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Evaluation of Chitin Synthesis Inhibitor, lufenuron 5.4 EC against *Maruca vitrata* (Geyer) in Blackgram

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Two field experiments were conducted during October 2011 – January 2012 and October 2012 to January 2013 with blackgram variety CO 6 and CO 5 in farmer's holdings at Kaliannanpudur and Valayapalayam, Coimbatore, respectively to evaluate the efficacy of lufenuron 5.4 EC at 20, 30, 40 and 60 g a.i. ha^{-1} against *Maruca vitrata* (Geyer). In the field experiments, lufenuron 5.4 EC at 60 g a.i. ha^{-1} reduced the flower damage by 66.05 and 88.37 per cent, respectively over untreated control after three rounds of spraying and cumulative reduction of flower damage was 56.07 and 74.60 per cent. The population of spiders was high in untreated control (5.51 and 6.53 per 10 plants, respectively), followed by lufenuron 5.4 EC at 20 g a.i. ha^{-1} (5.16 and 5.97 per 10 plants, respectively) which was on par with lufenuron 5.4 EC at 30 g, 40 g and 60 g a.i. ha^{-1}. The highest yields of 900.50 kg ha^{-1} and 937.50 kg ha^{-1}, respectively were obtained in plots treated with lufenuron 5.4 EC at 60 g a.i. ha^{-1} in both trials.

Key words: IGR, lufenuron, *Maruca vitrata*, Blackgram, Bio-efficacy, Yield.

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Blackgram, *Vigna mungo* (L) Hepper (Family: Fabaceae) also known as urdbean, mash, black maple *etc* . an important short -duration pulse crop is grown in many parts of India. Black gram originated in India, where it has been in cultivation from ancient times and is one of the most highly prized pulses. This crop is grown in cropping systems as a mixed crop, catch crop and sequential crop besides sole crop under residual moisture conditions and as summer crop under semi-irrigated and dryland conditions. It is grown in 3.10 million ha in India with an annual production of 1.40 million tonnes and productivity of 451.61 kg ha^{-1}. Among the total pulses, the blackgram accounts for 16.28 per cent in area and 11.48 per cent in production. In Tamil Nadu, it is cultivated in an area of 3.41 lakh ha with 1.21 lakh tonnes of production and with a productivity of 358.84 kg ha^{-1} (AICRP Report, 2012).

Pulse crops are attacked by more than 250 species of insects of which gram pod borer, *Helicoverpa armigera* (Hubner) (Noctuidae: Lepidoptera) and legume pod borer or spotted pod borer, *Maruca vitrata* (Geyer) (Crambidae: Lepidoptera) are the most important polyphagous pests in both tropics and sub-tropics because of their extensive host range, destructiveness and distribution on cowpea, mungbean, urdbean and field bean (Shanower *et.al.,* 1999). Insecticides have been successfully used against pod borers of pulses. Many insecticides were found effective against pod borers in pigeonpea (Yadav and Dahiya, 2004; Sreekanth and Seshamahalakshmi, 2012).

Maruca is basically a hidden pest and completes its larval development inside the web formed by rolling and tying together leaves, flowers, buds and pods. This typical concealed mode of feeding protects the larvae from natural enemies, human interventions or other adverse factors including insecticides (Sharma, 1998) . Any management method will be successful only when the first instar larva is killed before gaining safe entry into either flower webs or pods.

Insect growth regulators (IGR's) are the third generation pesticides, with mode of action different from those of conventional products (Ascher, 1993; Thompson *et. al.,* 1999). Lufenuron, is a relatively new member of the acylurea chitin synthesis inhibitor and has been effective against the embryonic and larval stages of Lepidoptera, Coleoptera and Thysanoptera. Pod borers in black gram have attained major pest status because of their capabilities to replace existing biotypes, invading new geographical ranges and rapidly developing resistance to new insecticides. The mode of action for chitin synthesis inhibitors is to block an important enzyme, called chitin synthase, which is directly responsible for the conversion of certain chemicals into chitin. In the absence of this enzyme, chitin cannot be synthesized. The prevention of chitin synthesis is fatal for the insect. Larval body parts that contain chitin such as the foregut, hindgut, peritrophic membrane, trachea and cuticular glands are also affected by the acylureas (Dean *et al.,*1999). The bioefficacy of this IGR was tested owing to its eco-friendly nature, considered to be less destructive

to ecosystem.

Materials and Methods

Two field experiments were conducted during October 2011 - January 2012 and October 2012 to January 2013 with blackgram variety CO 6 and CO 5 in farmer's holdings at Kaliannanpudur, Coimbatore and Valayapalayam, Coimbatore. There were eight treatments replicated thrice in randomized block design (RBD). The plot size was 9 m´ 5 m and the cultivars used were CO 6 and CO 5 (long duration. The treatments included lufenuron 5.4 EC @ 20, 30, 40 and 60 g. a.i. ha^{-1}. The checks used were indoxacarb 15.8 EC @75 g. a.i./ ha and quinalphos 25 EC @ 500 g. a.i. ha^{-1}. The foliar spraying of the insect growth chemicals were imposed three times during flowering stage (35 days after sowing- DAS) using pneumatic high volume knapsack sprayer with 500 litres of spray fluid per hectare. The sprays were given during morning hours in such a way to give uniform coverage on foliage and to avoid drift.

The flower damage per cent was assessed based on the webbing by *M. vitrata* on the flower bunches prior to spraying and on 3, 7, 10 and 14 days after spraying from ten randomly tagged plants per plot and the mean was worked out. Observations were also made on the occurrence of the number of spiders and coccinellids in 10 randomly marked plants from each plot. Per cent damage was worked out using following formula. Blackgram pods after maturity were harvested from each plot and yield recorded per hectare.

$$\text{Flower damage (\%)} = \frac{\text{Number of damaged/webbed flower}}{\text{Total number of flower bunches observed}} \text{X } 100$$

The damage on flowers was assessed using the formula given below.

Statistical analysis

The analysis of variance (ANOVA) was carried out by randomized block design using IRRISTAT Ver 3.1. The data obtained were transformed using arcsine transformation. The mean values of treatments were then separated by Duncan's Multiple Range Test (DMRT).

Results and Discussion

The results revealed that the flower damage by *M. vitrata* before imposing treatments ranged from 8.42 to 9.84 per cent (Table 1). After first spraying, the highest overall mean per cent reduction over control was recorded in plots treated with lufenuron 5.4 EC 60 g a.i. ha^{-1} (8.84 per cent flower damage with 43.20 PR) and indoxacarb 15.8 EC 75 g a.i. ha^{-1} (8.65 per cent with 44.46 PR), which was on par with lufenuron 5.4 EC 40 g and 30 g a.i. ha^{-1} (9.93 and 10.26 per cent damage with 36.19 and 34.10 PR), lufenuron 5.4 EC 30 g a.i. ha^{-1} and quinalphos 25 EC 500 g a.i. ha^{-1} with 10.39 per cent and 8.95 per cent damage with 33.26 and 42.50 per cent reduction over control, respectively. The lowest flower damage was recorded in lufenuron 5.4 EC at 20 g a.i. ha^{-1} (10.50 % 32.57 PR). The untreated control recorded the highest flower damage of 15.57 per cent (Table 1).

Table 1. Evaluation of lufenuron 5.4 EC against *M. vitrata* (Gey.) flower damage in black gram (Location: Kaliannanpudur - I season)

Treatment	Dose (g a.i. ha^{-1})	Flower damage (%)·								
		PTC	I spraying	PR	II spraying	PR	III spraying	PR	Cumulative mean	PR
Lufenuron 5.4 EC	20	9.00	10.50_{b}(18.90)	32.57	8.92_{a}(17.38)	51.84	6.30_{ab}(14.85)	46.93	8.57(17.02)	44.06
Lufenuron 5.4 EC	30	8.90	10.26_{ab}(18.68)	34.10	8.64_{a}(17.10)	53.34	5.52_{b}(14.59)	53.50	8.14(16.58)	46.87
Lufenuron 5.4 EC	40	9.84	9.93_{ab}(18.37)	36.19	7.51_{a}(15.91)	59.43	4.77_{a}(12.62)	59.81	7.40(15.79)	51.70
Lufenuron 5.4 EC	60	8.84	8.84_{ab}(17.30)	43.20	7.34_{a}(15.72)	60.38	4.03_{a}(12.29)	66.05	6.73(15.04)	56.07
Lufenuron 5.4 EC (standard check)	30	8.51	10.39_{ab}(18.80)	33.26	8.57_{a}(17.02)	53.76	6.67_{b}(15.06)	43.81	8.54(16.99)	44.26
Indoxacarb 15.8EC	75	8.42	8.65_{a}(17.10)	44.46	7.71_{a}(16.12)	58.36	7.27(15.64)	38.76	7.88(16.30)	48.56
Quinalphos 25EC	500	9.43	8.95_{ab}(17.41)	42.50	8.76_{a}(17.22)	52.69	6.84(15.16)	42.42	8.18(16.62)	46.61
Control		9.33	15.57_{c}(23.24)	-	18.52_{b}(25.49)	-	11.87(20.15)	-	15.32(23.04)	-

PTC – Pre Treatment Count

PR: Per cent reduction over control

Figures in parentheses are arcsine transformed values

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

·Mean of three replications

After second spraying, at 7 DAT and 14 DAT there was no significant difference between treatments. The highest mean reduction was recorded in plots treated with lufenuron 5.4 EC at 60 g a.i. ha^{-1} (60.38 PR), which was on par with lufenuron 5.4 EC at 40 g, 30 g and 20 g a.i. ha^{-1} that recorded 59.43, 53.34 and 51.84 per cent damage respectively. Indoxacarb 15.8 EC 75 g a.i. ha^{-1} and quinalphos 25 EC 500 g a.i. ha^{-1} recorded 58.36 and 52.69 per cent reduction over control (Table 1). After third round of spraying, on 7 DAT there was no significant difference between the treatments.

After third spraying the highest mean reduction over control was recorded in plots treated with lufenuron 5.4 EC at 60 g a.i. ha^{-1} (66.05 PR), which was on par with lufenuron 5.4 EC at 40 g a.i. ha^{-1} and 30 g a.i. ha^{-1} (59.81 PR and 53.50 PR respectively). Lufenuron 5.4 EC 20 g a.i. ha^{-1} (46.93 PR) and the lowest was recorded in indoxacarb 15.8

Table 2. Evaluation of lufenuron 5.4 EC against *M. vitrata* (Gey.) flower damage in black gram (Location: Valayapalayam - II season)

Treatment	Dose	Flower damage (%)*								
	(g a.i. ha^{-1})	PTC	I spraying	PR	II spraying	PR	III spraying	PR	Cumulative mean	PR
Lufenuron 5.4 EC	20	19.05	28.80c(32.44)	26.63	24.13bc(29.42)	53.80	15.65b(23.30)	65.15	23.48(28.98)	49.30
Lufenuron 5.4 EC	30	19.25	25.14bc(30.06)	34.71	23.02bc(28.67)	55.92	14.45b(22.34)	67.82	21.58(27.68)	53.39
Lufenuron 5.4 EC	40	20.04	18.49ab(25.47)	51.51	15.71a(23.35)	69.93	6.78a(15.09)	84.90	14.02(21.99)	69.73
Lufenuron 5.4 EC	60	19.25	16.37a(23.85)	58.37	12.66a(20.84)	75.76	5.22a(13.21)	88.37	11.76(20.05)	74.60
Lufenuron 5.4 EC (standard check)	30	19.44	24.51bc(29.67)	35.44	24.76c(29.84)	52.59	15.51b(23.19)	65.46	22.41(28.26)	51.59
Indoxacarb 15.8EC	75	20.37	15.52ab(22.99)	51.83	17.96ab(25.08)	65.61	7.31a(15.69)	83.72	15.13(22.89)	67.32
Quinalphos 25EC	500	20.63	16.06ab(22.85)	47.99	22.79bc(28.52)	56.36	13.96b(21.94)	68.90	19.50(26.20)	57.89
Control		19.44	39.97d(39.19)	-	52.23d(46.28)	-	44.90c(42.07)	-	46.30(42.88)	-

PTC – Pre Treatment Count; PR: Per cent reduction over control; Figures in parentheses are arcsine transformed values; In a column, means followed by a common letter(s) are not significantly different by DMRT (P=0.05); *Mean of three replications

EC 75 g a.i. ha^{-1}(38.76 PR) treated plots (Table 1).

The cumulative mean results obtained from the first season blackgram trial (Kaliannanpudur) after completion of three sprayings, the minimum flower damage was recorded in lufenuron 5.4 EC at 60 g a.i. ha^{-1} (6.73 % flower damage and 56.07) per cent reduction over control). Lufenuron 5.4 EC at 40 g a.i. ha^{-1} with 7.40 per cent and 51.70 per cent reduction over control, respectively. The highest damage was recorded in standard checks indoxacarb 15.8 EC 75 g a.i. ha^{-1} (7.88 %) and quinalphos 25 EC 500 g a.i. ha^{-1} (8.18 %) with 48.56 and 46.61 per cent reduction over control, respectively (Table 1). The

Table 3. Effect of lufenuron 5.4 EC on spider population in blackgram ecosystem (cumulative mean)*

Treatment	Dose (g a.i. ha^{-1})	Kaliannanpudur (I season)		Valayapalayam (II season)	
		PTC	Cumulative mean	PTC	Cumulative mean
Lufenuron 5.4 EC	20	5.33	5.16a(2.27)	6.67	5.97a(2.44)
Lufenuron 5.4 EC	30	5.33	5.24a(2.29)	6.67	6.10a(2.47)
Lufenuron 5.4 EC	40	5.00	5.16a(2.27)	7.00	6.09a(2.47)
Lufenuron 5.4 EC	60	5.33	5.14a(2.27)	6.67	5.91a(2.43)
Lufenuron 5.4 EC (standard check)	30	5.33	5.21a(2.28)	7.00	5.77a(2.40)
Indoxacarb 15.8EC	75	5.33	1.86b(1.36)	7.00	2.82b(1.68)
Quinalphos 25EC	500	5.00	1.29c(1.13)	7.33	2.35b(1.53)
Control		5.33	5.51a(2.35)	7.00	6.53a(2.56)

PTC- Pre Treatment count
PR- Per cent reduction over untreated control
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 value
* - Number of spiders per ten plants and mean of three replications

treated larval instars became lethargic, moribund, unable to feed and remained at one spot for many days before death. Reports of suppressed larval feeding or feeding deterrence were earlier recorded in *H. virescens and Spodoptera litura* and this could be due to the formation of poorly developed and unsclerotized mouth parts (Granett and Hejazi, 1983; Neuman and Guyer, 1987).

In the second season trial, the results revealed that the flower damage before imposing treatments ranged from 19.05 to 20.63 (Table 2). There was significant reduction in flower damage after first spraying and the minimum flower damage was recorded in lufenuron 5.4 EC 60 g a.i. ha^{-1} (16.37 per cent) followed by lufenuron 5.4 EC 40 g a.i. ha^{-1} (18.49 per cent). The maximum per cent was recorded in lufenuron 5.4 EC 20 g a.i. ha^{-1} as 28.80 per cent during the first spray (Table 2).

After second spraying the highest mean per cent reduction in flower damage was recorded in plots treated with lufenuron 5.4 EC at 60 g and 40 g a.i. ha^{-1} (75.76 and 69.93 PR) followed by indoxacarb 15.8 EC at 75 g a.i. ha^{-1} (65.61 per cent). Lufenuron 5.4 EC at 30 g and 20 g a.i. ha^{-1} recorded (55.92, 53.80 per cent, respectively), quinalphos 25 EC at 500 g a.i. ha^{-1} (56.36 per cent) and check lufenuron 5.4 EC 30 g a.i. ha^{-1} (52.59 per cent), while the untreated control recorded 52.23 per cent flower damage (Table 2).

After third round of spraying, the flower damage levels in lufenuron 5.4 EC at 60 g and 40 g a.i. ha^{-1} were 5.22 and 6.78 per cent with 88.37 and 84.90 PR followed by indoxacarb 15.8 EC 75 g a.i. ha^{-1} (7.31 per cent) and lufenuron 5.4 EC 30 g, 20 g a.i. ha^{-1} (14.45, 15.65 per cent damage, respectively). The check lufenuron 5.4 EC 30 g a.i. ha^{-1} recorded 15.51 per cent flower damage with 65.46 PR) and quinalphos 25 EC at 500 g a.i. ha^{-1} had 13.96 per cent flower damage. The untreated control recorded 44.90 per cent flower damage (Table 2).

The cumulative mean flower damage in the II season after completion of three sprayings was the minimum in lufenuron 5.4 EC at 60 g a.i. ha^{-1} (11.76

Table 4. Efect of lufenuron 5.4 EC on blackgram yield

Treatment	Dose (g a.i. ha^{-1})	Kaliannanpudur*		Valayapalayam*	
		Grain yield (kg ha^{-1})	Increase over control (%)	Grain yield (kg ha^{-1})	Increase over control (%)
Lufenuron 5.4 EC	20	700.25c	55.27	729.19c	58.34
Lufenuron 5.4 EC	30	840.50a	79.71	911.44a	97.91
Lufenuron 5.4 EC	40	875.20a	94.06	911.81a	97.99
Lufenuron 5.4 EC	60	900.50a	99.67	937.50a	103.57
Lufenuron 5.4 EC (standard check)	30	805.15b	78.53	844.13b	82.48
Indoxacarb 15.8EC	75	805.50b	78.60	862.88b	83.30
Quinalphos 25EC	500	800.50b	77.49	840.38b	87.37
Control		451.00d	-	460.53d	-

*****Mean of three replications; In a column, means followed by a common letter are not significantly different by DMRT (P=0.05)

per cent flower damage and 74.60 PR) followed by lufenuron 5.4 EC at 40 g a.i. ha^{-1} with 14.02 per cent. In indoxacarb 15.8 EC 75 g a.i. ha^{-1} and quinalphos 25 EC 500 g a.i. ha^{-1}, the damage levels were 15.13 and 19.50 per cent, respectively (Table 2).

After hatching, the young larvae of *M. vitrata* (1st, 2nd and 3rd instars) especially injured the terminal shoots and flower buds whereas, the older larvae (4th and 5th larval instars) particularly damaged the open flowers and pods. The larvae feed from inside a webbed mass of leaves, flowers, flower buds and pods. Older larvae were highly mobile, feeding continuously on flowers and newly formed pods, causing severe damage throughout the reproductive cycle of the crop. It is essential to kill the first instar larvae at the period when they hatch to till they enter the flowers and buds as documented by Yadav and Dahiya, (2004), Subharani and Singh (2010). Fenoxycarb + lufenuron acted faster against the first two larval instars of *Lymantria dispar* (LT $_{50}$ values were 0.99 and 1.81 days, respectively) as reported by Zartaloudis *et. al*. (2009). Herbert and Harper (1985) observed, the first instars of the corn ear worm, *Heliothis zea* (Boddie), to die more rapidly over a seven day period when exposed to the acylurea CME 134.

Effect of lufenuron on spiders in blackgram

In the first season experiment at Kaliannanpudur, the pretreatment population of spiders ranged from 5.00 to 5.33 per ten plants in treatments (Table 3). The cumulative mean after three rounds of spraying revealed that the numbers of spiders were higher in untreated control (5.51 per 10 plants) and in lufenuron treatments it ranged from 5.14 – 5.24 / 10 plants) and all were on par. Indoxacarb 14.5 SC at 75 g a.i. ha^{-1} (1.86 per 10 plants) and quinalphos 25 EC 500 g a.i. ha^{-1} (1.29 spiders per ten plants) had significantly lower spider numbers.

In the second season trial at Valayapalayam, the pre-treatment population of spiders ranged from 6.67 to 7.33 per ten plants in treatments. Although there was slight reduction in the population immediately after first spraying, there was progressive recovery in the population after three sprayings. The untreated control and all Chitin synthesis inhibitor (CSI) treatments had high number of spiders (5.77 – 6.10/ 10 plants). The cumulative mean after three sprayings revealed that the number of spiders was higher in untreated control (6.53 per 10 plants) followed by lufenuron 5.4 EC at 20 g a.i. ha^{-1} (5.97 per 10 plants), which was on par with lufenuron 5.4 EC at 30 g, 40 g and 60 g (6.10, 6.09 and 5.91 per 10 plants) and lufenuron 5.4 EC 30 g a.i. ha^{-1} (5.77 per 10 plants). The lowest spider numbers was in indoxacarb 14.5 SC at 75 g a.i. ha^{-1} (2.82 per 10 plants)and quinalphos 25 EC 500 g a.i. ha^{-1} (2.35 spiders per ten plants) (Table 3).

The yield was significantly higher in all the insecticidal treatments than untreated control at Kaliannanpudur (Table 4). The highest yield of 900.50 kg 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} (875.20 kg, 840.50 kg ha^{-1} respectively) and all were on par. while in the untreated control the yield was 451 kg ha^{-1}. The yield recorded in the Valayalapalayam (II season) also followed the same trend indicating that lufenuron 5.4 EC 60, 40 and 30 recorded 937.50 kg 911.81 kg and 911.44 kg ha^{-1}, respectively. The larvae of *M. vitrata* was considered a major factor limiting yields of cowpea in Nigeria (IITA, 1971) and cowpea, mungbean and pigeonpea in India (Lal *et. al.,* 1985). Thus the pod borer *M. vitrata* of blackgram which caused yield loss can be effectively managed by spraying lufenuron 5.4 EC @ 30 g a.i. ha^{-1} during the initial flowering phase, which resulted in good crop and higher yield.

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