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Management of Diamondback Moth (*Plutella xylostella* L.) in Cabbage at Tropical and Temperate Regions of Tamil Nadu with Chitin Synthesis Inhibitor

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Experiments were conducted during 2011 and 2012 to evaluate the biological efficacy of lufenuron 5.4 EC at 20, 30, 40, and 60 g a.i./ha against diamond back moth (DBM), *Plutella xylostella* L. in cabbage in tropical (Jahirnayakanpalayam, Coimbatore) and temperate regions (Kotagiri, Ooty) of Tamil Nadu. The results revealed that lufenuron 5.4 EC, indoxacarb 15.8 EC and cartap hydrochloride 50 SP were effective in reducing *P. xylostella* population in cabbage. Lufenuron 5.4 EC at 60 g a.i./ha showed the highest mortality in tropical (71.45%) and temperate (74.80%) conditions against *P. xylostella*. Lufenuron 5.4 EC at all the doses was comparatively less toxic to *Cotesia* (8.74 - 16.12%) in tropical and (9.59 – 14.44%) temperate regions on compared to standard check indoxacarb. Cartap hydrochloride was more toxic to *Cotesia* by recording a cumulative mean per cent reduction of 44.83, 39.37 at tropical and 47.56, 36.50 at temperate regions, respectively. Foliar application of lufenuron at 30, 60 and 120 g a.i./ha in cabbage at both regions did not cause any phytotoxic effects. The marketable yield recorded in lufenuron 5.4 EC at 60 g a.i./ha was 63.12 t/ha in tropical and 83.10 t/ha in temperate region which was also significantly higher than other treatments.

Key words: IGR, lufenuron, *Plutella*, bioefficacy, phytotoxicity, *Cotesia*, yield

Cabbage, *Brassica oleracea* var. *capitata* L. is an important crucifer in India, grown over an area of 3 million hectares with an annual production of 79.49 million tonnes (FAOSTAT, 2011). The diamondback moth (DBM), *Plutella xylostella* (Linnaeus) (Plutellidae: Lepidoptera), is the major destructive pest on cruciferous crops such as cauliflower, cabbage, and mustard, causing significant economic losses up to 50 per cent with an estimate of US $ 168 million per year. Most often growers resort to prophylactic and scheduled applications of insecticides. Continuous use of insecticides results in the destruction of natural enemies, development of resistance in target pest, residual problems and environmental pollution. Hence, there is a need to identify an effective, economically feasible and environmentally safer molecule which offers more protection against cabbage pests in the field, especially DBM. DBM has become very difficult to manage because of the development of high levels of resistance to several groups of organophosphorus, carbamate, and pyrethroid insecticides. Sole reliance on insecticides has resulted in rapid build -up of resistance in the multivoltine DBM, which undergoes 20 generations a year in the tropics (Talekar and Shelton, 1993). Biology of *P. xylostella* varies significantly with cruciferous crops and the most preferred hosts are cauliflower and cabbage. (Uthamasamy *et al.,* 2011).

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In order to overcome the problem of resistance to diamondback moth, some newer insecticides like benzoylphenylurea, are being exploited and are found to be effective against other lepidopteran pests complex also as chitin synthesis inhibitors.

Materials and Methods

Two field experiments were conducted during 2011 and 2012 to evaluate the biological efficacy of lufenuron 5.4 EC against diamond back moth (DBM), *Plutella xylostella* L. in cabbage at tropical region (latitude 10°98'N and longitude 76° 79'E) (Jahirnayakanpalayam, Coimbatore) and temperate region (latitude 11° 45'N and longitude 76° 87'E) (Kotagiri, Ooty) in Tamil Nadu. The experiments were laid out in a simple randomized block design with eight treatments and three replications. The cabbage crop (Hybrid: Arithani at tropical and Sandoz cuiser at temperate regions) was sprayed with lufenuron at four doses *viz.* 20, 30, 40, and 60 g a.i./ ha. Lufenuron 5.4 EC (Cigna®) 30 g a.i./ha, indoxacarb 15.8 EC 25 g a.i./ha, and cartap hydro chloride 50 SP 400 g a.i./ha were used as standard check for comparison. The damage was assessed based on pest population present over cabbage head and the per cent reduction was worked out using Henderson and Tilton (1955) formula.

The treatments were imposed three times at 14 days interval commencing from 42 - 46th days after planting with a pneumatic knapsack sprayer using 600 litres of spray fluid per hectare during morning hours in such a way to give uniform coverage on foliage and to avoid drift and degradation of the insecticides. Observations on larval population were made 24 hours prior to spraying and on 3, 7, 10 and 14 days after spraying from 5 randomly selected and tagged plants in each plot. In the same bioefficacy trial, the braconid parasitoid *Cotesia plutellae* pupal population was also recorded. The data on yield of marketable cabbage head was recorded treatment at the harvest and then per hectare yield was worked out and subjected to statistical analysis.

Statistical analysis

The corrected per cent reduction of pests over control in the field population was worked out by using the formula given by Henderson and Tilton (1955).

$$\text{Corrected per cent reduction} = 1 - \left[\frac{T_a - {}_b}{T_b - C_a}\right] \times 100$$

where,

T_a - No. of insects in the treatment after spraying

T_b -No. of insects in the treatment before spraying

C_b -No. of insects in the untreated check before spraying

C_a - No. of insects in the untreated check after spraying

The analyses of variance were carried out by randomized block design using AGRES and AGDATA. The data obtained were transformed to corresponding values using square root transformation. The mean values of treatments were then separated using Least Significance Difference (LSD) (Gomez and Gomez, 1984).

Phytotoxicity

Observations were made on 3, 7, and 10 days after spraying on different phytotoxicity parameters *viz.,* leaf chlorosis, leaf tip burning , leaf necrosis, leaf epinasty, leaf hyponasty, vein clearing , wilting and rosetting on phytotoxicity scale, as per the protocol of Central Insecticidal Board Registration Committee (C.I.B and R.C). Phytotoxicity ratings were recorded based on the following visual scale

Rating	Leaf area damage (%)
0	No phytotoxicity
1	1-10
2	11-20
3	21-30
4	31-40
5	41-50
6	51-60
7	61-70
8	71-80
9	81-90
10	91-100

The per cent leaf injury was calculated using the formula,

$$\text{Per cent leaf injury} = \frac{\text{Total grade points}}{\text{Max. grade x No. of leaves observed}} \times 100$$

Results and Discussion

Field trials conducted at tropical region (Jagirnayakkanpalayam) revealed that the new formulation, lufenuron 5.4 EC @ 60 g a.i./ha performed well even at lower concentrations (20 g a.i./ha). The reduction in the population was however marked in lufenuron 5.4 EC @ 60 g a.i/ha treated plots wherein reduction was to a tune of 41.9 per cent 81.4 per cent and 90.4 per cent after I, II and III sprays respectively. Similar results were obtained in the trials conducted at temperate region (Kotagiri), where lufenuron 5.4 EC @ 60 a.i./ha registered 52.01, 81.6 and 90.3 per cent reduction in population after I, II and III sprays respectively. Lufenuron gave low mortality at field dose after l2 hours but it increased 48 hours after treatment which was similar to the observations of Solong *et al.* (1995) in South-East Asia. Lufenuron is an insect growth regulator which alters the moulting process by interfering with the synthesis of chitin in insects and the mortality is prominent 48 hours after treatment as documented by Muhammad Naveed Rafiq (2005).

Analysis on the pooled mean population of DBM larvae after three sprays at tropical region revealed that population reduction ranged from 47.8 (cartap hydrochloride 50 SP) to 73.2 per cent (lufenuron 5.4 EC@ 60 g a.i/ha). The existing formulation of lufenuron (Cigna®) registered 67.7 per cent reduction in the larval population (Table 1). The data on temperate region also revealed reduction in larval population to the tune of 73.1 per cent in lufenuron @ 60 g a.i/ha treated plots followed by the same formulation at 40 g a.i/ha (70.3%). The insecticidal formulation is new and hence this is the first report of its efficacy against diamond back moth. The efficacy of lufenuron was also earlier documented against cotton boll worms complex by Aulakh *et al.* (2009). Josan *et al.*, (2000) reported that the sublethal effect of lufenuron against immature stages of DBM caused only 14 per cent adult emergence from pupae and reduced the fecundity (10.2 eggs/female) and also oviposition period (3.2 days).

Lufenuron 5.4 EC at all the doses was comparatively less toxic to the natural enemies on cabbage and the highest dose 60 g.a.i/ha registered a mean population reduction of 16.12 per cent in tropical and 14.44 per cent in temperate region. The standard check indoxacarb and cartap hydrochloride were more toxic to *Cotesia* population by recording a cumulative mean reduction of 44.83 per cent, 39.37 per cent at tropical and 47.56 per cent, 36.50 per cent at temperate region, respectively

Table 1. Effect of lufenuron 5.4 EC against diamondback moth, *Plutella xylostella* (L.) on cabbage (tropical and temperate regions)

Treatment	Tropical region (Jahirnayakkanpalayam)					Temperate region (Kotagiri)			
	Dosage (g a.i./ ha)	Pre-treatment population	Mean population after 3 sprays	Per cent reduction from control	Yield (t/ ha)	Pre-treatment population	Mean population after 3 sprays	Per cent reduction from control	Yield (t/ ha)
Lufenuron 5.4 EC	20	7.87	3.11abc (1.90)	53.02	46.24	5.93	2.45ab (1.72)	59.07	57.30
Lufenuron 5.4 EC	30	7.93	2.19a (1.64)	67.17	62.72	5.93	1.87a (1.54)	68.75	81.90
Lufenuron 5.4 EC	40	7.73	2.04a (1.59)	68.68	63.04	5.73	1.63a (1.46)	71.80	83.01
Lufenuron 5.4 EC	60	7.80	1.87a (1.54)	71.45	63.12	5.80	1.49a (1.41)	74.80	83.10
Lufenuron 5.4 EC (Cigna)®	30	7.87	2.26ab (1.66)	65.80	62.60	5.87	1.86a (1.54)	68.65	80.80
Indoxacarb 15.8 EC	25	7.93	3.43bc (1.98)	48.50	55.40	5.93	3.39b (1.97)	43.44	76.82
Cartap hydrochloride 50 SP	400	7.87	3.67c (2.04)	44.61	52.88	5.93	3.39b (1.97)	43.39	72.54
Control	-	7.87	6.62d (2.67)	0.00	38.56	5.87	5.93c (2.54)	0.00	49.81
SED			0.4151				0.4861		
CD (0.05)			0.8905				1.0426		

-All values are mean of three replications; - In a column, means followed by same letter(s) are not significantly different at P=0.05 by LSD ; -Values in parentheses are $\sqrt{X+0.5}$ transformed values of five observations.

(Table 2). Reena and Basvanagoud (2008) reported that lufenuron was moderately toxic to *Cotesia plutellae*.

The results of the field experiment conducted at tropical and temperate regions to assess the phytotoxic effect of lufenuron 5.4 EC revealed that cabbage plants sprayed with lufenuron 5.4 EC each at 30, 60 and 120 g a.i./ha doses did not show any phytotoxic effects like epinasty, hyponasty, leaf injury, wilting, vein clearing and necrosis. Clarke and Fleischer (2003) reported that the lepidopteran

Table 2. Effect of lufenuron 5.4 EC against natural enemies, *Cotesia plutellae* on cabbage (tropical and temperate regions)

Treatment	Tropical region (Jahirnayakkanpalayam)				Temperate region (Kotagiri)		
	Dosage (g a.i./ ha)	Pre-treatment population	Mean population after 3 sprays	Per cent reduction from control	Pre-treatment population	Mean population after 3 sprays	Per cent reduction from control
Lufenuron 5.4 EC	20	3.20	3.13abcd (1.91)	8.74	6.80	6.60bc (2.66)	9.59
Lufenuron 5.4 EC	30	3.10	3.00de (1.87)	9.80	6.60	6.40c (2.63)	9.67
Lufenuron 5.4 EC	40	3.10	2.80de (1.82)	15.82	6.80	6.30c (2.61)	13.70
Lufenuron 5.4 EC	60	3.00	2.70e (1.79)	16.12	6.75	6.20c (2.59)	14.44
Lufenuron 5.4 EC (Cigna)®	30	3.20	3.00cde (1.87)	12.62	6.80	6.50c (2.65)	10.96
Indoxacarb 15.8 EC	25	3.30	1.95bc (1.57)	44.83	6.75	3.80b (2.07)	47.56
Cartap hydrochloride 50 SP	400	3.10	2.02b (1.59)	39.37	6.80	4.65b (2.27)	36.30
Control	-	3.20	3.43a (1.98)	0.00	6.80	7.30a (2.79)	0.00
SED			0.5657			0.4861	
CD (0.05)			1.2135			1.0426	

-All values are mean of three replications; - In a column, means followed by same letter(s) are not significantly different at P=0.05 by LSD ; -Values in parentheses are $\sqrt{X+0.5}$ transformed values of five observations.

pests like *Spodoptera exigua* of vegetables needed safer insecticides like emamectin benzoate with least phytotoxic effects with efficient control of the insect pests. Phytotoxicity scores recorded zero on all leaf damage parameters during the course of investigation and thus, safety of lufenuron to plants was evident.

The yield of cabbage was also high in lufenuron @ 60 g a.i/ha treated plots. A maximum of 63.12 t/ha and 83.10 t/ha was observed in tropical and temperate region respectively which corresponds was more than 60 per cent compared to the control which recorded 38.56 t/ha and 49.81 t/ha in tropical and temperate region respectively. Nagesh and Verma (1997), reported that the application of lufenuron to cabbage farms in India led to a great increase in cabbage yield as well as a high mortality of the DBM larvae. Similar studies by Kim *et al*. (2000) revealed that lufenuron was highly effective (> 80 %) against the DBM larvae in South Korea. Ananth (2011) also recorded yield ranging from 61.40 to 74.50 t/ha.

Thus, it could be inferred that lufenuron 5.4 EC @ 60 g a.i/ha was effective in containing the larval population of DBM with higher yield without detriment to the larval parasitoid, *Cotesia plutellae* and phytotoxic effects and hence could be used under field conditions.

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