

**BIO-EFFICACY OF NEWER MOLECULES OF INSECTICIDES
AGAINST CHICKPEA POD BORER, *Helicoverpa armigera* (HUBNER)
HARDWICK**

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ABSTRACT

Ten insecticides [emamectin benzoate (Proclaim 5 WG) 0.0025%, thiodicarb (Larvin 75 WP) 0.075, indoxacarb (Fego 15.5 SC) 0.007%, spinosad (Spintor 45 SC) 0.0135%, novaluron (Remon 10 EC) 0.01%, lufenuron (Match 5 EC) 0.005%, flubendiamide (Fame 480 SC) 0.01%, rynaxypyr (Coragen 20 SC) 0.006% and endosulfan (Thiodan 35 EC) 0.07% were evaluated in laboratory for their ovicidal and larvicidal action against *Helicoverpa armigera* (Hubner) Hardwick. These insecticides were also evaluated in field condition during *rabi* 2009-10 for their bio-efficacy against *H. armigera* infesting chickpea (*Cicer arietinum* Linnaeus) based on larval population, damage to pods at green pod and maturity stage, seed yield and net incremental cost:benefit ratio (NICBR). Flubendiamide and thiodicarb recorded more than 70% egg mortality in the laboratory experiment and found most effective as ovicide. Flubendiamide, emamectin, rynaxypyr and spinosad recorded more than 90% larval mortality in the laboratory experiment and found most effective as larvicide. Based on larval population per plant and per cent reduction in population over control (given in bracket after each treatment, respectively) in chickpea in the field experiment, the order of insecticides for their efficacy against *H. armigera* in comparison to control was: flubendiamide (0.07 & 97.02) > rynaxypyr (0.17 & 92.76) > emamectin = indoxacarb (0.20 & 91.47) > spinosad (0.22 & 90.64) > thiodicarb (0.29 &

87.66) > novaluron = lufenuron (0.32 & 86.38) > endosulfan (1.11 & 69.36). Based on per cent pod damage and per cent reduction in pod damage over control, the order was: flubendiamide (5.46 & 90.24) > emamectin (6.01 & 87.27) > indoxacarb (7.38 & 86.82) > thiodicarb (8.01 & 85.70) > spinosad (8.78 & 84.32) > lufenuron (9.45 & 83.12) > novaluron (9.59 & 82.87) > rynaxypyr (11.24 & 79.93) > endosulfan (13.21 & 76.41) > control (56.00) at green pod stage; while it was flubendiamide (7.10 & 87.96) > emamectin (7.19 & 88.76) > thiodicarb (9.16 & 85.68) > spinosad (9.52 & 85.12) > novaluron (10.18 & 84.09) > indoxacarb (10.57 & 83.48) > lufenuron (10.95 & 82.88) > rynaxypyr (13.26 & 79.27) > endosulfan (18.60 & 79.27) > control (63.98) at maturity stage. Based on seed yield (kg /ha) and per cent reduction in yield over control (given in bracket after each treatment, respectively), the order was flubendiamide (1111.10 & 92.31) > emamectin = rynaxypyr (1088.86 & 88.46) > spinosad (1011.10 & 75.00) > indoxacarb (988.87 & 71.15) > lufenuron (951.10 & 64.61) > novaluron (933.32 & 61.54) > thiodicarb (811.10 & 40.38) > endosulfan (700.32 & 21.21) > control (577.77). Based on NICBR, the order of insecticides was: flubendiamide (1:4.19) > rynaxypyr (1:4.14) > lufenuron (1:4.07) > emamectin (1:3.62) > endosulfan (1:3.32) > indoxacarb (1:3.03) > thiodicarb (1:2.79) > novaluron (1:2.76) > spinosad (1:1.48). Overall, flubendiamide 0.01% was found most effective treatment followed by emamectin benzoate 0.0025%, rynaxypyr 0.006% and spinosad 0.0135% for the management of pod borer, *H. armigera* in chickpea crop.

KEY WORDS: *Helicoverpa armigera*, chickpea, newer insecticides, ovicide, larvicide, pod damage

INTRODUCTION

Chickpea is the most important crop with high acceptability and wider use. Besides being rich in protein, its ability to enrich the soil fertility by fixing large quantities of atmospheric nitrogen with the help of symbiotic bacteria mainly *Rhizobium* species is economically sounder and environmentally acceptable (Baldev *et al.*, 1988). In India, the area under chickpea was 7.58 million hectares with a production of 6.91 million

tonnes and productivity of 780 kg ha⁻¹ during *rabi*-2007-08 (Singh, 2008). Four states viz., Madhya Pradesh, Uttar Pradesh, Maharashtra and Rajasthan together contribute about 87 per cent of production from 65 per cent area. In Gujarat, chickpea is cultivated in about 2, 14,800 hectares of land producing 0.21 million tones of seeds with an average productivity of 979 kg ha⁻¹ (Anonymous, 2008a). The production of cereals has increased manifold in the recent past but that of pulses has remained more or less static. Insect pests are probably the main factor limiting the legume production. More than 150 species of insect pests are known to attack pulse crops in India. Of these, about 25 species cause serious damage to pulse crops grown in monsoon and winter (Bindra, 1968). Out of them, gram pod borer, *Helicoverpa armigera* (Hubner) Hardwick (Lepidoptera: Noctuidae) is a cosmopolitan, polyphagous and notorious pest which attacks numerous crops of agricultural importance and widely distributed for the tropic and sub-tropic. The low yield of chickpea is attributed to the regular outbreaks of pod borer, *H. armigera* which is considered as one of the major pest of chickpea crop. The pest feeds voraciously from seedling stage to maturity and causes about 50 to 60 per cent damage to the chickpea pods (Khare and Ujagir, 1977). In India, losses caused by *H. armigera* on chickpea and pigeon pea fields exceeded Rs. 12,000 million per year as per survey carried out by ICRISAT (Anonymous, 1996). Farmers of Asian countries in most cases solely depend on insecticides for the management of the pest. Over-dependence of a particular group of chemicals is one of the important reasons for rapid development of resistance. Among the several avenues to overcome the insecticidal resistance problem, replacement with new molecules of insecticide is one of the important considerations. Therefore, evaluation of newer molecules having novel mode of action for their efficacy against a pest like *H. armigera* is necessary. Considering above facts, the present investigation was carried on evaluation of newer molecules of insecticides for their bio-efficacy against pod borer, *H. armigera* in chickpea.

MATERIALS AND METHODS

Laboratory experiment:

Two separate experiment, one for ovicidal and another for larvicidal action against *H. armigera* were carried out following completely randomized design with 10 treatments [9 insecticides (Table 1) + control] and 3 repetitions. For ovicidal action, 10 eggs glued on a glass slide (7.5 x 2.5 mm) under each repetition were sprayed with respective insecticide at respective concentration using baby sprayer and allowed to drying under fan. One set of 3 glass slides with eggs under control treatment was sprayed with tap water. The eggs on each slide were observed daily under microscope till all the eggs hatched out (up to 5 days). The unhatched eggs were considered as dead. The data on per cent mortality were corrected by using Abbott's formula $[(\% \text{ mortality in treatment} - \% \text{ mortality in control}) \div (100 - \% \text{ mortality in control}) \times 100]$ (Abott, 1925) and subjected to ANOVA. For larvicidal action, the larvae were enclosed individually in plastic container (5 X 3.5 cm) covered with perforated lid for feeding the leaves of chickpea. Ten larvae (kept unfed for 24 hours) under each repetition were fed with leaves of chickpea (which were treated by dipping in the aqueous solution of respective insecticide for one minute) for 24 hours. Later on fresh and untreated leaves of chickpea were provided to the surviving larvae as food every day. Under control treatment, the larvae were fed with untreated leaves. The observations on larval mortality were recorded after 24, 48 and 72 hours of feeding. The data on per cent mortality were corrected by using Abotts formula and subjected to ANOVA. The larvicidal efficacy of insecticides was also evaluated through field-cum-laboratory experiment by feeding the larvae on the leaves which were sprayed with respective insecticides in the field. For the purpose, a laboratory experiment was carried out after first spray application of insecticides in the field experiment. The methodology adopted to evaluate larvicidal action of various insecticides was the same as mentioned above.

Field Experiment

In order to study the field bio-efficacy of newer insecticides against pod borer, *H. armigera* infesting chickpea, an experiment was laid out in a randomized block design with 10 treatments (Table 2) and 3 replications during *rabi* 2009-10 on College Agronomy Farm, B. A. College of

Agriculture, Anand Agricultural University, Anand. Chickpea variety GG-1 was sown in a plot (5.00 x 3.00 m) at spacing of 30 × 10 cm. All the recommended agronomical practices except plant protection were followed for raising the crop. The foliar application of respective insecticides was made with the help of knapsack sprayer at the pressure of 3.5 kg /sq cm to the extent of slight run-off from the leaves. Two sprays of respective insecticides were carried out, first at flowering on 50 % plant and second at pod setting on 50 % plant. Observations on number of eggs and larvae of *H. armigera* per plant were recorded on 10 randomly selected plants from net plot area (4.00 x 2.40 m) before first spray and 3, 5, 7 and 10 days after each spray application. The periodical data on eggs and larval population were subjected to ANOVA after transforming them to $\sqrt{x + 0.5}$. The data were also pooled over periods and sprays. In order to record the pod damage at green pod stage and at harvesting stage, 100 pods were plucked from each sector, brought to the laboratory and sorted out into healthy and damaged pods due to *H. armigera* to obtain per cent pod damage. The data on per cent pod damage were subjected to ANOVA after transforming them to arcsine. The data on seed yield after threshing and cleaning of pods was recorded replication-wise in each treatment, converted into kilograms per hectare and subjected to ANOVA. To work out insecticidal cost benefit ratio (ICBR) of the different insecticidal treatments, the total cost of plant protection was worked out on the basis of prevailing market price of insecticidal formulation and labour charges for spray application. Gross realization of a treatment was worked out by considering the yield and its market price. Net realization was worked out by deducting the gross realization in control from gross realization in insecticidal treatment. Net profit of treatment was worked out by deducting the total cost of plant protection from net realization. Gross ICBR was worked out dividing the net realization over control by total cost of plant protection. Finally, net ICBR for each insecticidal treatment was calculated dividing the net profit by total cost of plant protection.

RESULTS AND DISCUSSION

Efficacy based on ovicidal action:

The data on per cent corrected egg mortality of *H. armigera* recorded in the laboratory experiment (column 2 in Table 1) revealed that the treatment difference was significant. The chronological order of

insecticides for their ovicidal action against *H. armigera* (with per cent corrected egg mortality given in bracket after each insecticide) was flubendiamide 0.01 % (77.75) > thiodicarb 0.075 % (74.27) > rynaxypyr 0.006 % (68.89) > novaluron 0.01 % (66.32) > emamectin 0.0025 % (64.63) > lufenuron 0.005 % (58.61) > indoxacarb 0.015 % (49.93) > spinosad 0.025 % (45.72) > endosulfan 0.07 % (40.59). Flubendiamide which was found most effective as ovicide, was at par with thiodicarb, rynaxypyr, novaluron, emamectin and lufenuron but significantly superior to indoxacarb, spinosad and endosulfan.

Efficacy based on larvicidal action:

The data on per cent corrected larval mortality of *H. armigera* recorded in the laboratory experiment (column 3 in Table 1) revealed that the treatment difference was significant. The chronological order of insecticides for their larvicidal action against *H. armigera* (with per cent corrected larval mortality given in bracket after each insecticide) was flubendiamide = emamectin (97.13) > rynaxypyr = spinosad (91.57) > indoxacarb (86.84) > thiodicarb (86.18) > novaluron (83.45) > lufenuron (80.47) > endosulfan (77.30). Flubendiamide and emamectin were found most effective as larvicide, at par with rynaxypyr and spinosad, but significantly superior to rest of the insecticides. The data on per cent corrected larval mortality of *H. armigera* recorded in the field-cum-laboratory experiment (column 4 in Table 1) revealed that the treatment difference was significant. The chronological order of insecticides for their larvicidal action against *H. armigera* (with per cent corrected larval mortality given in bracket after each insecticide) was flubendiamide = rynaxypyr = spinosad (99.67) > indoxacarb (95.34) > emamectin (88.75) > novaluron = endosulfan (86.18) > lufenuron (77.30) > thiodicarb (70.03). Flubendiamide, rynaxypyr and spinosad were found most effective, significantly superior to lufenuron and thiodicarb, but at par with rest of the insecticides.

Efficacy based on larval population:

The data on larval population per plant recorded in the field experiment and pooled over periods and sprays (column 2 in Table 2) revealed that all the insecticides recorded significantly lower population than control. The chronological order of insecticides based on larval

population per plant and per cent reduction in population over control (given in bracket after each treatment, respectively) in comparison to control was flubendiamide (0.07 & 97.02) > rynaxypyr (0.17 & 92.76) > emamectin = indoxacarb (0.20 & 91.47) > spinosad (0.22 & 90.64) > thiodicarb (0.29 & 87.66) > novaluron = lufenuron (0.32 & 86.38) > endosulfan (1.11 & 69.36). Flubendiamide, rynaxypyr, emamectin and indoxacarb recording more than 90% larval mortality were found most effective, at par with each other but significantly more effective than endosulfan.

Efficacy based on damage to pods:

The data on per cent damaged green pods recorded in the field experiment (column 3 in Table 2) revealed that all the insecticides recorded significantly lower pod damage than control. The chronological order of insecticides based on per cent pod damage and per cent reduction in pod damage over control (given in bracket after each treatment, respectively) was flubendiamide (5.46 & 90.24) > emamectin (6.01 & 87.27) > indoxacarb (7.38 & 86.82) > thiodicarb (8.01 & 85.70) > spinosad (8.78 & 84.32) > lufenuron (9.45 & 83.12) > novaluron (9.59 & 82.87) > rynaxypyr (11.24 & 79.93) > endosulfan (13.21 & 76.41) > control (56.00). Though flubendiamide recording lowest pod damage, and highest per cent reduction was found most effective, it was at par with rest of the insecticides except endosulfan, which was least effective in preventing the damage to pod by *H. armigera*. The data on per cent damaged pods at maturity stage recorded in the field experiment (column 4 in Table 2) revealed that all the insecticides recorded significantly lower pod damage than control. The chronological order of insecticides based on per cent pod damage and per cent reduction in pod damage over control (given in bracket after each treatment, respectively) was flubendiamide (7.10 & 87.96) > emamectin (7.19 & 88.76) > thiodicarb (9.16 & 85.68) > spinosad (9.52 & 85.12) > novaluron (10.18 & 84.09) > indoxacarb (10.57 & 83.48) > lufenuron (10.95 & 82.88) > rynaxypyr (13.26 & 79.27) > endosulfan (18.60 & 79.27) > control (63.98). Though flubendiamide recording lowest pod damage and highest per cent reduction in pod damage over control was found most effective, it was at

par with rest of the insecticides except rynaxypyr and endosulfan, which were least effective in preventing the damage to pod by *H. armigera*.

Efficacy based seed yield:

The data on seed yield recorded in the field experiment (column 4 in Table 2) revealed that all the insecticides except endosulfan recorded significantly lower yield than control. The chronological order of insecticides based seed yield (kg /ha) and per cent reduction in yield over control (given in bracket after each treatment, respectively) was flubendiamide (1111.10 & 92.31) > emamectin = rynaxypyr (1088.86 & 88.46) > spinosad (1011.10 & 75.00) > indoxacarb (988.87 & 71.15) > lufenuron (951.10 & 64.61) > novaluron (933.32 & 61.54) > thiodicarb (811.10 & 40.38) > endosulfan (700.32 & 21.21) > control (577.77). Though flubendiamide recording highest seed yield and highest per cent increase in yield over control was found most effective, it was at par with rest of the insecticides except thiodicarb and endosulfan, which were least effective in increasing the yield.

Efficacy based economics

The details on insecticidal cost benefit ratio (ICBR) calculated for different insecticidal treatments are presented in Table 3. The highest net realization was obtained in the treatment flubendiamide 0.01 % (Rs. 12266) followed by emamectin 0.0025 % and rynaxypyr 0.006 % (Rs. 11755). The chronological order of various insecticidal treatments based on net ICBR (NICBR) given in bracket after each insecticide was: flubendiamide (1:4.19) > rynaxypyr (1:4.14) > lufenuron (1:4.07) > emamectin (1:3.62) > endosulfan (1:3.32) > indoxacarb (1:3.03) > thiodicarb (1:2.79) > novaluron (1:2.76) > spinosad (1:1.48).

Work on efficacy of different insecticides against chickpea pod borer, *H. armigera* has been reported by different researchers in last 10 years. Flubendiamide (Anonymous, 2008b; Patil *et al.*, 2008), spinosad (Ahmed *et al.*, 2004; Singh and Verma, 2006; Singh and Yadav, 2007; Patil *et al.*, 2007), emamectin benzoate (Raghawani and Poshia, 2006; Singh and Verma, 2006; Patil *et al.*, 2007), Novaluron (Raghawani and

Poshiya, 2006; Singh and Verma, 2006), indoxacarb (Rahman *et al.*, 2006; Gowda *et al.*, 2007; Singh and Yadav, 2007), lufenuron (Jadhav *et al.*, 2005) and endosulfan (Prasad and Kumar, 2002; Shah *et al.*, 2003; Shahzad and Shah 2003) are reported effective insecticides against *H. armigera* in chickpea. During present investigation, flubendiamide 0.01% was found most effective insecticide followed by emamectin benzoate 0.0025%, rynaxypyr 0.006% and spinosad 0.0135% for the management of pod borer, *H. armigera* in chickpea crop.

CONCLUSION

Overall, flubendiamide 0.01% recording highest ovicidal and larvicidal action in the laboratory; highest reduction in larval population (97.02%), pod damage at green pod stage (90.24%) and maturity stage (87.96%); highest increase in yield over control (92.31%); and highest NICBR was found most effective treatment against *H. armigera* in chickpea. The next effective treatments with egg mortality, larval mortality, reduction in pod damage at green pod and maturity stage, increase in seed yield and NICBR (given in bracket, respectively after each insecticide) were rynaxypyr 0.006% (68.89%, 91.57%, 92.76%, 86.82%, 85.12, 88.46 & 1:4.14), spinosad 0.0135% (68.89%, 91.57%, 92.76%, 79.93%, 88.46 & 1:4.14) and emamectin benzoate 0.0025% (64.63%, 97.13%, 91.47%, 87.27%, 88.76% & 1:3.62).

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Table 1. Ovicidal and larvicidal action of different newer molecules of insecticides against *H. armigera* in comparison to endosulfan

Treatments	Laboratory Experiment		Field-cum-lab Experiment
	Corrected egg mortality (%) within 5 days	Corrected per cent larval mortality within 3 days after feeding on treated leaves	Corrected per cent larval mortality 3 days after spray
1	2	3	4
Emamectin 0.0025 %	53.51abc (64.63)	80.26a (97.13)	70.41abc (88.75)
Thiodicarb 0.075 %	59.52a (74.27)	68.18bc (86.18)	56.81c (70.03)
Indoxacarb 0.015 %	44.96bcd (49.93)	68.73bc (86.84)	77.54ab (95.34)
Spinosad 0.025 %	42.55cd (45.72)	73.13ab (91.57)	84.67a (99.13)
Novaluron 0.01 %	54.53abc (66.32)	66.00bc (83.45)	68.18abc (86.18)
Lufenuron 0.005 %	49.96abcd (58.61)	63.78bc (80.47)	61.55bc (77.30)
Flubendiamide 0.01 %	61.86a (77.75)	80.26a (97.13)	84.67a (99.13)
Rynaxypyr 0.006 %	56.10ab (68.89)	73.13ab (91.57)	84.67a (99.13)
Endosulfan 0.07 %	39.58d (40.59)	61.55c (77.30)	68.18abc (86.18)
S. Em. $\pm$	4.10	5.22	5.60
C. D. at 5 %	12.19	10.15	16.66
C. V. %	13.83	12.83	13.31

Note: Figures in parentheses are retransformed values, those outside are arcsine transformed values; Treatment means with letter in common are not significant at 5 % level of significance within a column.

Table 2. Impact of different newer molecules of insecticides on different parameters related to *H. armigera* in comparison to endosulfan

Treatments	Larval population of <i>H. armigera</i> *	Per cent damaged pods		Seed yield (kg /ha)
		At green pod stage	At maturity stage	
Emamectin 0.0025%(Proclaim 5 WG)	0.84abc (0.20) [91.49]	14.20ab (6.01) [89.27]	15.56a (7.19) [88.76]	1088.87a [88.46]
Thiodicarb 0.075%(Larvin 75 WP)	0.89bc (0.29) [87.66]	16.45ab (8.01) [85.70]	17.62ab (9.16) [85.68]	811.10bc [40.38]
Indoxacarb 0.015%(Fego 15.5 SC)	0.84b (0.20) [91.49]	15.77ab (7.38) [86.82]	18.98ab (10.57) [83.48]	988.87ab [71.15]
Spinosad 0.025%(Spintor 45 SC)	0.85bc (0.22) [90.64]	17.24ab (8.78) [84.32]	18.00ab (9.52) [85.12]	1011.10a [75.00]
Novaluron 0.01%(Remon 10 EC)	0.92c (0.34) [86.38]	18.04ab (9.59) [82.87]	18.61ab (10.18) [84.09]	933.32ab [61.54]
Lufenuron 0.005%(Match 5 EC)	0.92c (0.34) [85.53]	17.91ab (9.45) [83.12]	19.33ab (10.95) [82.88]	951.10ab [64.61]
Flubendiamide 0.01%(Fame 480 SC)	0.76a (0.07) [97.02]	13.52a (5.46) [90.24]	15.46a (7.10) [87.96]	1111.10a [92.31]
Rynaxypyr 0.006%(Coragen 20 SC)	0.82ab (0.17) [92.76]	19.59ab (11.24) [79.93]	21.36bc (13.26) [79.27]	1088.87a [88.46]
Endosulfan 0.07%(Thiodan 35 EC)	1.11d (0.73) [69.36]	21.32b (13.21) [76.41]	25.55c (18.60) [70.93]	700.32cd [21.21]
Control (Water spray)	1.69 e (2.35)	48.45c (56.00)	53.12d (63.98)	577.77d
S. Em. $\pm$	0.02	2.45	1.70	86.05
C. D. at 5 %	0.08	7.26	5.04	180.78
C. V. %	10.60	20.91	13.15	11.34

Note: *Per plant (Pooled over periods & sprays); Figures outside the parentheses are $\sqrt{x + 0.5}$ transformed values in column 1, while arcsine transformed values in column 3 & 4; Figure in [] are per cent decrease over control in column 2, 3, & 4, while per cent increase over control in column 5; Figures in () are retransformed values; Treatment means with letter in common are not significant at 5 % level of significance within a column.

Table 3. Economic of various insecticides evaluated for field efficacy against pod borer, *H. armigera* infesting chickpea

Treatments	Quantity for 2 sprays	Cost of insecticide (₹/l or kg)	Total cost of plant protection	Yield (kg/ha)	Gross realization (₹/ha)	Net realization over control (₹/ha)	Net profit (₹ /ha)	Gross ICBR	NICBR
Emamectin 0.0025 %	0.40 litre	7119	3247	1088.87	25044	11755	8508	1 : 3.62	1 : 2.62
Thiodicarb 0.075 %	0.80 litre	1900	1920	811.10	18653	5366	3446	1 : 2.79	1 : 1.79
Indoxacarb 0.015 %	0.80 litre	3400	3120	988.87	22724	9455	6335	1 : 3.03	1 : 2.03
Spinosad 0.025 %	0.45 litre	14000	6700	1011.10	23255	9966	3266	1 : 1.48	1 : 0.48
Novaluron 0.01 %	0.80 litre	3200	2960	933.32	21466	8177	5217	1 : 2.76	1 : 1.76
Lufenuron 0.005 %	0.80 litre	2137	2109	951.10	21875	8586	6477	1 : 4.07	1 : 3.07
Flubendiamide 0.01 %	0.16 litre	16000	2960	1111.10	25555	12266	9306	1 : 4.19	1 : 3.19
Rynaxypyr 0.006 %	0.24 litre	10000	2800	1088.87	25044	11755	8955	1 : 4.14	1 : 3.14
Endosulfan 0.07 %	1.60 litre	280	848	700.32	16107	2819	1971	1 : 3.32	1 : 2.32
Control (Water spray)	-	-	-	577.77	13289	-	-	-	-

Note: Market price of chickpea seeds: ₹ 23 /kg; Labour charge: ₹ 200 /2 labour /spray /ha (Total ₹ 400 /2 sprays /ha)