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Evaluation of Bioefficacy of Emamectin Benzoate Against Gram Pod Borer (*Helicoverpa armigera* Hubner) and Natural Enemies on chickpea *(Cicer arietinum)*

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ABSTRACT
A field experiment was carried out to the bioefficacy of Emamectin benzoate against the larvae of Helicoverpa armigera and their natural enemies on Chickpea at Breeding Seed Production Farm, Jawaharlal Nehru Krishi Vishwa Vidhyalaya, Jabalpur during rabi season 2009. This trial was laid out with seven treatments and replicated thrice following the Randomized Block Design. Emamectin benzoate 5% WG @ 6.9 g a.i. ha^{-1} was found to be the most effective dose against H. armigera which was at par with the higher doses of Emamectin benzoate 5% WG @ 9.4 and 8.1 g a.i. ha^{-1}. Lowest pod damage (%) was with Emamectin benzoate 5% WG @ 6.9 g a.i. ha^{-1} and above doses were found to be superior over rest of the treatments and were at par with each other. The damaged pods were recorded 7.22% in check as compared to only 0.87 to 0.89% damaged pods in doses of Emamectin benzoate 5% WG @ 6.9, 8.1 and 9.4 g a.i. ha^{-1}. The standard treatments of Chlorpyrifos 20 EC @ 500 g a.i. ha^{-1} and Ethion 50 EC @ 500 g a.i. ha^{-1} were recorded 4.86% and 5.11% damaged pods, respectively. All the treatments of Emamectin benzoate 5% WG did not show any adverse effects against natural enemies in the treated plots (viz., Lady bird beetle and Chrysopa). Seed yield was obtained higher (2256 kg ha^{-1}) with the increased dose of Emamectin benzoate 5% WG @ 9.4 g a.i ha^{-1} followed by Emamectin benzoate 5% WG @ 5.6, 6.9 and 8.1 g a.i ha^{-1}.
Keywords: Chickpea, *Helicoverpa amigera*, natural enemies, emamectin benzoate, yield

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INTRODUCTION
Pulses are the best source of vitamins and medicinal value and acts as a blood purifier. Among pulses chickpea (*Cicer arietinum* L.) is the most important pulse crop of the world which is also known as gram or Bengal gram. It is cultivated and consumed in large quantities from South East Asia to India and in the Middle East and Mediterranean countries. Chickpea is a highly nutritious legume crop which is well accounts for rich and cheapest source of energy, protein and soluble and insoluble fiber. Mature chickpea grains contain 60-65% carbohydrates, 6% fat, and between 12- 31% protein higher than any other pulse crop (Kumar et al., 2015). India occupies first position in the world in accounts of area (66%) and production (70%). In India the crop was occupies 8.25 million ha area with production of 7.33 million tonnes and 889 kg ha^{-1} productivity. In Madhya Pradesh chickpea is cultivated in 2.85 million ha with an annual production of 2.96 million tonnes and productivity of 1039 kg ha^{-1} (Agricultural Statistics at a Glance, 2016). In the last four decades it has experienced that the area, production and productivity of chickpea fluctuated widely. One of the most practical resorts of increasing chickpea production is to minimize losses caused by the biotic constraints, which include insect-pests, diseases and weeds under field conditions. About 36 species of insect pests are attack on chickpea during different growth stage of the crop in India (Nayer et al., 1982). Among the insect pests the gram pod borer (*Helicoverpa armigera* Hubner) alone causes 29% yield losses in chickpea at national level. Gram pod borer is one of the most devastating and polyphagous pest in worldwide and feeds on more than 300 plant species and solely responsible for considerable damage to many field and horticultural crops (Arora et al., 2005). The attack of this alarming pest begins from early vegetative to maturity stage. At early stage the young larvae start feeding to leaflets, buds, flowers and pods of

chickpea (Mandal and Roy, 2012). A reduction in yield ranging from 40-50% has been reported and may cause even total loss of the crop (Rai et al., 2003). A single larva of the gram pod borer alone can destroy 30-40 pods before its maturity. Annual losses due to insect pests are estimated to be 15 % in chickpea (Chandrashekar et al., 2014). The low yield of chickpea is attributed to the regular outbreaks of pod borer which is considered to be one of the major pests of chickpea crop. Crop damage by insect pests could be minimized and kept under economic threshold level effectively by adopting one of the important component of integrated pest management i.e., chemical control by selecting some newer insecticides which should have selective and less harmful to natural enemies. Scientific data based on toxicity, effectiveness and economics of chemical insecticide is very essential before the application in pest management. Thus, keeping the above facts in mind the present study was carried out to evaluate the efficacy of some most popular chemical insecticides against the gram pod borer in chickpea ecosystem.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season-2009 at Breeding Seed Production Farm, J. Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India to the bio-efficacy of Emamectin benzoate 5% WG against pod borer and natural enemies on Chickpea, variety JG-1-09. The trial was conducted with seven treatments and replicated thrice following the Randomized Block Design (RBD). Each plot size was kept 4×5 m with row×plant spacing of 45×05 cm. There are total three foliar sprays of insecticides were given from 50% flowering as per treatment scheduled and thereafter 15 days interval with a high volume Knapsack sprayer @ 500 liter spray fluid ha^{-1}. Due care was taken to avoid the drift of insecticides on neighboring plots. The observations on larval population were recorded one day before spray and 3 and 7 days after application of each spray on 3 meter row length (mrl^{-1}) plants of randomly selected plants. Similar method was also followed to count the occurrence of natural enemies. Mean larval populations were transformed with square root of n+1 for statistical analysis. Per cent pod damage were recorded on ten randomly sampled plants per plot at the time of harvest by counting the total number of healthy and damaged pods with following formula as suggested by Kumar et al. (2013).

$$\%\ \text{pod damage} = \frac{\text{Total number of damaged pods}}{\text{Total number of examined pods}} \times 100$$

These obtained % pod damage were further transformed to angular transformation values for statistical analysis. Similarly grain yield was recorded from each plot after harvest and worked out for one hectare area. Observations on phytotoxicity symptoms were recorded visually in field as per guidelines of Central Insecticide Board, Govt. of India on 0-10 scale, EWRC system. Effect on crop health viz., leaf yellowing, tip necrosis, scorching, epinasty and hyponasty etc., were recorded 1, 3, 5, 7, and 10 days after application of each spray using following score and per cent effect was worked out with following method (Nishantha et al., 2009).

Score	% crop health affected	Score	% crop health affected
0	No Phytotoxicity	6	51-60
1	1-10	7	61-70
2	11-20	8	71-80
3	21-30	9	81-90
4	31-40	10	91-100
5	41-50		

RESULTS AND DISCUSSION

1. Management of *Helicoverpa armigera*

The larval population of gram pod borer ranged between 3.31 and 3.43 larvae mrl^{-1} before first application, which was statistically identical in different plots. At 3 DA1A (Days after first application) all the insecticidal treatments were significantly superior as compared to control plot in reducing the larval population of pod borer and recorded 1.17 to 2.99 larvae mrl^{-1} in different treatments as against 3.51 larvae mrl^{-1} in control plot (Table1). All the treatments were found very effective and significantly at par except check. However, T_3, T_4 and T_5, (Emamectin benzoate 5% WG @ 6.9, 8.1 and 9.4 g a.i. ha^{-1}) were significantly superior and at par with each other and recorded 1.26, 1.20 and 1.17 larvae mrl^{-1}. At 7 and 10 DA1A (Days after first application) all the insecticidal treatments were significantly superior as compared to check in reducing the larval population of gram pod borer and Emamectin benzoate 5% WG @ 6.9 g a.i. ha^{-1} and above doses were significantly superior and at par with each other. Similar trends were observed even after 2nd and 3rd spray application. During the period of 3, 7 and 10 days after 2nd application the larval population of gram pod borer in check treatment was in the range of 4.54 to 5.06 larvae mrl^{-1}. Further at 3, 7 and 10 DA2A (Days after second application) the larval population of gram pod borer significantly reduced in all the treatments except check. Emamectin benzoate 5% WG @ 6.9 g a.i. ha^{-1} and above doses again showed superiority over rest of the treatments and were at par with each other. After the third application the larval population in check treatment was in the range of 4.10 to 3.42 larvae mrl^{-1}. During the harvest observations of pod damage indicated that Emamectin benzoate 5% WG @ 6.9 g a.i. ha^{-1} and above doses were found to be superior over rest of the treatments and were at par with each other (Table2). At harvest 7.22% damaged pods were observed in check as compared to only 0.87 to 0.89% damaged pods in doses of Emamectin benzoate 5% WG @ 6.9, 8.1 & 9.4 g a.i. ha^{-1}. The standard treatments of Chloropyrifos 20% EC @ 500 g a.i. ha^{-1} and Ethion 50% EC @ 500 g a.i. ha^{-1} recorded 4.86% and 5.11% damaged pods. Bharti et al. (2015) reported minimum larval population of gram pod borer which were 0.33, 5.00, 7.00, 4.00 and 2.33 at 5th, 10th, 15th, 20th and at harvest, respectively. Whereas lowest pod damage (%) per plot was recorded on the 5th (1.49%), 10th (2.9%), 15th (3.52%), 20th (4.49%) and at harvest (5.00%), respectively, after second spray of Emamectin benzoate (5 g a.i. ha^{-1}) in comparison to untreated control and the treatment differences were significant. Mittal and Ujagir (2005) also recorded lower numbers of *H. armigera* and lower pod damage with different concentrations of Spinosad in pigeonpea. Flubendiamide (2.46%), Chlorantraniliprole (2.60%), Emamectin benzoate (2.85%) were next best treatments and at par with Indoxacarb (3.18%) with 81.9, 80.9, 79.1 and 76.7% reduction in pod damage over control, respectively. The untreated plot has maximum pod damage of 13.65%. Kumar and Sarada (2015) observed that pod damage due to gram pod borer, *H. armigera* was lowest in plots treated with Spinosad 45% SC (1.53%), Flubendiamide 20% WG (2.46%), Chlorantraniliprole 20% SC (2.60%) and Emamectin benzoate 5% SG (2.85%) with 88.8, 81.9, 80.9 and 79.1% reduction over control, respectively. Raghuraman et al. (2008) also agreed and found Emamectin benzoate at the dose of 11 g a.i. ha^{-1} was effective in reducing the incidence of bollworm in cotton and increase the yield. Sarnaik and Chiranjeevi (2017) were also found the best treatment to Emamectin benzoate 5 WG @ 15.0 g a.i. ha^{-1} with minimum larval population of *H. armigera* i.e. 0.37, 0.27 and 0.13 larvae $plant^{-1}$; lowest pod damage i.e. 8.30,6.89 and 5.83% at one, three and seven days after spray, respectively.

2 Effect on natural enemies of gram pod borer

The population of Lady bird beetle and Chrysopa were recorded at negligible level during the trial period and the statistical analysis was non-significant (Table 3). However, the population of beneficial insects were near about the same as check in the tested doses of Emamectin benzoate 5% WG. In this present study the Emamectin benzoate was found to be much safe to beneficial insects. The present findings are in agreement to the Kambrekar et al., (2012) who recorded that the Emamectin benzoate 5% SG @ 13 g a.i. ha^{-1} was found safe and no any adverse effects on the natural enemies and no phytotoxic effects on chickpea crop.

3 Seed yield

All the doses of Emamectin benzoate 5% WG were recorded significantly higher seed yield over untreated control (Table 2). While, recommended standard insecticides like Chlorpyrifos 20% EC @ 500 g a.i. ha^{-1} and Ethion 50% EC @ 500 g a.i. ha^{-1} recorded lower seed yield (1827 and 1788 kg ha^{-1}). Untreated control plot recorded minimum yield of 1673 kg ha^{-1}. Emamectin benzoate 5% WG @ 9.4, 8.1 and 6.9 g a.i. ha^{-1} were at par with each other and recorded grain yield of 2256, 2181 and 2130 kg ha^{-1} respectively. Kumar and Sarada (2015) recoded that highest yield was recorded in Spinosad 45% SC treated plots (1244.4 kg ha^{-1}) with 121.8 per cent increase over control, followed by Chlorantraniliprole 20% SC (1180.5 kg ha^{-1}), Flubendiamide 20% WG (1157.4 kg ha^{-1}) and Emamectin benzoate 5% SG (1078.7 kg ha^{-1}) with 110.4, 106.3 and 92.2% increase over control, respectively against the minimum yield of 561.1 kg ha^{-1} in the control plot. Sharma et al. (2011) reported Emamectin benzoate was found effective to minimize yield losses caused by *H. armigera* in pigeonpea which support the present findings. Raghuraman et al. (2008) also agreed and found Emamectin benzoate at the dose of 11 g a.i. ha^{-1} was effective in reducing the incidence of bollworm in cotton and increase in yield. Bharti et al. (2015) found effective to Emamectin benzoate 5 WSG at @ 5 g a.i. ha^{-1} against the gram pod borer which was given maximum seed yield (1800 kg ha^{-1}) followed by Spinosad 45 SC @ 75 g a.i. ha^{-1} (1717 kg ha^{-1}). Whereas, Sarnaik and Chiranjeevi (2017) also recorded maximum grain yield of chickpea (2196 kg h^{-1}) with the application of Emamectin benzoate 5 WG @ 15.0 g a.i. ha^{-1}..

4 Phytotoxicity effect of Emamectin benzoate 5% WG on Bengal gram crop

On the basis of per cent crop health and score by visual observation, results clearly indicated that no phytotoxicity effects and symptoms were observed in the plots treated with Emamectin benzoate 5% WG @ 5.6, 6.9, 8.1, 9.4 and 18.8 g a.i. ha^{-1} (Table 4). Kambrekar et al., (2012) also corroborated with the application of Emamectin benzoate 5% SG @ 13 g a.i. ha^{-1} resulted in without any adverse effects of different doses and found to be non-phytotoxic effects on chickpea crop. Similar findings were also reported by Nishantha et al. (2009) on chickpea.

Table 1: Efficacy of Emamectin benzoate 5% WG against pod borer (*Helicoverpa armigera*) in Chickpea

Sr. No.	Treatments	Dose		Number of larvae mrl-1*									
		g a.i. ha-1	Product (g, ml ha-1)	(1st spray)				(2nd spray)			(3rd spray)		
				Pre count	3 DA1A	7 DA1A	10 DA1A	3 DA2A	7 DA2A	10 DA2A	3 DA3A	7 DA3A	10 DA3A
T1	Check (Control)	-	-	3.33 (1.95)	3.51 (1.99)	3.87 (2.09)	4.26 (2.18)	4.54 (2.24)	4.92 (2.33)	5.06 (2.36)	4.10 (2.14)	3.66 (2.04)	3.42 (1.97)
T2	Emamectin benzoate 5% WG	5.6	112 g	3.36 (1.95)	2.39 (1.68)	1.88 (1.53)	1.57 (1.43)	1.24 (1.31)	1.42 (1.38)	0.36 (0.92)	1.34 (1.35)	0.62 (1.05)	0.34 (0.91)
T3	Emamectin benzoate 5% WG	6.9	138 g	3.31 (1.94)	1.26 (1.31)	1.10 (1.25)	0.85 (1.14)	0.70 (1.07)	0.38 (0.94)	0.10 (0.77)	0.14 (0.80)	0.06 (0.75)	0.00 (0.71)
T4	Emamectin benzoate 5% WG	8.1	162 g	3.34 (1.95)	1.20 (1.26)	1.09 (1.25)	0.83 (1.13)	0.63 (1.04)	0.28 (0.88)	0.09 (0.77)	0.11 (0.78)	0.00 (0.71)	0.00 (0.71)
T5	Emamectin benzoate 5% WG	9.4	188 g	3.43 (1.97)	1.17 (1.26)	0.85 (1.14)	0.65 (1.05)	0.57 (1.01)	0.19 (0.83)	0.18 (0.76)	0.01 (0.71)	0.00 (0.71)	0.00 (0.71)
T6	Chloropyrifos 20% EC	500	2500 ml	3.35 (1.95)	2.90 (1.84)	2.47 (1.72)	2.47 (1.72)	2.66 (1.77)	2.47 (1.72)	2.58 (1.75)	2.68 (1.78)	2.81 (1.82)	2.67 (1.77)
T7	Ethion 50 % EC	500	1000 ml	3.39 (1.96)	2.99 (1.86)	2.74 (1.79)	2.74 (1.79)	2.88 (1.83)	2.66 (1.78)	2.67 (1.78)	2.80 (1.81)	2.69 (1.78)	2.54 (1.74)
SEm±				0.06	0.04	0.03	0.03	0.04	0.02	0.02	0.05	0.04	0.06
CD(p=0.05)				0.21	0.15	0.10	0.10	0.12	0.06	0.08	0.17	0.15	0.21

Figures in parenthesis are square root transformed values (√ X + 0.5)

mrl*=meter row length; DA1A = day after 1st application; DA2A = day after 2nd application, DA3A = day after 3rd application

Table 2: Efficacy of Emamectin benzoate 5% WG pod damaged and yield

Tr. No.	Treatments	Dose		% Pod damage (At harvest)*	Yield (kg/ha)
		g a.i ha^{-1}	Product (g, ml/ha)		
T_1	Check (Control)	-	-	7.22(15.58)	1673
T_2	Emamectin benzoate 5% WG	5.6	112 g	2.42(8.91)	1795
T_3	Emamectin benzoate 5% WG	6.9	138 g	0.89(5.43)	2130
T_4	Emamectin benzoate 5% WG	8.1	162 g	0.87(5.35)	2181
T_5	Emamectin benzoate 5% WG	9.4	188 g	0.87(5.35)	2256
T_6	Chloropyrifos 20% EC	500	2500 ml	4.86 (12.73)	1827
T_7	Ethion 50 % EC	500	1000 ml	5.11(13.06)	1788
SEm±				0.31	19.92
CD(p=0.05)				0.97	61.40

*Figures in parenthesis are angular transformed values

Table 3: Effect of Emamectin benzoate 05% WG on natural enemies of chickpea crop

Sr. No.	Treatments	Dose		Population of natural enemies/mrl^{-1}*	
		g a.i ha^{-1}	Product (g, ml ha^{-1})	Number of Lady bird beetle	Number of Chrysopa
T_1	Check (Control)	-	-	0.34 (0.62)	0.36 (0.64)
T_2	Emamectin benzoate 5% WG	5.6	112 g	0.33 (0.62)	0.35 (0.63)
T_3	Emamectin benzoate 5% WG	6.9	138 g	0.33 (0.62)	0.34 (0.62)
T_4	Emamectin benzoate 5% WG	8.1	162 g	0.32 (0.61)	0.35 (0.63)
T_5	Emamectin benzoate 5% WG	9.4	188 g	0.25 (0.55)	0.28 (0.57)
T_6	Chloropyrifos 20% EC	500	2500 ml	0.16 (0.46)	0.21 (0.51)
T_7	Ethion 50 % EC	500	1000 ml	0.21 (0.51)	0.26 (0.56)
SEm±				0.04	0.03
CD(p=0.05)				NS	NS

Figures in parenthesis are square root transformed values (√ X + 0.5)
mrl^{-1}*= meter row length, NS= Non significant

CONCLUSION

Results revealed that Emamectin benzoate 5% WG @ 6.9 g a.i. ha^{-1} was found to be the most effective dose against *H. armigera* which was at par with higher doses of Emamectin benzoate 5% WG @ 9.4 and 8.1 g a.i. ha^{-1} which was given higher seed yield. It was significantly superior over the market standards used as a standard checks. The higher dose of Emamectin benzoate 5% WG @ 376 g ha^{-1} (18.8 g a.i. ha^{-1}) did not cause any phytotoxicity symptoms on Bengal gram crop and not showed any adverse effects on natural enemies.

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