Madras Agric. J., 101 (10-12): 382-385, December 2014
https://doi.org/10.29321/MAJ.10.001220

Effect of Chitin Synthesis Inhibitor, Lufenuron 5.4 EC on Cotton Bollworm *Helicoverpa armigera* (Hubner)

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Field experiments were conducted during November 2011 to August 2012 at Narashimmanaiyakenpalayam and Pujanganoor, Coimbatore District, Tamil Nadu to evaluate the efficacy of Lufenuron 5.4 EC at 20, 30, 40 and 60 g a.i./ha. against *Helicoverpa armigera* (Hubner). In the two field experiments, Lufenuron 5.4 EC applied at 60 g a.i. ha^{-1} reduced the incidence of *H. armigera* by 86.83 and 85.37 per cent respectively over untreated control after three rounds of spraying. The highest yields of 20.58 q ha^{-1} and 16.25 q ha^{-1} were obtained in the plots treated with Lufenuron 5.4 EC at 60 g a.i. ha^{-1} at two locations followed by Lufenuron 5.4 EC at 40 g and 30 g a.i. ha^{-1} .

Keywords: IGR, lufenuron, *Helicoverpa armigera,* Bio-efficacy, Cotton, Phytotoxicity, Yield

Cotton crop is infested by many insect pests. The cotton bollworm, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae) referred to as American bollworm or gram pod borer, holds the first rank amongst agricultural pests of both tropical and temperate countries of the world attacking a number of food, subsidiary and cash crops including ornamental and medicinal plants (Han *et al.,* 1999; Regupathy *et al.,* 2004). The polyphagous and multigenerational noctuid pest with a wide host range of over 181 plant species of 39 families and 200 weed plants, 25 crop plants including cotton, maize, sorghum, sunflower, tomato, *okra* and legumes like pigeon pea, chick pea, *etc.,* breeds throughout the year causing extensive damage (Regupathy *et al*., 1997). In India, farmers even apply 36 to 40 rounds of insecticides to the cotton crop of a duration of 150-180 days in a single season *i.e.,* one spray every five days (Banerjee *et al.,* 2000). The continued use of synthetic pyrethroids in the eighties effectively checked *H. armigera,* In spite of excessive, indiscriminate use and often exclusive dependence on insecticides, large scale failure to control *H. armigera* in many crops are common with many complicated problems, such as environmental pollution, resistance, phytotoxicity and inadequate pollination. Therefore, available safe control measures should be adopted to control insect pests to keep the environment (ecosystem) clean, safe and healthy. (Abou El-Nasr *et al.,* 1978; Amer, 2004). Use of safer insecticides at correct doses by safe methods is the primary requisite to successful control. One of the options is the use of chitin synthesis inhibitors of benzoylphenyl urea group to mitigate the problems of residues and resistance in crop ecosystem.

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Materials and Methods

Two field experiments were conducted in farmer's fields during November 2011 to April 2012 (Rabi 2011) at Narashimmanaiyakenpalayam, Coimbatore and March 2012 to August 2012 (Summer 2012) at Pujanganoor, Karamadai block, Coimbatore) in a simple randomized block design with eight treatments and three replications using the hybrid cotton Surabi. Each plot consisted of 6 rows with a spacing of 75cm between rows and 60 cm between plants with plot size of 5 m´ 5 m. The treatments included lufenuron 5.4 EC at 20, 30, 40 and 60 g a.i./ha. Indoxacarb 15.8 EC 75 g a.i./ha and quinalphos 25 EC 500 g a.i./ha were used as standard checks along with water sprayed untreated control for comparison.

The treatments were imposed thrice at an interval of 14 days, with a pneumatic knapsack sprayer using 500 litre of spray fluid per hectare. Spraying was done in morning hours so as to give uniform coverage on foliage and to avoid drift, Indron® 1 ml/l. was used as sticker / spreading agent. The number of larvae of *H. armigera* was counted by observing on the fruiting bodies with fresh faecal pellets in ten randomly selected plants per plot before insecticide application and on 3, 7, 10 and 14 days after treatments (DAT).

The data on seed cotton with kapas were recorded from each plot at an interval of five days between each picking. Totally five pickings were completed and per hectare yield was worked out and subjected to statistical analysis.

The analysis of variance was carried out using IRRISTAT Ver 3.1. The data were transformed using square root transformation. The mean values of

treatments were then separated by using Duncan's Multiple Range Test (DMRT).

Results and Discussion

The results of the field experiments conducted at Narashimmanaiyakenpalayam revealed that lufenuron 5.4 EC at 20, 30, 40 and 60 g a.i. ha^{-1} recorded significant reduction in larval numbers of *H. armigera* and the results are presented in Table 1. The larval numbers before imposing treatments ranged from 10.00 to 10.33 per ten plants. There was significant reduction in the larval numbers after spraying lufenuron 5.4 EC.

During the first round, maximum larval numbers was recorded in lufenuron 5.4 EC 20 g a.i. ha^{-1} (9.75 larvae / 10 plants) followed by lufenuron 5.4 EC 30 g a.i. ha^{-1} (9.33 larvae per 10 plants). The least larval numbers was recorded with lufenuron 5.4 EC 60 g a.i. ha^{-1} as 8.50 larvae per 10 plants during the first spray. Similar trend was recorded in second round of spray also. After three rounds of spraying, lufenuron 5.4 EC at 60 g, 40 g and 30 g a.i. ha^{-1} recorded 2.25, 3.17 and 3.75 larvae per 10 plants followed by lufenuron 5.4 EC at 20 g a.i. ha^{-1} (5.50 larvae/10 plants). Moderate larval population was recorded with indoxacarb 15.8 EC 75 g a.i. ha^{-1} (7.17

Table 1. Effect of lufenuron 5.4 EC on larval population of *Helicoverpa armigera* (Hubner) in cotton (Location: Narashimanaiyakenpalayam – Rabi 2011)

Treatment	Dose (g a.i. ha^{-1})	No. of larvae/ 10 plants*										Cumulative mean	PR
		I spraying				II spraying			III spraying				
		PTC	3 DAT	14 DAT	Mean	3 DAT	14 DAT	Mean	3 DAT	14 DAT	Mean		
Lufenuron 5.4 EC	20	10.33	10.33$_{c}$	9.33$_{ab}$	9.75$_{bc}$	9.00$_{b}$	8.33$_{c}$	8.58$_{c}$	7.67$_{d}$	3.67$_{ab}$	5.50$_{bc}$	7.94	45.00
			(3.21)	(3.06)	(3.12)	(3.00)	(2.89)	(2.93)	(2.77)	(1.91)	(2.35)	(2.82)	
Lufenuron 5.4 EC	30	10.00	9.67$_{ab}$	9.33$_{ab}$	9.33$_{ab}$	9.00$_{b}$	7.00$_{b}$	8.08$_{ab}$	5.33$_{ab}$	2.00$_{a}$	3.75$_{ab}$	7.06	51.15
			(3.11)	(3.06)	(3.06)	(3.00)	(2.65)	(2.84)	(2.31)	(1.41)	(1.94)	(2.66)	
Lufenuron 5.4 EC	40	10.33	9.33$_{ab}$	9.00$_{ab}$	9.08$_{ab}$	8.67$_{b}$	5.33$_{a}$	7.42$_{ab}$	4.67$_{ab}$	1.33$_{a}$	3.17$_{a}$	6.56	54.62
			(3.06)	(3.00)	(3.01)	(2.94)	(2.31)	(2.72)	(2.16)	(1.15)	(1.78)	(2.56)	
Lufenuron 5.4 EC	60	10.33	9.00$_{ab}$	8.00$_{a}$	8.50$_{a}$	7.67$_{a}$	4.33$_{a}$	6.50$_{a}$	3.33$_{a}$	1.00$_{a}$	2.25$_{a}$	5.75	60.19
			(3.00)	(2.83)	(2.92)	(2.77)	(2.08)	(2.55)	(1.83)	(1.00)	(1.50)	(2.40)	
Indoxacarb 15.8 EC	75	10.00	8.33$_{a}$	10.67$_{bc}$	8.92$_{ab}$	6.67$_{a}$	9.67$_{d}$	8.33$_{b}$	6.67$_{bc}$	8.00$_{c}$	7.17$_{cd}$	8.14	43.65
			(2.89)	(3.27)	(2.99)	(2.58)	(3.11)	(2.89)	(2.58)	(2.83)	(2.68)	(2.85)	
Quinalphos 25 EC	500	10.33	7.67$_{a}$	10.67$_{bc}$	9.00$_{ab}$	7.33$_{a}$	10.00$_{d}$	8.67$_{c}$	7.00$_{cd}$	8.33$_{c}$	7.75$_{d}$	8.47	41.35
			(2.77)	(3.27)	(3.00)	(2.71)	(3.16)	(2.94)	(2.65)	(2.89)	(2.78)	(2.91)	
Control		10.00	10.67$_{c}$	12.00$_{c}$	11.08$_{d}$	14.33$_{c}$	16.00$_{e}$	15.17$_{d}$	16.67$_{e}$	18.00$_{d}$	17.08$_{e}$	14.44	-
			(3.27)	(3.46)	(3.33)	(3.79)	(4.00)	(3.89)	(4.08)	(4.24)	(4.13)	(3.80)	

PTC- Pre-treatment count; PR: Per cent reduction over control; DAT – Days after treatment; In a column means followed by a common letter are not significantly different by DMRT (P=0.05); Values in parentheses are $\sqrt{x+0.5}$ transformed values; Mean of three replications

larvae / 10 plants) followed by quinalphos 25 EC at 500 g a.i. ha^{-1} (7.75 larvae / 10 plants), respectively after III round. This was in accordance with Gogi *et al.* (2006) who reported that lufenuron applied at 37 and 49 g a.i. ha^{-1} effectively suppressed *H. armigera* populations, resulting in significant reduction in crop damage in cotton.

Cumulative effect for three rounds of spraying of lufenuron 5.4 EC 60 g, 40 g, 30 g and 20 g a.i. ha^{-1} recorded 5.75, 6.56, 7.06 and 7.94 larvae per 10 plants with 60.19, 54.62, 51.15 and 45.00 per cent reduction at Narashimmanaiyakenpalayam. Indoxacarb 15.8 EC 75 g a.i. ha^{-1} registered (8.14 larvae with 43.65 PR). The maximum larval numbers was recorded in quinalphos 25 EC at 500 g a.i. ha^{-1} (8.47 larvae), whereas control recorded the highest mean larval population of 14.44 larvae after three rounds of spraying.

In the second season trial at Pujanganoor after first round, the lowest larval population was recorded with lufenuron 5.4 EC 60 g, 40 g and 30 g a.i. ha^{-1} (8.60, 9.00 and 9.33 larvae/ 10 plants respectively) (Table 2). Indoxacarb 15.8 EC 75 g a.i. ha^{-1} (9.60 larvae) and quinalphos 25 EC at 500 g a.i. ha^{-1} (10.00 larvae / 10 plants) were equal in efficacy. Untreated control recorded highest numbers (11.33 larvae / 10 plants) of larvae.

Mean population after second round of spraying, revealed that the lowest larval population was recorded with lufenuron 5.4 EC 60 g and 40 g a.i. ha^{-1} (6.40 larvae and 6.87 larvae respectively), followed by lufenuron 5.4 EC 30 g and 20 g a.i. ha^{-1} (7.93 and 8.60 larvae respectively) and indoxacarb 15.8 EC 75 g a.i. ha^{-1} (8.67 larvae) and were on par with each other followed by quinalphos 25 EC at 500 g a.i. ha^{-1} (9.13 larvae) (Table 2).

Results for third round of spraying revealed that the lowest mean larval population was recorded with lufenuron 5.4 EC 60 g and 40 g a.i. ha^{-1} (2.00 larvae and 3.20 larvae / 10 plants respectively), lufenuron 5.4 EC 30 g a.i. ha^{-1} (4.00 larvae / 10 plants), followed by lufenuron 5.4 EC 20 g a.i. ha^{-1} 5.60 larvae per 10 plants, which was on par with indoxacarb 15.8 EC 75 g a.i. ha^{-1} registered (5.80 larvae) and quinalphos 25 EC at 500 g a.i. ha^{-1} (6.00 larvae / 10 plants) whereas, untreated control recorded the highest larvae of 13.67 per 10 plants (Table 2).

Table 2. Effect of lufenuron 5.4 EC a larval population of *H. armigera* in cotton (Location: Pujanganoor – Summer 2012)

Treatment	Dose (g a.i. ha^{-1})	No. of larvae/ 10 plants*										Cumulative mean	PR
		I spraying				II spraying			III spraying				
		PTC	3 DAT	14 DAT	Mean	3 DAT	14 DAT	Mean	3 DAT	14 DAT	Mean		
Lufenuron 5.4 EC	20	10.33	10.00$_{a}$	9.33$_{ab}$	9.67$_{b}$	9.33$_{b}$	7.67$_{ab}$	8.60$_{bc}$	8.33$_{c}$	3.67$_{c}$	5.60$_{cd}$	7.96	37.52
			(3.16)	(3.06)	(3.11)	(3.06)	(2.77)	(2.93)	(2.89)	(1.91)	(2.37)	(2.82)	
Lufenuron 5.4 EC	30	10.00	10.00$_{a}$	9.00$_{ab}$	9.33$_{ab}$	8.00$_{ab}$	7.00$_{ab}$	7.93$_{b}$	7.00$_{bc}$	1.67$_{b}$	4.00$_{bc}$	7.09	44.33
			(3.16)	(3.00)	(3.06)	(2.83)	(2.65)	(2.79)	(2.65)	(1.29)	(2.00)	(2.66)	
Lufenuron 5.4 EC	40	10.67	9.67$_{a}$	8.33$_{a}$	9.00$_{ab}$	7.00$_{ab}$	6.33$_{a}$	6.87$_{a}$	5.33$_{a}$	1.67$_{b}$	3.20$_{ab}$	6.36	50.09
			(3.11)	(2.89)	(3.00)	(2.65)	(2.52)	(2.62)	(2.31)	(1.29)	(1.79)	(2.52)	
Lufenuron 5.4 EC	60	10.00	9.33$_{a}$	8.00$_{a}$	8.60$_{a}$	6.67$_{a}$	6.00$_{a}$	6.40$_{a}$	4.33$_{a}$	0.33$_{a}$	2.00$_{a}$	5.67	55.50
			(3.06)	(2.83)	(2.93)	(2.58)	(2.45)	(2.53)	(2.08)	(0.58)	(1.41)	(2.38)	
Indoxacarb 15.8 EC	75	10.33	8.33$_{a}$	10.67$_{bc}$	9.60$_{b}$	9.33$_{b}$	8.33$_{ab}$	8.67$_{bc}$	6.67$_{b}$	7.33$_{d}$	5.80$_{cd}$	8.02	37.00
			(2.89)	(3.27)	(3.10)	(3.06)	(2.89)	(2.94)	(2.58)	(2.71)	(2.41)	(2.83)	
Quinalphos 25 EC	500	10.67	9.00$_{a}$	10.67$_{bc}$	10.00$_{b}$	9.33$_{b}$	10.00$_{b}$	9.13$_{c}$	6.67$_{b}$	7.67$_{d}$	6.00$_{cd}$	8.38	34.21
			(3.00)	(3.27)	(3.16)	(3.06)	(3.16)	(3.02)	(2.58)	(2.77)	(2.45)	(2.89)	
Control		10.67	11.00$_{b}$	12.00$_{c}$	11.33$_{c}$	12.67$_{c}$	14.00$_{c}$	13.20$_{d}$	14.33$_{d}$	16.00$_{e}$	13.67$_{e}$	12.73	-
			(3.32)	(3.46)	(3.37)	(3.56)	(3.74)	(3.63)	(3.79)	(4.00)	(3.70)	(3.57)	

PTC- Pre-treatment count; PR: Per cent reduction over control; DAT – Days after treatment; In a column means followed by a common letter are not significantly different by DMRT (P=0.05); ·Values in parentheses are $\sqrt{x+0.5}$ transformed values; ·Mean of three replications

Overall results at Pujanganoor revealed that the lowest larval population was recorded with lufenuron 5.4 EC at 60 g a.i. ha^{-1} recorded 5.67 larvae with 55.50 per cent reduction followed by lufenuron 5.4 EC at 40 g, 30 g and 20 g a.i. ha^{-1} (6.36 larvae, 7.09 larvae and 7.96 larvae / 10 plants respectively), indoxacarb 15.8 EC at 75 g a.i. ha^{-1} (8.02 larvae) and quinalphos 25 EC at 500 g a.i. ha^{-1} (8.38 larvae / 10 plants). Untreated control recorded the highest larvae of 12.73 per 10 plants (Table 2).

The results recorded that reduction in the population was noticed only after 7 days. The population of *H.armigera* was suppressed only a week after spray in many field trials (Karim *et. al*., 1999; Yong-sheng *et. al.*, 2009; Aulakh and Butter, 2009) and this could be possible because of the unique mode of action of IGR's like lufenuron.

In the two field experiments, lufenuron 5.4 EC applied at 60 g a.i. ha^{-1} reduced the incidence of *H. armigera* by 60.19 and 55.50 per cent, respectively over untreated control after three rounds of spraying. These findings are in accordance with that of Javaid *et. al.* (1999) who reported better control of *Spodoptera littoralis* larvae provided by lufenuron.

Lufenuron registered better efficacy against cotton pests *viz., H. armigera*, *Earias* sp*. etc.,* under field conditions. Lufenuron, at 40-50 g a.i. /ha was effective in the control of tobacco budworm (*H. virescens*) on cotton (Sechser *et. al.,* 2001). Al-

Table 3. Effect of lufenuron 5.4 EC on cotton yield

Treatment	Dose (g a.i. ha^{-1})	Narashimmanaiyakenpalayam *		Pujanganoor*		Mean (Q ha^{-1})
		Quintals ha^{-1}	Per cent increase over control	Quintals ha^{-1}	Per cent increase over control	
Lufenuron 5.4 EC	20	11.78$_{c}$	14.26	12.50$_{c}$	36.00	12.14
Lufenuron 5.4 EC	30	19.43$_{a}$	47.70	15.25$_{a}$	47.54	17.34
Lufenuron 5.4 EC	40	20.46$_{a}$	48.02	15.50$_{a}$	48.39	17.98
Lufenuron 5.4 EC	60	20.58$_{a}$	50.92	16.25$_{a}$	50.77	18.42
Indoxacarb 15.8 EC	75	17.41$_{a}$	50.64	14.25$_{ab}$	43.86	15.83
Quinalphos 25 EC	500	15.36$_{b}$	41.99	12.75$_{c}$	37.25	14.10
Control	-	10.10$_{c}$	-	8.00$_{d}$	-	9.05

*Mean of three replications

In a column means followed by a common letter are not significantly different by DMRT (P=0.05)

shannaf, *et. al.* (2012) opined that the initial reduction of the American bollworm larvae was 75.0 per cent after 3 days of treatment and 7 days of application mean of reduction percentages was 83.3 per cent with chlorfluazuron. Similar findings of effectivenessof IGRs (chlorfenapyr, meth oxyfenozide, spinosad and tebufenozide) against caterpillar pest in cotton were recorded by Adamczyk *et.al.* (1999). Lufenuron suppressed the population of *Spodoptera frugiperda* in corn (Cruz and Turpin, 1982) There was significant reduction in *H. armigera* larvae in cotton ecosystems (Abou Kahla *et. al*., 1990). Khajepour *et al.* (2012) reported Application of hexaflumuron and lufenuron on last instar larvae of *Ephestia figulilella* caused not only mortality in larval stage, but also caused defects in pupal and adult stages and in some cases produced larval-pupal intermediates. Kareem *et. al.* (1999) also

reported that Bt in combination with lufenuron, greatly affected the population of *H. armigera*.

The highest yield of 20.58 q ha^{-1} was obtained in the plots treated with lufenuron 5.4 EC at 60 g a.i. ha^{-1} followed by lufenuron 5.4 EC at 40 g and 30 g a.i. ha^{-1} (20.46 q and 19.43 q, respectively) after first season. In the second season highest yield of 16.25 q ha^{-1} was obtained in the plots treated with lufenuron 5.4 EC at 60 g a.i. ha^{-1} followed by lufenuron 5.4 EC at 40 g and 30 g a.i. ha^{-1} (15.50 q, 15.25 q ha^{-1}) followed by indoxacarb 14.5 SC at 75 g a.i. ha^{-1} (17.41 q and 14.25 q ha^{-1}) and quinalphos 25 EC 500 g a.i. ha^{-1} (15.36 q and 12.75 q ha^{-1})in both the locations. Over the two seasons, the mean yield was the highest (18.42 q ha^{-1}) in lufenuron 5.4 EC at 60 g a.i. ha^{-1} followed by lufenuron 5.4 EC at 40 g a.i. ha^{-1} (17.98 q ha^{-1}).

Acknowledgement

The authors are grateful to M/s. Crystal Crop Protection Pvt. Ltd., New Delhi, for their financial assistance to carry out this work.

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Received: August 20, 2013; Revised: August 25, 2014; Accepted: August 28, 2014