. Mandal, *et al.*, 2003[13] Reported highest B:C ratio with the application of *B. thuringiensis* contradicts the present results.

5. Conclusion

The overall efficacy of insecticides at different time intervals evaluated against *H. armigera* in respect to population reduction and pod damage over control revealed that indoxacarb (1.0 ml/lit.) was found most effective followed by NSKE (5.0 ml/lit.) and azadirachtin (5.0 ml/lit.). The insecticides NSKE (5.0 ml/lit.) and azadirachtin (5.0 ml/lit.) stood second in order of efficacy against *H. armigera* in present investigation. Whereas in reducing order of effectiveness among bio-pesticides were HaNPV > *B. thuringiensis* > Garlic extract.

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