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Influence of biorational insecticides on the extent of crop losses done by gram pod borer (*Helicoverpa armigera* Hub.)

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Abstract: *A field experiment was conducted at agricultural research farm of B N P G College, Rath, Hamirpur (U.P.) during 2016-17 and 2019-20 cropping season. Chickpea pod borer (H. armigera) was observed as most destructive insect pest of chickpea in Bundelkhand agro climatic region of Uttar Pradesh that inflicted 19%, 17.49% and 10% pod damage, grain damage and grain weight loss, respectively in chickpea. The plots treated with emamectin benzoate was found most effective in reducing pod damage (4.5%), grain damage (3.68%) and grain weight loss (2.70%). The pod damage in emamectin benzoate, spinosad and indoxacarb varied significantly with each other while, NSKE 5% and HaNPV was found at par with each other. Among biorational insecticides Bacillus thuringiensis var. kurstaki was found least effective in reducing the crop losses (pod damage, grain damage and grain weight loss) and produced minimum grain yield. The second most important treatment was spinosad @ 100 g.a.i. /ha which received 6%, 5.76% and 4.94% pod damage, grain damage and grain weight loss, respectively. Among botanicals and microbial insecticides NSKE 5% was most effective in reducing pod damage (12.83%) grain damage (9.58%) grain weight loss (6.52%) and produced 15.84 q/ha grain yield. The biorational insecticides significantly influenced crop loss reduction over control and increase the percentage grain yield over untreated control plot during both the cropping season. The efficacy of various biorational insecticides in reducing the percentage pod damage, grain damage, grain weight loss and increases crop yield over untreated control plots were found in order of emamectin benzoate > spinosad > indoxacarb > NSKE 5 % > HaNPV > B.t. > control.*

Key Words: *Chickpea (Cicer arietinum L.), Chickpea pod borer (Helicoverpa armigera Hub.), Pod and Grain damage.*

1. INTRODUCTION :

Chickpea (*Cicer arietinum* L.) is attacked by more than 25 species of insect pests and of them gram pod borer (*Helicoverpa armigera* Hub.) and gram cut worm, *Agrotis ipsilon* (Hub) are major importance of national significance (Sharma *et al*., 2020). Chickpea pod borer is a polyphagous insect pest of pulses and widely distributed in the world. In India, it has been observed to feed on 181 cultivated and uncultivated species belonging to 45 families. The pod damage due to chickpea pod borer on chickpea could increase up to 100% in India (Washeem *et al.*, 2019). Chickpea pod borer (*Helicoverpa armigera* Hub.) is one of the major pests of chickpea. The pest starts its activity from vegetative stage of the crop and become severe at pod formation and maturity stage of the crop. A single larva of gram pod borer can damage up to 40 pods of gram in its life span. It feeds on tenders shoots, buds and pods. It makes holes on pods and inserts its half body in to pod and eat the developing grains. In India, the extent of crop losses due to *Helicoverpa armigera* Hub. in chickpea is up to 27.9% in North West Plan Zone, 13.2% in North East Plane, 24.3% in Central Zone and 36.4% in South Zone. In Uttar Pradesh alone 15.3% of chickpea crop worth rupees 462.5 million is lost annually due to infestation of chickpea pod borer, 17.2% in Karnataka and 28.5% in Delhi (Chaturvedi *et al*., 2019).

Biorational insecticides composed of natural product derived from nature *i.e.* animals plants, microbes and minerals. It has low environmental risk, specificity and safety to non- target organism, low risk of resistant development and lower environmental resistant. Use of biorational insecticides against insect pest is a recent approaches, which has drawn special attention to the entomologist all over the world. The pest management strategies involving the use of non-toxic and selective insecticides, that preserve ecological health and minimize negative effects on beneficial insect. The utilization of botanicals, microbial and novel insecticides which have specific mode of action, highly selective in nature and have minimum effects on bio diversity, environment and human health could be termed as biorational strategies of pest management. Insecticide application is the easiest before the farmers who are eager to apply anything and everything which can increase profit. Though good selective insecticides having less or nominal environmental impacts are available in India. Few farmers are aware of that new lot of molecules mainly due to lack of communication and in such situation the insecticide dealers and retailers, who are only concerned about their sale figures, play role as the most trusted advisors to the farmers. In today's world farmers of our country have a chance to supply its produce to international market with the advent of globalization of market; one cannot ignore the stringent regulatory measures regarding pesticides content of food material monitored by state or international agencies. Rejection of food or seed consignment due to learn non-chemical pest management methods to reduce pesticides load in their commodity to make its acceptable in international market. Implementation of integrated pest management (IPM) and biorational pest management approaches are the only way to make that possible in the future.

2. Materials and Methods :

A field experiment was conducted at agricultural research farm of B N P G College, Rath, Hamirpur (U.P.) during 2016-17 and 2019-20 cropping season. In this set of experiment examined the efficacy of biorational insecticides (Indoxacarb 14.5 SC, Emamectin benzoate 5 SG, Spinosad 45 SC, HaNPV 250 LE/ha, *Bacillus thuringiensis*(*B.t.*) 1.40 kg/ha and Neem Seed kernel Extract (NSKE) 5%) in respect of crop losses *i.e.* pod damage and grain damage (by number and by weight) inflicted by *H. armigera* in chickpea. The experiment was laid out by following the randomized complete block design (RCBD) with three replications. All the biorational insecticides were sprayed thrice at 10 days intervals from the bud initiation and flowering stage of chickpea. At the time of harvesting 500 pods were collected randomly from each plot. All the pods picked up from each plot were pooled together and mixed thoroughly. A representative sample of 200 pods/plot was examined in the laboratory. The pod damage by *Helicoverpa armigera* larvae marked by the presence of big irregular circular holes on the pods and with few/all grains fed except some testa intact with placenta. On the basis of nature of damage of *Helicoverpa armigera* larvae the damaged pods were counted.

All the 200 pods were opened in the laboratory to record number of healthy pods and grains and damaged pods and grains by the chickpea pod borer (*Helicoverpa armigera*). The weight of healthy grains and damaged grains were recorded by using electronic balance. The data were subjected to the following formula to calculate per cent pod damage, grain damage and grain weight loss by *Helicoverpa armigera* larvae are given below.

Pod damage (%) = $\frac{\text{NPD}}{\text{TNPE}} \times 100$

Where,

NPD = Number of pods damaged by *H. armigera* in each sample
TNPE = Total number of pods examined

Grain damage (%) = $\frac{\text{NSD}}{\text{TNSE}} \times 100$

Where,

NSD= Number of seeds damaged by *H. armigera* in each sample TNSE=Total number of seeds examined

Grain weight loss (%) = $\frac{\text{CWDG}-\text{AWDG}}{\text{CWTPG}} \times 100$

Where,

CWDG = Calculated weight (g) of damaged grain (equivalent to healthy grain)

AWDG = Actual weight (g) of damage grain by *H. armigera*

CWTPG = Calculated weight (g) of total potential grains (healthy and damage)

The percentage data were used for analysis of variance after transformation by using arc sin transformation as suggested by Gomez and Gomez (1976). The analysis of variance table was prepared by following the methods of

Randomized Complete Block Design (RCBD). The critical difference was calculated to ascertain the significance of differences among the various biorational insecticides on per cent pod and grain damage (by number and by weight).

3. Results and Discussion :

Chickpea (*Cicer arietinum* L.) is exposed to a wide range of insect pests, of which pod borer, *Helicoverpa armigera* (Hub.) is most common and critical challenge for chickpea productivity in India. In case of outbreaks, yield losses caused by chickpea pod borer range from 10 to 90% depending upon the insect population and susceptibility of genotype. In India *H. armigera* caused significant yield losses (85%) in chickpea (Mahmood, 2020). Management of *H. armigera* is of prime importance to achieve sustainable chickpea yields by adopting sustainable management approaches, which includes varietal resistant, adoption of recommended cultural practices and cropping system, use of botanicals and microbial insecticides and ecofriendly selective insecticides. The chickpea pod borer was observed as major insect pest of chickpea in Bundelkhand agro climatic zone during 2016-17 and 2019-20 cropping seasons.

3.1. Pod damage (%) by *H. armigera* in chickpea

The efficacy of biorational insecticides *i.e.* indoxacarb 14.5 SC @ 100 g.a.i./ha emamectin benzoate 5 SG @ 11 g.a.i./ha, spinosad 45 SC @ 100 g.a.i. /ha, HaNPV @ 250 LE/ha, *B.t*. var. *kurstaki* @ 1.4 kg/ha, NSKE 5% were tested on pod damage by chickpea pod borer (*H. armigera*) in chickpea and observed that emamectin benzoate was the most effective in reducing the pod damage (5.5% and 3.5%). It was followed by spinosad (7.00% and 5.00%) and indoxacarb (10.17 % and 8.17 %) during 2016-17 and 2019-20 cropping seasons (Table-1). Among microbial and botanical insecticides NSKE 5 % was found best treatment with the minimum pod damage 13.83% and 11.83% and maximum pod damage reduction over control 39.42% and 22.02% respectively during 2016-17 and 2019-20 cropping seasons. The efficacy of *Bacillus thuringiensis* var. *kurstaki* was observed minimum in pod damage and pod damage reduction over control which received 16.33 and 14.17% pod damage and 28.47% and 6.59% pod damage reduction over control, respectively during both the cropping season. The similar efficacy of novel insecticides, microbial and botanical insecticides on chickpea pod damage by *H. armigera* reported earlier by Chitralekha *et al*. (2018) who reported 20.23% pod damage in emamectin benzoate treated plots. Babar *et al.*(2012) reported per cent pod damage and per cent reduction in pod damage over control was maximum 0.01% and 87.27% in emamectin benzoate it was followed by 7.38% and 86.82% in indoxacarb and 8.78% and 84.32% in spinosad treated plots. In present experiment emamectin benzoate was found most effective followed by spinosad, indoxacarb, NSKE 5 %, HaNPV and *B.t. kurstaki* for the management of pod damage by *H. armigera* in chickpea crop. Similar efficacy of emamectin benzoate in reduction of pod damage was made earlier by Singh *et al*.(2015), Babar *et al*.(2012), Yadav *et al*.(2019) and Chitralekha *et al*. (2018) who observed emamectin benzoate was most effective for the management of gram pod borer, *Helicoverpa armigera* in chickpea crop.

3.2. Grain damage (%) by *H. armigera* in chickpea

The biorationals insecticides significantly influenced the grain damage in chickpea by chickpea pod borer as compared to untreated control plots which had maximum grain damage (18.49 and 16.49%) during both the cropping season. While, the grain damage among various treated plots varied from 4.68% to 14.55% and 2.68% to 12.22% respectively during 2016-17 and 2019-20 cropping season(Table-2). The chickpea crop treated with emamectin benzoate @ 11 g.a.i./ha was found best with minimum grain damage (4.68% and 2.68%) and maximum grain damage reduction over control (74.69% and 83.75%) during both the cropping season. The average grain damage was observed minimum in emamectin benzoate (3.68%) followed by spinosad (5.76%) varied significantly with each other and other biorational insecticides treated plots. The per cent grain damage in indoxacarb, NSKE 5%, HaNPV and *B.t*. was found at par with each other and varied from 7.89% to 13.39% but varied significantly from untreated control plots which received maximum (17.49%) grain damage. Akanksha and Singh (2020) reported that combination of botanicals, microbial and novel insecticides was found to be significantly superior over the untreated control for the management of crop losses in chickpea by chickpea pod borer (*H. armigera*).

The percent reduction in grain damage over untreated control was maximum (74.69% and 83.75%) and minimum (21.31% and 25.89%) was observed in emamectin benzoate and *B.t. kurstaki* treated plots. The per cent grain damage reduction over control in various treated plots if arranged in ascending order would be as *B.t. kurstaki* (23.60%) > HaNPV (27.71%) >NSKE 5 % (45.38%) > indoxacarb (55.07%) > spinosad (67.29%) > emamectin benzoate (79.22%). Babar *et al*. (2012) observed similar pattern on reduction of crop losses by *H. armigera* and observed emamectin benzoate was most effective followed by indoxacarb and spinosad.

3.3. Grain weight loss (%) by *H. armigera* in chickpea

The minimum grain damage by weight was observed from the plots treated with emamectin benzoate 5 SG @ 11 g.a.i./ha (3.7% and 1.7%) while, the maximum grain damage (11.68% and 10.12%) was observed from untreated control plots. The grain damage varied from 3.7% to 9.21% and 1.7% to 7.88% in various treated plots during both the cropping seasons(Table-3). Biorational insecticides significantly reduced grain weight loss by *H. armigera* as compared to untreated control plots. The efficacy of spinosad, indoxacarb and NSKE 5% and NSKE 5% and HaNPV was found statistically at par with each other in reducing the grain weight loss of chickpea. The NSKE 5% was observed to be equally effective as in spinosad and indoxacarb treated plots. The similar report made by Sai *et al*.(2021) observed that efficacy of microbial and botanical insecticides *i.e.* NSKE, neem oil, *B.t.*, HaNPV and *Beauvaria bassiana* alone or in combination insecticides was statistically at par with chemical insecticides for the management of *Helicoverpa armigera* in chickpea.

The percentage grain damage (by weight) reduction over untreated control was observed maximum (68.32 and 83.20%) in emamectin benzoate and minimum (21.15 and 22.13%) was observed from *B.t.* var. *kurstaki* treated plots. These mean values if arranged in descending order would be as emamectin benzoate (75.76%)> spinosad (55.11%)> indoxacarb (50.03%) > NSKE 5 % (40.54%) > HaNPV (30.86%) > *B.t. kurstaki* (21.64%).

3.4. Influence of grain yield of chickpea

The maximum (19.35 and 20.85 q/ha) grain yield chickpea was observed in emamectin benzoate 5 SG @ 11 g.a.i. /ha and produced 55.42% and 64.82% more grain yield over untreated control plots which produced minimum (12.45 and 12.65 q/ha) grain yield during 2016-17 and 2019-20 cropping season(Table-4). The biorationals insecticides had significant influence to increase the grain yield of chickpea except emamectin benzoate and spinosad and indoxacarb, NSKE 5%, HaNPV and *B.t. kurstaki* treated plots which did not varied significantly with each other in their respective groups. The chickpea treated with *Bacillus thuringiensis* var. *kurstaki* was found least effective in increasing the grain yield and produced 14.90 and 16.07 q/ha during both the cropping seasons. Earlier report made by Vikrant *et al.* (2019) who observed significantly higher seed yield from spinosad 45 EC @ 166 ml./ha (2550 and 2680 kg/ha).Yadav *et al*.(2019) observed that emamectin benzoate 5 SG @ 11 g.a.i./ha treated plots gave maximum grain yield (18.00 q/ha) and was found at par with flubendiamide and rynaxypyr.

The per cent grain yield increase over control was observed maximum (55.42% and 64.82%) in plots treated with emamectin benzoate it was followed by spinosad (41.77% and 50.36%), indoxacarb (29.32% and 37.15%), NSKE 5% (22.49% and 29.88%), HaNPV (20.48% and 27.75%) and *B.t.* var. *kurstaki* (19.68% and 27.04%) during 2016-17 and 2019-20 cropping season(Table-4). Similar findings on efficacy of biorationals insecticides on grain yield of chickpea was made earlier by Babar (2012) reported per cent increase in grain yield over control was maximum in emamectin benzoate (88.46%) followed by spinosad (75.00%) and indoxacarb (71.15%) treated plots. Over all emamectin was found most effective followed by spinosad, indoxacarb, NSKE 5%, HaNPV and *B.t. kurstaki* for the management of crop losses in chickpea by pod borer (*Helicoverpa armigera*). While, Mihreti (2020) reported increase grain yield/ ha of chickpea in indoxacarb (48.11%) and spinosad (43.37 %) gave maximum yield.

4. Conclusion :

The biorational insecticides significantly influenced pod damage, grain damage, (in number and by weight) by *H. armigera* and increases grain yield as compared to untreated control plot. Emamectin benzoate @ 11 g.a.i./ha was found most effective in reducing pod damage (4.5%), grain damage (3.68 %), grain weight loss (2.70%) and increasing grain yield (20.10q/ha). While, untreated control plots had maximum pod damage (19.00%) grain damage (17.49%), grain weight loss (10.90%) and produce minimum (12.55 q/ha) grain yield of chickpea.

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Conflict of interest
The authors declare no conflict of interest

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Table-1. Influence of biorational insecticides on pod damage (%) by chickpea pod borer (*Helicoverpa armigera*) in chickpea

S.No.	Treatment	Doses	Pod damage (%)			Pod damage reduction over Control (%)		
			2016-17	2019-20	Average	2016-17	2019-20	Average
1	Indoxacarb 14.5 SC (T_1)	100 g a.i./ha	10.17 (18.63)	8.17 (16.64)	9.17 (17.64)	55.45	46.14	50.80
2	Emamectin benzoate 5 SG (T_2)	11 g a.i./ha	5.50 (13.56)	3.50 (10.47)	4.50 (12.02)	75.91	76.93	76.42
3	Spinosad 45 SC (T_3)	100 g a.i./ha	7.00 (15.34)	5.00 (12.92)	6.00 (14.13)	69.34	67.04	68.19
4	HaNPV (T_4)	250 LE/ha	14.33 (22.22)	12.33 (20.53)	13.33 (21.38)	37.23	18.72	27.98
5	*Bt. kurstaki* (T_5)	1.4 kg/ha	16.33 (23.81)	14.17 (22.14)	15.25 (22.98)	28.47	6.59	17.53
6	NSKE 5 % (T_6)	5% grinded	13.83 (21.81)	11.83 (20.09)	12.83 (20.95)	39.42	22.02	30.72
7	Control (T_7)	-	22.83 (28.52)	15.17 (22.98)	19.00 (25.75)	-	-	-
CD (P=0.05)			2.69	2.02	1.53			

The figures in parentheses are arc sin transformed values

Table-2. Influence of biorational insecticides on grain damage (%) by chickpea pod borer (*Helicoverpa armigera*) in chickpea

S.No.	Treatment	Doses	Grain damage (%)			Grain damage reduction over Control (%)		
			2016-17	2019-20	Average	2016-17	2019-20	Average
1	Indoxacarb 14.5 SC (T_1)	100 g a.i./ha	8.89 (17.36)	6.89 (17.05)	7.89 (17.21)	51.91	58.22	55.07
2	Emamectin benzoate 5 SG (T_2)	11 g a.i./ha	4.68 (12.52)	2.68 (9.46)	3.68 (10.99)	74.69	83.75	79.22
3	Spinosad 45 SC (T_3)	100 g a.i./ha	6.76 (15.12)	4.76 (12.66)	5.76 (13.89)	63.44	71.13	67.29
4	HaNPV (T_4)	250 LE/ha	13.66 (21.72)	11.66 (20.00)	12.66 (20.86)	26.12	29.29	27.71
5	*Bt. kurstaki* (T_5)	1.4 kg/ha	14.55 (22.38)	12.22 (20.44)	13.39 (21.41)	21.31	25.89	23.60
6	NSKE 5 % (T_6)	5% grinded	10.58 (19.00)	8.58 (18.34)	9.58 (18.67)	42.78	47.97	45.38
7	Control (T_7)	-	18.49 (25.48)	16.49 (23.97)	17.49 (24.73)	-	-	-
CD (P=0.05)			3.36	2.67	2.06			

The figures in parentheses are arc sin transformed values

Table-3. Influence of biorational insecticides on grain weight loss (%) by chickpea pod borer (*Helicoverpa armigera*) in chickpea

S.No.	Treatment	Doses	Grain weight loss (%)			Grain weight loss reduction over Control (%)		
			2016-17	2019-20	Average	2016-17	2019-20	Average
1	Indoxacarb 14.5 SC (T_1)	100 g a.i./ha	6.49 (14.77)	4.49 (12.25)	5.49 (13.51)	44.43	55.63	50.03
2	Emamectin benzoate 5 SG (T_2)	11 g a.i./ha	3.70 (11.09)	1.70 (7.49)	2.70 (9.29)	68.32	83.20	75.76
3	Spinosad 45 SC (T_3)	100 g a.i./ha	5.94 (14.06)	3.94 (11.39)	4.94 (12.73)	49.14	61.07	55.11
4	HaNPV (T_4)	250 LE/ha	8.57 (17.05)	6.57 (14.89)	7.57 (15.97)	26.63	35.08	30.86
5	*Bt. kurstaki* (T_5)	1.4 kg/ha	9.21 (17.66)	7.88 (16.32)	8.55 (16.99)	21.15	22.13	21.64
6	NSKE 5 % (T_6)	5% grinded	7.52 (15.89)	5.52 (13.56)	6.52 (14.73)	35.62	45.45	40.54
7	Control (T_7)	-	11.68 (20.96)	10.12 (19.15)	10.90 (20.06)	-	-	-
CD (P=0.05)			2.21	2.79	2.04			

The figures in parentheses are arc sin transformed value

Table-4. Influence of biorational insecticides on grain yield of chickpea.

S.No.	**Treatment**	**Doses**	**Grain yield (q/ha)**			**Grain yield increase over Control (%)**		
			2016-17	**2019-20**	**Average**	**2016-17**	**2019-20**	**Average**
1	Indoxacarb 14.5 SC (T_1)	100 g a.i./ha	16.10	17.35	16.73	29.32	37.15	33.24
2	Emamectin benzoate 5 SG (T_2)	11 g a.i./ha	19.35	20.85	20.10	55.42	64.82	60.12
3	Spinosad 45 SC (T_3)	100 g a.i./ha	17.65	19.02	18.34	41.77	50.36	46.07
4	HaNPV (T_4)	250 LE/ha	15.00	16.16	15.58	20.48	27.75	24.12
5	*Bt. Kurstaki* (T_5)	1.4 kg/ha	14.90	16.07	15.48	19.68	27.04	23.36
6	NSKE 5 % (T_6)	5% grinded	15.25	16.43	15.84	22.49	29.88	26.19
7	Control (T_7)	-	12.45	12.65	12.55	-	-	-
CD (P=0.05)			2.08	2.58	1.51			