A-5977
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RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume Issue : ()

Efficacy of New Generation Insecticides in Comparison with Biopesticides and their Economics against Chickpea Pod Borer (*Helicoverpa armigera* Hub.)

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ABSTRACT

Background: Chickpea (*Cicer arietinum* L.) is one of the most important pulses. *Helicoverpa armigera* [Hubner] is the most devastating chickpea pest responsible for substantial yield loss. Chickpea crop is damaged by a large number of insect species, both under field conditions and in storage. Productivity losses by gram pod borer range from 20 to 90 per cent depending upon the severity of insect attack. Among the biotic factors responsible for low yield the, damage due to insect pests is the major limiting factor. Keeping the above facts in view, the present investigation was planned and carried out to establish a new generation molecules are comparatively safer to natural enemies, honeybees and other pollinators than old generation molecules play an important role in reducing the pest populations.

Methods: Field experiment was during *Rabi* season 2018-19 on chickpea in district Rewa. The field was prepared following the recommended package of practices. The incidence of *H. armigera* was observed from five randomly selected plants from four middle rows of each plot at weekly interval. The spray of insecticides was applied as soon as the pest incidence is noted. The first spray was done at 50% flowering stage of the crop and repeated after 15 days. Pre-treatment observation on pest population was undertaken one day before the application of the first spray by direct counting of *H. armigera* larvae per five randomly pre-selected plants in each plot. Similar procedure was followed for post-treatment observation which was recorded at 1, 3, 7, 10, 15 days after both the spray operations.

Result: The experiment was laid out in randomized block design with 09 treatments (Chlorantraniliprole 18.5 SC @ 37 g a.i./ha, Fipronil 5% SC @ 50 g a.i./ha, Indoxacarb 15.8 EC @ 79 g a.i./ha, Spinosad 45 SC @ 90 g a.i./ha, Novaluron 10 EC @ 100 g a.i./ ha, Emamectine benzoate 5 SG @ 10 g a.i./ha, Neem oil 0.15% , Bt.K. 3.5% and untreated check. First spray of insecticides over all mean analysis indicated that all the insecticidal treatments were significantly effective in reducing the larval population of *Helicoverpa armigera* Hub. as compared to untreated plots (1.56 larvae/plant) in the first and second spray (0.92 larva/plant) of insecticides over all mean larval population Indoxacarb 15.8 EC @ 79 g a.i./ha was effective in controlling the incidence of gram pod borer due to the first spray (0.59 larva/plant) and also the second spray (0.27 larva/plant) among all treatments. Resulting in the seed yield 1989.00 kg/ha with the highest cost: benefit ratio of 1:12.3, which was followed by the treatment of Emamectin benzoate 5 SG @ 10 g a.i./ha with cost benefit ratio of 1:10.83.

Key words: Biopesticides, Chickpea, *Helicoverpa armigera,* Insecticides.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops cultivated in 89.28 Lakh hectares with a production of 83.65 Lakh tonnes in Madhya Pradesh comprising the Rewa Division with, 0.64 Lakh ha area producing 0.64 lakh metric tonnes and productivity of 999 kg/ha (Anonymous 2015). *Helicoverpa armigera* [Hubner] is the most devastating chickpea pest responsible for substantial yield loss. Productivity losses by gram pod borer range from 20 to 90 percent depending upon the severity of insect attack (Akhtar *et al*., 2022). Chickpea crop is damaged by a large number of insect species, both under field conditions and in storage (Clement *et al*., 2000). Among them *Helicoverpa armigera* Hub. is known to be the key pest due to high reproduction rates and short life cycle (Kumar and Singh, 2014). Pod borer, *H. armigera* is a noxious and polyphagous pest of global importance ravaging more than 200 cultivated and wild hosts (Yadav *et al*., 2011) which is the major factor for low yield of chickpea damaging the crop from vegetative to podding stage (Dhingra *et al*., 2003). Among the biotic factors responsible for low yield

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How to cite this article: Tripathi, V., Kumar, A., Singh, S., Singh, R., Baghel, K.S. and Pandey, A.K. (2022). Efficacy of New Generation Insecticides in Comparison with Biopesticides and their Economics against Chickpea Pod Borer (*Helicoverpa armigera* Hub.). Indian Journal of Agricultural Research. DOI: 10.18805/IJARe.A-5977. ():

Submitted: 24-02-2022 **Accepted:** 22-04-2022 **Online:** 16-05-2022

the, damage due to insect pests is the major limiting factor. Keeping the above facts in view, the present investigation was planned and carried out to establish a new generation molecules are comparatively safer to natural enemies, honeybees and other pollinators than old generation molecules play an important role in reducing the pest populations.

MATERIALS AND METHODS

A field experiment was conducted at the Entomology Instructional Farm, JNKVV College of Agriculture Rewa during *Rabi* season 2018-19 on chickpea variety JG-16 in District Rewa. The field was prepared following the recommended package of practices with plant spacing of 30 × 10 cm with plot size 3 m × 2.7 m . The incidence of *H. armigera* was observed from five randomly selected plants from four middle rows of each plot at weekly interval. The spray of insecticides was applied as soon as the pest incidence is noted. The first spray was done by knapsac sprayer at 50% flowering stage of the crop and repeated after 15 days. Pre-treatment observation on pest population was undertaken one day before the application of the first spray by direct counting of *H. armigera* larvae per five randomly pre-selected plants in each plot. Similar procedure was followed for post-treatment observation which was recorded at 1, 3, 7, 10, 15 days after both the spray operations. The data were analyzed as per the experimental design to test the significant of the treatment by suitably transforming the larval population to square root ($\sqrt{x+0.5}$) for the statistical analysis. Pod damage and grain yield in different treatments recorded per plot.

Pod damage

Per cent pod damage was calculated under different treatments as per formula:

Per cent pod damage =

$$\frac{\text{Total damage pod}}{\text{Total number of pods}} \times 100$$

Benefit cost ratio

Gross return was calculated by multiplying total yield with the market price of the produce. Cost of cultivation and cost of treatment imposition was deducted from the gross returns, to find out net returns and cost benefit ratio by following formula:

$$\text{B:C} = \frac{\text{Gross returns}}{\text{Total cost of cultivation}} \times 100$$

Where, B:C = Benefit cost ratio.

Grain yield

Yield was calculated under different treatments as per formula:

$$\text{Yield / ha} = \frac{\text{Factor} \times \text{Grain yield}}{\text{plot}}$$

RESULTS AND DISCUSSION

Pod borer (*H. armigera*) incidence

All insecticides were found very effective and significantly superior over untreated control. However, T_3 and T_6 (indoxacarb and emamectine benzoate) were the best among them (Table 1). Over all mean analysis indicated that all the insecticidal treatments were significantly effective in reducing the larval population of *H. armigera* as compared to untreated plots (1.56 larvae/plant). Indoxacarb was the most effective in controlling the incidence of gram pod borer (0.59 larva/plant) among all treatments. Whereas efficacy of rest of the treatments were in the order of Emamectin benzoate @ 10 g a.i./ha (0.75 larva/plant), chlorantraniliprole @ 37 g a.i./ha (0.79 larva/plant), spinosad @ 90 g a.i./ha (0.80 larvae/plant), Fipronil @ 50 g a.i./ha (0.83 larva/plant), Bt.K. @ 35 g a.i./ha (0.89 larvae/plant), novalurone @ 100 g a.i./ha (0.95 larvae/plant) and neem oil @ 4.5 g a.i./ha (0.97 larvae/plant). In chickpea two sprays of Indoxacarb 14.5 SC @ 72 gram ai/ha first at 50% flowering and pod formation stage and second spray after 15 days applied were effective to reduced the pod borer population (Kumar *et al*., 2013).

In case of second spray of insecticides also, the indoxacarb was superior over th rest of the treatments and all insecticides were found to be very effective and significantly superior over control (Table 2). Over all mean analysis indicated that all the insecticidal treatments were significantly effective in reducing the larval population of *H. armigera* as compared to untreated plots (0.92 larva/plant) (Table 5). Indoxacarb was the most effective in controlling the incidence of gram pod borer (0.27 larva/plant) among all treatments, while the efficacy of rest of the treatments were in the order of Emamectin benzoate (0.44 larva/plant), chlorantraniliprole (0.47 larva/plant), spinosad (0.49 larva/ plant), Fipronil (0.50 larva/plant), Bt.K. (0.52 larva/plant), novalurone (0.56 larva/plant) and neem oil (0.57 larva/ plant). In chickpea two sprays of Indoxacarb 14.5 SC @ 72 gram ai/ha first at 50% flowering and pod formation stage and second spray after 15 days applied were effective to reduced the pod borer population (Kumar et al., 2013).The highest grain yield was recorded with indoxacarb (1989.00 kg/ha) while the lowest grain yield was with neem oil (1414.00 kg/ ha) which is accordance with the report of Gowda et. al. (2007) indicating that indoxacarb 14.5 SC @ 25 g a.i./ha. was found to be highly effective as compared to chlorpyriphos 20 EC @ 250 g a.i./ ha irrespective of spray equipment and offering maximum protection against pods which resulted in increased grain yield. Yogeeswarudu and Venkata Krishna (2014) also reported that indoxacarb 14.5 SC @ 0.5 ml/l was found the best treatment with the lowest population of *H. armigera*, (recording 1.53, 0.46 and 0.73 larva/five plants) and 89.45, 97.01and 95.83 percent reduction over control at 3 , 5 and 7 days after first spraying, respectively and (0.00, 0.26 and 0.00 larva/five plants) with

Table 1: Efficacy of insecticides treatment against chickpea pod borer first spray during *Rabi* 2018-19.

Treatments	Name of insecticides	Doses in g a.i. /ha	Trade name	One day before	Pod borer per plants First spray after treatment					All over mean
					1 DAT	3 DAT	7 DAT	10DAT	15 DAT	
T_1	Chlorantraniliprole	37	Coragen	1.73	1.20	0.73	0.63	0.65	0.75	0.79
	18.5 SC			(1.65)	(1.48)	(1.31)	(1.27)	(1.28)	(1.32)	(1.33)
T_2	Fipronil	50	Ruler	1.76	1.13	0.86	0.66	0.80	0.73	0.83
	5% SC		(KR)	(1.66)	(1.45)	(1.36)	(1.29)	(1.34)	(1.31)	(1.35)
T_3	Indoxacarb	79	Avaunt	1.76	0.90	0.58	0.46	0.50	0.53	0.59
	15.8 EC			(1.66)	(1.37)	(1.25)	(1.20)	(1.22)	(1.23)	(1.25)
T_4	Spinosad	90	ONEUP	1.73	1.18	0.76	0.66	0.74	0.70	0.80
	45 SC			(1.65)	(1.47)	(1.32)	(1.29)	(1.31)	(1.30)	(1.33)
T_5	Novaluron	100	Rimon	1.70	1.50	1.00	0.70	0.66	0.90	0.95
	10 EC			(1.64)	(1.58)	(1.41)	(1.30)	(1.28)	(1.37)	(1.38)
T_6	Emamectin benzoate	10	Proclaim	1.76	1.00	0.80	0.60	0.65	0.70	0.75
	5 SG			(1.66)	(1.41)	(1.34)	(1.26)	(1.28)	(1.30)	(1.31)
T_7	Neem oil	4.5	AZADIR	1.76	1.50	1.00	0.73	0.63	1.00	0.97
	0.15%		ACTINE	(1.66)	(1.58)	(1.41)	(1.31)	(1.27)	(1.41)	(1.39)
T_8	Bt.K.8L	35	ABTEC	1.70	1.43	0.95	0.68	0.60	0.80	0.89
	3.5% ES			(1.64)	(1.55)	(1.39)	(1.29)	(1.26)	(1.34)	(1.36)
T_9	Untreated	-	-	1.80	1.93	1.71	1.53	1.35	1.30	1.56
	check			(1.67)	(1.71)	(1.64)	(1.59)	(1.53)	(1.51)	(1.59)
		SEm±		0.032	0.045	0.029	0.016	0.033	0.033	
		CD at 5%		N/S	0.136	0.088	0.048	0.099	0.1	

* Figure in parenthesis are $\sqrt{x+0.5}$ values; DAT = Day after treatment, NS = Non significant.

Table 2: Efficacy of insecticides treatment against chickpea pod borer second spray during *Rabi* 2018-19.

Treatments	Name of insecticides	Doses in g a.i. /ha	Trade name	Pod borer per plants After second spray treatment					Over all mean
				1 DAT	3 DAT	7 DAT	10DAT	15 DAT	
T_1	Chlorantraniliprole	37	Coragen	0.63	0.48	0.38	0.33	0.53	0.47
	18.5 SC			(1.27)	(1.21)	(1.17)	(1.15)	(1.23)	(1.20)
T_2	Fipronil	50	Ruler	0.66	0.51	0.41	0.36	0.56	0.50
	5% SC		(KR)	(1.29)	(1.23)	(1.19)	(1.16)	(1.25)	(1.22)
T_3	Indoxacarb	79	Avaunt	0.43	0.28	0.18	0.20	0.26	0.27
	15.8 EC			(1.19)	(1.13)	(1.08)	(1.09)	(1.12)	(1.12)
T_4	Spinosad	90	ONEUP	0.66	0.51	0.39	0.36	0.55	0.49
	45 SC			(1.29)	(1.23)	(1.17)	(1.16)	(1.24)	(1.21)
T_5	Novaluron	100	Rimon	0.73	0.55	0.48	0.49	0.55	0.56
	10 EC			(1.31)	(1.24)	(1.21)	(1.22)	(1.24)	(1.24)
T_6	Emamectin benzoate	10	Proclaim	0.60	0.45	0.35	0.30	0.50	0.44
	5 SG			(1.26)	(1.20)	(1.16)	(1.14)	(1.22)	(1.19)
T_7	Neem oil	4.5	AZADIR	0.73	0.58	0.48	0.43	0.63	0.57
	0.15%		ACTINE	(1.31)	(1.25)	(1.21)	(1.19)	(1.27)	(1.24)
T_8	Bt.K.8L	35	ABTEC	0.68	0.53	0.43	0.38	0.58	0.52
	3.5% ES			(1.29)	(1.23)	(1.19)	(1.17)	(1.25)	(1.22)
T_9	Untreated	-		1.15	1.00	0.9	0.80	0.75	0.92
	check			(1.46)	(1.41)	(1.37)	(1.34)	(1.32)	(1.38)
		SEm±		0.024	0.018	0.015	0.015	0.012	
		CD at 5%		0.072	0.055	0.045	0.045	0.038	

*Figure in parenthesis are $\sqrt{x+0.5}$ values; DAT = Day after treatment, NS = Non significant.

100, 98.74 and 100 percent reduction over control, at 3, 5 and 7 after second spray, respectively. The effectiveness of Spinosad, Indoxacarb and Fipronil insecticides treatment was in reducing larval population, pod damage and recorded higher good yield in comparison to untreated plot (Nitharwal *et al*., 2017).

Effect on grain yield and pod damage

The result on the yield per plot (Table 3 and Table 4) shows a significant deference among the treatments. The highest yield of 1989.00 kg/ha, was recorded in the plot treated with Indoxacarb as against in the untreated control the yield of 1240.00 kg/ha.

The order of yield as influenced by insecticide was found in descending order Indoxacarb (1989.00 Kg/ha.) > Emamectin benzoate (1850.00 Kg/ha) > Chlorantraniliprole (1780.00 Kg/ha.) > Spinosad (1730.00 kg/ha) > Fipronil (1690.00 kg/ha) > Bt.K. (1642.00 kg/ha) > Novaluron (1530.00 kg/ha) > Neem oil (1414.00 kg/ha). Ghugal *et al* .(2013) reported that spinosad 45 SC @ 73 g a.i./ha was the most effective in controlling pod borer and resulting in the lowest pod damage (4.11%) and highest grain yield

Table 3: Effect of insecticide on grain yield of chickpea, *Rabi* 2018-19.

Treatment	Name of treatments	Doses in g a.i./ha	Yield (kg/plot)	Average yield (kg/ha)	Additional yield over control (kg/ha)	% Yield increased
T_1	Chlorantraniliprole 18.5 SC	37	1.44	1780.00	540.00	43.54
T_2	Fipronil 5% SC	50	1.36	1690.00	450.00	36.29
T_3	Indoxacarb 15.8 EC	79	1.61	1989.00	749.00	60.40
T_4	Spinosad 45 SC	90	1.40	1730.00	490.00	39.51
T_5	Novaluron 10 EC	100	1.23	1530.00	290.00	23.38
T_6	Emamectin benzoate 5 SG	10	1.49	1850.00	610.00	49.19
T_7	Neem oil 0.15%	4.5	1.14	1414.00	174.00	14.03
T_8	Bt.K.8L 3.5% ES	35	1.33	1642.00	402.00	32.41
T_9	Untreated check	37	1.00	1240.00	-	-
	SEm±	-	0.013	-	-	-
	CD at 5%	-	0.038	-	-	-

Table 4: Pod damage and grain yield at harvest under different treatments.

Treatments	Name of insecticides	Doses in g a.i. /ha	Pod damage (%)	Yield (q/ha)
T_1	Chlorantraniliprole 18.5 SC	37	10.25(18.64)	17.30
T_2	Fipronil 5% SC	50	12.3(20.50)	16.90
T_3	Indoxacarb 15.8 EC	79	7.33(15.69)	19.89
T_4	Spinosad 45 SC	90	11.1(19.43)	17.80
T_5	Novaluron 10 EC	100	16.25(23.75)	16.42
T_6	Emamectin benzoate 5 SG	10	9.2(17.62)	18.50
T_7	Neem oil 0.15%	4.5	18.35(25.34)	14.14
T_8	Bt.K.8L 3.5% ES	35	14.5(22.36)	15.30
T_9	Untreated check	-	26.74(31.12)	12.40
SEm±	-	-	0.189	0.009
CD at 5%	-	-	0.573	0.026

Table 5: The economics of pests control by insecticides on chickpea, *Rabi* 2018-19.

Treatment	Name of treatments	Price of insecticide (Rs./liter)	Cost of insecticides Rs/ ha (2 spray)	Protection cost for Rs./ha (2 spray)	Yield (Kg/ha)	Additional yield over control (Kg/ha)	Additional income over control	Net return (Rs./ha)	C:B ratio
T_1	Chlorantraniliprole 18.5 SC	13500	5400	6000	1780	540	24948	18948	1:4.1
T_2	Fipronil 5% SC	1200	2400	3000	1690	450	20790	17790	1:6.9
T_3	Indoxacarb 15.8 EC	2200	2200	2800	1989	749	34603.8	31803.8	1:12.3
T_4	Spinosad 45 SC	20000	8000	8600	1730	490	22638	14038	1:2.6
T_5	Novaluron 10 EC	1050	2100	2700	1530	290	13398	10698	1:4.9
T_6	Emamectin benzoate 5 SG	5000	2000	2600	1850	610	28182	25582	1:10.83
T_7	Neem oil 0.15%	700	4200	4800	1414	174	8038.8	3238.8	1:1.6
T_8	Bt.K.8L 3.5% ES	1110	2220	2820	1642	402	18572.4	15752.4	1:6.5
T_9	Untreated check	-	-	-	1240	-	-	-	-

(2261.66 kg/ha) with CBR 1:7.37. Among biopesticides, *Beauveria bassiana*@ 1500 g/ha and NSKE 5% suffered 7.73 and 7.89 per cent pod damage producing 2011.66 kg/ha and 2001.66 kg/ha seed yield with CBR 1:12.6 and 1:5.78, respectively. Nitharwal et. al. (2017) reported that effectiveness of Spinosad, Indoxacarb and Fipronil insecticides was in reducing larval population, pod damage and recorded higher good yield in comparison to untreated plot.

Differences in pod damage among insecticidal treatments were found significant CD value 0.573 and the pod damage ranged between 7.33 per cent in Indoxacarb to 26.74 per cent in untreated control.

The cost benefit ratio

The C:B ratio of various insecticide treatments was calculated and presented in table 5 which divulge that maximum C:B ratio (1:12.3) was recorded from Indoxacarb treatment followed by Emamectin benzoate (1:10.83), Fipronil (1:6.9), Bt.K. (1:6.5), Novaluron (1:4.9), Chlorantraniliprole (1:4.1), Spinosad (1:2.6) and Neem oil (1:1.6). However, the minimum CB ratio was noted in the plot treated with The order of C:B ratio due to different insecticide treatments is given below.

Indoxacarb (T3) > Emamectin benzoate (T6) > Fipronil (T2) > Bt.K. (T8) > Novaluron (T5) > Chlorantraniliprole (T1) > Spinosad (T4) > Neem oil (T7).

Highest cost: benefit ratio of 1:12.3 was observed in the treatment of Indoxacarb 15.8 EC @ 79 g a.i./ha, followed by the treatment of Emamectin benzoate 5 SG @ 10 g a.i./ha with cost benefit ratio was 1:10.83.

CONCLUSION

As the chickpea pod borer was the key pest in the region demanding population suppression by insecticide which has eco-friendly impact on the agro-ecosystem, lower dose of indoxacarb 79 g a.i./ha was found to be effective by initiating the first spray at 50% flowering and second spraying after 15 could affect desirable control of the pest. Following the indaxocarb, emamectin benzoate 5 SG @ 10 g a.i./ha were found superior pod borer management.

Conflict of interest: None.

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