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Research Article

Safety of Newer Insecticides to Natural Enemies in the Irrigated Black Gram Ecosystem of Karaikal, U.T. of Puducherry

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Abstract

A field experiment was conducted at the Eastern farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA and RI), Karaikal during *Kharif* and *Rabi* 2019-2020 to study the effect of newer insecticides to natural enemies of black gram pests. Three foliar applications were carried out at interval of 15 days after pod borer and defoliators reached economic threshold level. The results showed that the highest population of predatory coccinellids was recorded in the untreated check (2.13, 2.54 and 2.86/ plant), followed by azadirachtin 0.03 EC at 2000 ml/ha (1.95,2.12 and 2.02/ plant), chlorantraniliprole 18.5 SC at 100 ml/ha (1.60,1.85 and 1.79/ plant) and flubendiamide 20 WG at 125 g/ha (1.40, 1.60 and 1.63/ plant) during *kharif* 2019. Similar results were also observed in the *rabi* 2019-2020. These newer insecticides can be included in IPM in black gram for sustainable pest management which will maintain natural enemy population compared to synthetic insecticides.

Keywords: newer insecticides, predatory coccinellids, spiders, black gram ecosystem

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Introduction

Black gram (*Vigna mungo* L.) is a short-duration legume crop which belongs to the family, Leguminosae with high level of protein content (26.2%) [1]. Black gram is attacked from 40 to 60 insect species at different stages of the crop growth. On an average, 2.5 to 3.0 million tonnes of pulses are lost annually due to pest problems in India [2]. The natural enemies, predators and parasitoids will impart the effect over the population of black gram pests under favorable environmental conditions. The effect of newer insecticides coragen with different concentration against natural enemies such as ladybird beetles, *Coccinella* spp. and *Scymnus* spp. and spiders in clack gram crop was evaluated by [3]. Several newer insecticides were evaluated in black gram crop to control pod borer complex and defoliators in Karaikal, but their effects over natural enemies of black gram pests were not evident. In irrigated black gram ecosystem of Karaikal, newer insecticides were not evaluated against the major pests of black gram and their performance was not studied on the natural enemies of the pod borer and defoliator complex. Hence, the present investigation was taken up to know the effect of newer insecticides against predatory coccinellids and spiders.

Materials and Methods

The evaluation of newer insecticides against the natural enemies of irrigated black gram, was carried out in the Eastern farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA and RI), Karaikal, U. T. of Puducherry during 2019-2020. The experiment was laid out in a randomized block design (RBD) with nine treatments *viz*., chlorantraniliprole 18.5SC @ 100 ml/ha (T_1), emamectin benzoate 5SG @ 220 g/ha (T2), flubendiamide 20WG @ 125 g/ha (T3), lambda cyhalothrin 2.5EC @ 500 ml/ha (T4), azadirachtin 0.03EC @ 2000 ml/ha (T5), indoxacarb 14.5SC @ 400 ml/ha (T_6), thiodicarb 75WP @ 750 g/ha (T_7), novaluron 10EC @ 750 ml/ha (T_8) and untreated check (Water spray- T_9), which were replicated thrice. The seeds of the variety were sown in the plots (4 x 5 m) with a spacing of 30 x 10 cm. The crop received three foliar applications - first spray during 20 days after sowing (DAS), second spray during 35 DAS (vegetative stage) and third spray during 50 DAS (flowering stage). The populations of natural enemies namely predatory coccinellids and spiders were recorded in the field experiment I (*kharif)* and II (*rabi)*on ten randomly selected plants per plot by leaving the border rows prior to treatment and at 3, 7, 10 and 14 DAT. The total number of natural enemies were counted and expressed as numbers per plant [4]

Results and Discussion

Population of predatory coccinellids

The effect of newer insecticides on the population of predatory coccinellids during *Kharif* 2019 on the black gram variety VBN (Bg) 5 (**Table 1**). The population of predatory coccinellids was observed from 15 DAS and continued upto harvesting. Before the first foliar application, the population of coccinellids ranged from 1.73 to 1.90/ plant and there was no significant difference in the population of predatory coccinellids among the treatments. After the application, the population of predatory coccinellids ranged from 0.33 to 2.00, 0.21 to 2.13, 0.40 to 2.30 and 0.48 to 2.44/ plant at 3, 7, 10 and 14 DAT respectively, irrespective of the treatments. A low population of predatory coccinellids were recorded at 3 DAT and continued upto 7 DAT (0.21 to 2.13/ plant). There was an increasing trend in the population of predatory coccinellids from 10 DAT and continued upto 14 DAT (0.48 to 2.44/ plant). However, the population of predatory coccinellids was higher in untreated check (2.00 to 2.44/ plant), followed by azadirachtin 0.03 EC at 2000 ml/ha (1.90 to 2.30/ plant), chlorantraniliprole 18.5 SC at 1000 ml/ha (1.63 to 2.00/ plant) and flubendiamide 20 WG at 125 g/ha (1.18 to 1.69/ plant) compared to the other treatments. Similar trend was also observed at second foliar application. Before the third foliar application, the population of predatory coccinellids ranged from 0.87 to 2.70/ plant. It was found that after the third foliar application, the population of predatory coccinellids was higher in untreated check (2.80 to 2.98/ plant), followed by azadirachtin 0.03 EC at 2000 ml/ha (1.61 to 2.32/ plant), chlorantraniliprole 18.5 SC at 100 ml/ha (1.40 to 2.00/ plant) and flubendiamide 20 WG at 125 g/ha (1.21 to 1.83/ plant) over the other treatments. Similar trend was also observed during *Rabi* 2019-2020 (**Table 2**).

Table 1 Effect of newer insecticides on the population of predatory coccinellids in the black gram variety VBN (Bg) 5 during *Kharif 2019* (Field experiment I)

T	Conc. ml/g per ha	Number of predatory coccinellids/ plant #														
		I Foliar application					II Foliar application					III Foliar application				
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT
T1	100	1.87 (1.36)	1.21 (1.03)^c	1.63 (1.27)^c	1.80 (1.34)^c	2.00 (1.41)^c	2.00 (1.41)^c	1.80 (1.32)^c	1.65 (1.28)^c	1.93 (1.38)^c	2.00 (1.41)^c	2.00 (1.41)^c	1.91 (1.38)^c	1.40 (1.18)^c	1.83 (1.35)^c	2.00 (1.41)^c
T2	220	1.84 (1.33)	0.71 (0.95)^e	0.97 (0.98)^e	1.33 (1.15)^e	1.40 (1.18)^e	1.40 (1.18)^e	1.30 (1.41)^e	1.11 (1.05)^e	1.41 (1.18)^e	1.60 (1.26)^e	1.60 (1.26)^e	1.51 (1.22)^e	1.00 (1.00)^e	1.50 (1.22)^e	1.62 (1.27)^e
T3	125	1.80 (1.34)	0.96 (1.13)^d	1.18 (1.08)^d	1.50 (1.22)^d	1.69 (1.30)^d	1.69 (1.30)^d	1.58 (1.25)^d	1.40 (1.18)^d	1.60 (1.26)^d	1.90 (1.38)^d	1.90 (1.38)^d	1.81 (1.34)^d	1.21 (1.09)^d	1.62 (1.27)^d	1.83 (1.35)^d
T4	500	1.80 (1.34)	0.33 (0.48)^i	0.21 (0.45)^i	0.40 (0.62)^i	0.48 (0.68)^i	0.48 (0.68)^i	0.37 (0.60)^i	0.17 (0.40)^i	0.72 (0.85)^i	0.87 (0.93)^i	0.87 (0.93)^i	0.62 (0.78)^i	0.30 (0.54)^i	0.85 (0.92)^i	1.00 (1.00)^i
T5	2000	1.80 (1.34)	1.84 (1.32)^b	1.90 (1.37)^b	2.01 (1.41)^b	2.30 (1.51)^b	2.30 (1.51)^b	2.10 (1.44)^b	1.90 (1.37)^b	2.00 (1.41)^b	2.41 (1.55)^b	2.41 (1.55)^b	2.00 (1.41)^b	1.61 (1.26)^b	2.00 (1.41)^b	2.32 (1.52)^b
T6	400	1.80 (1.34)	0.81 (0.85)^f	0.78 (0.88)^f	0.92 (0.95)^f	1.13 (1.06)^f	1.13 (1.06)^f	0.93 (0.96)^f	0.86 (0.92)^f	1.20 (1.09)^f	1.30 (1.14)^f	1.30 (1.14)^f	1.21 (1.09)^f	0.93 (0.96)^f	1.31 (1.14)^f	1.52 (1.23)^f
T7	750	1.90 (1.37)	0.49 (0.66)^h	0.47 (0.68)^h	0.57 (0.75)^h	0.68 (0.82)^h	0.68 (0.82)^h	0.60 (0.77)^h	0.37 (0.60)^h	0.82 (0.90)^h	0.98 (0.98)^h	0.98 (0.98)^h	0.72 (0.85)^h	0.53 (0.72)^h	1.00 (1.00)^h	1.31 (1.14)^h
T8	750	1.73 (1.31)	0.62 (0.75)^g	0.63 (0.79)^g	0.76 (0.86)^g	0.90 (0.94)^g	0.90 (0.94)^g	0.77 (0.87)^g	0.63 (0.79)^g	1.00 (1.00)^g	1.10 (1.05)^g	1.10 (1.05)^g	1.00 (1.00)^g	0.74 (0.86)^g	1.07 (1.03)^g	1.41 (1.18)^g
T9	-	1.83 (1.35)	2.00 (1.41)^a	2.13 (1.46)^a	2.30 (1.54)^a	2.44 (1.56)^a	2.44 (1.56)^a	2.46 (1.56)^a	2.54 (1.59)^a	2.60 (1.61)^a	2.70 (1.64)^a	2.70 (1.64)^a	2.80 (1.67)^a	2.89 (1.70)^a	2.90 (1.70)^a	2.98 (1.72)^a
S. Ed.		0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.04	0.04	0.01	0.01	0.02	0.04	0.03	0.04
CD(P=0.05)		NS	0.04*	0.10*	0.10*	0.03*	0.03*	0.17*	0.18*	0.02*	0.002*	0.002*	0.01*	0.02*	0.02*	0.01*

In a column mean followed by a common letter are not significantly different by DMRT (P=0.05)
Values in Parentheses are $\sqrt{X + 0.5}$ transformed values
* - Significant at P = 0.05; #-Mean of 3 replications; PTC- Pretreatment count; DAT- Day after treatments

The overall mean population of predatory coccinellids ranged at 1st, 2nd and 3rd foliar application ranged from 0.58 to 2.13, 0.68 to 2.54 and 0.69 to 2.86/ plant irrespective of treatments during kharif 2019 (Table 1). The highest population of predatory coccinellids was recorded in the untreated check (2.13, 2.54 and 2.86/ plant), followed by azadirachtin 0.03 EC at 2000 ml/ha (1.95,2.12 and 2.02/ plant), chlorantraniliprole 18.5 SC at 100 ml/ha (1.60,1.85 and 1.79/ plant) and flubendiamide 20 WG at 125 g/ha (1.40, 1.60 and 1.63/ plant). Similar trend was repeated in *Rabi* 2019-2020 (Table 5).

Table 2 Effect of newer insecticides on the population of predatory coccinellids in the black gram variety VBN (Bg) 5 during *Rabi* 2019-2020 (Field experiment II)

T	Conc. ml/g per ha	Number of predatory coccinellids/ plant #														
		I Foliar application					II Foliar application					III Foliar application				
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT
T1	100	1.47 (1.20)	1.10 (1.05)^{c}	0.81 (0.89)^{c}	0.90 (0.95)^{c}	1.41 (1.18)^{c}	1.41 (1.18)^{c}	1.21 (1.09)^{c}	1.00 (1.04)^{c}	1.21 (1.00)^{c}	1.31 (1.09)^{c}	1.31 (1.09)^{c}	1.00 (1.00)^{c}	0.81 (0.90)^{c}	1.91 (1.38)^{c}	2.21 (1.48)^{c}
T2	220	1.40 (1.68)	0.90 (0.95)^{e}	0.60 (0.77)^{e}	0.71 (0.84)^{e}	1.21 (1.10)^{e}	1.21 (1.10)^{e}	1.00 (1.00)^{e}	0.81 (0.95)^{e}	1.00 (0.89)^{e}	1.11 (1.00)^{e}	1.11 (1.00)^{e}	0.81 (0.89)^{e}	0.62 (0.78)^{e}	1.73 (1.31)^{e}	2.00 (1.41)^{e}
T3	125	1.43 (1.18)	1.00 (1.00)^{d}	0.71 (0.84)^{d}	0.80 (0.89)^{d}	1.31 (1.14)^{d}	1.31 (1.14)^{d}	1.10 (1.04)d	0.91 (1.00)^{d}	1.10 (0.95)^{d}	1.21 (1.04)^{d}	1.21 (1.04)^{d}	0.91 (0.95)^{d}	0.70 (0.83)^{d}	1.83 (1.35)^{d}	2.11 (1.45)^{d}
T4	500	1.70 (1.28)	0.50 (0.70)^{i}	0.21 (0.45)^{i}	0.30 (0.55)^{i}	0.81 (0.89)^{i}	0.81 (0.89)^{i}	0.61 (0.78)^{i}	0.41 (0.72)^{i}	0.60 (0.63)^{i}	0.71 (0.77)^{i}	0.71 (0.77)^{i}	0.41 (0.63)^{i}	0.21 (0.46)^{i}	1.31 (1.14)^{i}	1.61 (1.26)^{i}
T5	2000	1.33 (1.13)	1.20 (1.09)^{b}	0.90 (0.95)^{b}	1.10 (1.04)^{b}	1.51 (1.22)^{b}	1.51 (1.22)^{b}	1.31 (1.14)^{b}	1.10 (1.09)^{b}	1.30 (1.04)^{b}	1.41 (1.14)^{b}	1.41 (1.14)^{b}	1.10 (1.05)^{b}	0.91 (0.95)^{b}	2.00 (1.41)^{b}	2.30 (1.51)^{b}
T6	400	1.50 (1.22)	0.81 (0.89)^{f}	0.50 (0.70)^{f}	0.60 (0.77)^{f}	1.10 (1.04)^{f}	1.10 (1.04)^{f}	0.90 (0.95)^{f}	0.71 (0.89)^{f}	0.92 (0.84)^{f}	1.00 (1.14)^{f}	1.00 (1.14)^{f}	0.71 (0.84)^{f}	0.52 (0.72)^{f}	1.62 (1.27)^{f}	1.91 (1.38)^{f}
T7	750	1.47 (1.91)	0.60 (0.77)^{h}	0.31 (0.55)^{h}	0.41 (0.63)^{h}	0.90 (0.95)^{h}	0.90 (0.95)^{h}	0.71 (0.84)^{h}	0.50 (0.78)^{h}	0.72 (0.70)^{h}	0.80 (0.90)^{h}	0.80 (0.90)^{h}	0.50 (0.70)^{h}	0.31 (0.55)^{h}	1.41 (1.18)^{h}	1.71 (1.30)^{h}
T8	750	1.33 (1.15)	0.71 (0.84)^{g}	0.40 (0.63)^{g}	0.50 (0.70)^{g}	1.00 (1.00)^{g}	1.00 (1.00)^{g}	0.80 (0.89)^{g}	0.61 (0.84)^{g}	0.82 (0.77)^{g}	0.92 (0.90)^{g}	0.92 (0.90)^{g}	0.61 (0.77)^{g}	0.41 (0.64)^{g}	1.52 (1.23)^{g}	1.81 (1.34)^{g}
T9	-	1.50 (1.22)	1.73 (1.31)^{a}	1.78 (1.33)^{a}	1.79 (1.33)^{a}	1.80 (1.34)^{a}	1.80 (1.34)^{a}	1.82 (1.34)^{a}	1.84 (1.35)^{a}	1.85 (1.35)^{a}	1.86 (1.36)^{a}	1.86 (1.36)^{a}	1.88 (1.37)^{a}	1.91 (1.38)^{a}	1.91 (1.38)^{a}	1.94 (1.39)^{a}
S. Ed.		0.13	0.002	0.004	0.002	0.001	0.001	0.002	0.01	0.001	0.002	0.002	0.002	0.01	0.01	0.01
CD(P=0.05)		NS	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*

In a column mean followed by a common letter are not significantly different by DMRT (P=0.05) Values in Parentheses are $\sqrt{X+0.5}$ transformed values
* - Significant at P = 0.05; #-Mean of 3 replications; PTC- Pretreatment count; DAT- Day after treatments

Population of predatory spiders

The effect of newer insecticides on the population of spider during *Kharif* 2019 on the black gram variety VBN (Bg) 5 are presented in **Table 3**. The population of spiders was observed from 15 days after sowing (DAS) and continued upto harvesting. Before the first foliar application, the population of spiders ranged from 2.30 to 2.43/ plants and there was no significant difference in the population of spiders among the treatments.At 3 DAT, the population of spiders ranged from 1.14 to 2.43/ plant. The highest population was recorded in the untreated check 2.43/ plant, followed by azadirachtin 0.03 EC at 2000 ml/ha (2.25/ plants), chlorantraniliprole 18.5 SC at 100 ml/ha (2.11/ plant), and flubendiamide 20 WG at 125 g/ha (1.95/ plant). The other treatments registered a low population of spiders which ranged from 1.14 to 1.82/ plant. Similar trend was also observed at 7 DAT. There was an increasing trend in the population of spiders from 10 DAT and continued upto 14 DAT (1.15 to 3.15/ plant), irrespective of treatments. However, the population of spiders was higher in the untreated check (2.43 to 3.15/ plant), followed by azadirachtin 0.03 EC at 2000 ml/ha (2.09 to 2.85/plant), chlorantraniliprole 18.5 SC 100 ml/ha (1.88 to 2.56/ pant), and flubendiamide 20 WG at 125 g./ha (1.61 to 2.28/ plant) than the other treatments. Similar trend was also observed at second foliar application. Before the third foliar application, the population of spiders ranged from 1.50 to 3.70/ plant. After the third foliar application, a low population of spiders was low at 3 DAT and continued upto 7 DAT which ranged from 0.83 to 4.00/ plant, irrespective of the treatments. It was found that the population of spider was higher in the untreated check (3.73 to 4.33/ plant), followed by azadirachtin 0.03 EC at 2000 ml /ha (3.10 to 3.60/ plant), chlorantraniliprole 18.5 SC 100 ml/ha (2.57 to 2.97/ plant) and flubendiamide 20 WG at 125 g/ha (2.33 to 2.67/ plant) than the other treatments. Similar trend was observed in *Rabi* 2019-2020 (**Table 4**)

The overall mean population of predatory spiders ranged at 1st, 2nd and 3rd foliar application ranged from 1.21 to 2.64, 1.18 to 3.39 and 1.20 to 3.96/ plant irrespective of treatments during kharif 2019 (Table 1). The highest population of predatory spiders was recorded in the untreated check (2.64, 3.39 and 3.96/ plant), followed by azadirachtin 0.03 EC at 2000 ml/ha (2.38, 2.98 and 3.34/ plant), chlorantraniliprole 18.5 SC at 100 ml/ha (2.20, 2.66 and 2.85 / plant) and flubendiamide 20 WG at 125 g/ha (2.49, 2.40 and 2.69/ plant). Similar trend was repeated in *Rabi* 2019-2020 (**Table 5**).

Table 3 Effect of newer insecticides on the population of predatory spiders in the black gram variety VBN (Bg) 5 during *Kharif 2019* (Field experiment I)

T	Conc. ml/g per ha	Number of predatory spiders / plant #														
		I Foliar application					II Foliar application					III Foliar application				
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT
T1	100	2.33 (1.59)	2.11 (1.45)^{c}	1.88 (1.37)^{c}	2.30 (1.51)^{c}	2.56 (1.59)^{c}	2.56 (1.59)^{c}	2.37 (1.53)^{c}	2.00 (1.68)^{c}	2.95 (1.71)^{c}	3.08 (1.75)^{c}	3.08 (1.75)^{c}	2.97 (1.72)^{c}	2.57 (1.60)^{c}	2.77 (1.66)^{c}	2.97 (1.72)^{c}
T2	220	2.43 (1.43)	1.82 (1.38)^{e}	1.46 (1.20)^{e}	1.83 (1.35)^{e}	2.05 (1.43)^{e}	2.05 (1.43)^{e}	1.92 (1.38)e	1.55 (1.51)^{e}	2.50 (1.58)^{e}	2.53 (1.59)^{e}	2.53 (1.59)^{e}	2.44 (1.56)^{e}	2.11 (1.46)^{e}	2.30 (1.51)^{e}	2.47 (1.57)^{e}
T3	125	2.35 (1.51)	1.95 (1.39)^{d}	1.61 (1.26)^{d}	2.07 (1.43)^{d}	2.28 (1.51)^{d}	2.28 (1.51)^{d}	2.15 (1.46)d	1.88 (1.59)^{d}	2.74 (1.65)^{d}	2.80 (1.67)^{d}	2.80 (1.67)^{d}	2.67 (1.63)^{d}	2.33 (1.52)^{d}	2.47 (1.57)^{d}	2.67 (1.63)^{d}
T4	500	2.40 (1.07)	1.14 (1.06)^{i}	0.76 (0.87)^{i}	0.97 (0.98)^{i}	1.15 (1.07)^{i}	1.15 (1.07)^{i}	1.01 (1.00)^{i}	1.22 (1.10)^{i}	1.37 (1.16)^{i}	1.50 (1.22)^{i}	1.50 (1.22)^{i}	1.44 (1.20)^{i}	0.83 (0.91)^{i}	0.97 (0.98)^{i}	1.27 (1.12)^{i}
T5	2000	2.30 (1.68)	2.25 (1.50)^{b}	2.09 (1.44)^{b}	2.57 (1.60)^{b}	2.85 (1.68)^{b}	2.85 (1.68)^{b}	2.70 (1.64)b	2.45 (1.77)^{b}	3.20 (1.78)^{b}	3.38 (1.83)^{b}	3.38 (1.83)^{b}	3.20 (1.78)^{b}	3.10 (1.81)^{b}	3.43 (1.85)^{b}	3.60 (1.89)^{b}
T6	400	2.33 (1.34)	1.71 (1.30)^{f}	1.27 (1.12)^{f}	1.62 (1.27)^{f}	1.82 (1.34)^{f}	1.82 (1.34)^{f}	1.73 (1.31)f	1.11 (1.42)^{f}	2.20 (1.48)^{f}	2.27 (1.50)^{f}	2.27 (1.50)^{f}	2.14 (1.46)^{f}	1.77 (1.32)^{f}	2.03 (1.42)^{f}	2.13 (1.46)^{f}
T7	750	2.36 (1.16)	1.40 (1.18)^{h}	0.91 (0.95)^{h}	1.21 (1.09)^{h}	1.36 (1.16)^{h}	1.36 (1.16)^{h}	1.15 (1.07)h	0.99 (1.24)^{h}	1.63 (1.27)^{h}	1.76 (1.32)^{h}	1.76 (1.32)^{h}	1.67 (1.29)^{h}	1.30 (1.41)^{h}	1.40 (1.18)^{h}	1.60 (1.26)^{h}
T8	750	2.30 (1.25)	1.53 (1.23)^{g}	1.10 (1.05)^{g}	1.42 (1.91)^{g}	1.57 (1.25)^{g}	1.57 (1.25)^{g}	1.37 (1.68)^{g}	1.01 (1.34)^{g}	1.92 (1.38)^{g}	2.01 (1.41)^{g}	2.01 (1.41)^{g}	2.02 (1.37)^{g}	1.47 (1.21)^{g}	1.80 (1.34)^{g}	2.00 (1.41)^{g}
T9	-	2.35 (1.77)	2.43 (1.55)^{a}	2.60 (1.61)^{a}	2.83 (1.68)^{a}	3.15 (1.77)^{a}	3.15 (1.77)^{a}	3.18 (1.78)a	3.45 (1.85)^{a}	3.64 (1.90)^{a}	3.70 (1.92)^{a}	3.70 (1.92)^{a}	3.73 (1.93)^{a}	4.00 (2.00)^{a}	4.10 (2.02)^{a}	4.33 (2.08)^{a}
S. Ed.		0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01
CD(P=0.05)		NS	0.04*	0.05*	0.04*	0.03*	0.03*	0.03*	0.03*	0.05*	0.03*	0.03*	0.04*	0.05*	0.03*	0.03*

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

Values in Parentheses are $\sqrt{X+0.5}$ transformed values

* - Significant at P = 0.05; #-Mean of 3 replications; PTC-Pretreatment count; DAT- Day after treatments

Table 4 Effect of newer insecticides on the population of predatory spiders in the black gram variety VBN (Bg) 5 during *Rabi* 2019-2020 (Field experiment II)

T	Conc. ml/g per ha	Number of predatory spiders / plant #														
		I Foliar application					II Foliar application					III Foliar application				
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT
T1	100	2.73 (1.64)	2.31 (1.51)^{c}	2.51 (1.58)^{c}	2.80 (1.67)^{c}	3.20 (1.78)^{c}	3.20 (1.78)^{c}	2.51 (1.64)^{c}	2.20 (1.64)^{c}	2.30 (1.51)^{c}	3.30 (1.81)^{c}	3.30 (1.81)^{c}	2.71 (1.64)^{c}	2.39 (1.54)^{c}	3.30 (1.81)^{c}	3.51 (1.87)^{c}
T2	220	3.13 (1.76)	2.00 (1.41)^{e}	1.90 (1.37)^{e}	2.41 (1.55)^{e}	2.80 (1.67)^{e}	2.80 (1.67)^{e}	2.20 (1.48)^{e}	1.20 (1.30)^{e}	1.61 (1.26)^{e}	2.80 (1.67)^{e}	2.80 (1.67)^{e}	2.21 (1.48)^{e}	1.90 (1.37)^{e}	2.70 (1.64)^{e}	3.00 (1.73)^{e}
T3	125	2.73 (1.65)	2.20 (1.55)^{d}	2.20 (1.48)^{d}	2.61 (1.61)^{d}	3.07 (1.75)^{d}	3.07 (1.75)^{d}	2.70 (1.58)^{d}	1.50 (1.41)^{d}	1.90 (1.37)^{d}	3.03 (1.74)^{d}	3.03 (1.74)^{d}	2.51 (1.58)^{d}	2.20 (1.48)^{d}	3.00 (1.73)^{d}	3.20 (1.78)^{d}
T4	500	2.80 (1.66)	0.82 (0.90)^{i}	0.61 (0.78)^{i}	1.00 (1.00)^{i}	1.31 (1.14)^{i}	1.31 (1.14)^{i}	0.90 (0.95)^{i}	0.21 (0.84)^{i}	0.51 (0.71)^{i}	2.00 (1.41)^{i}	2.00 (1.41)^{i}	1.41 (1.18)^{i}	1.03 (1.01)^{i}	1.51 (1.22)^{i}	2.00 (1.41)^{i}
T5	2000	2.67 (1.63)	2.70 (1.34)^{b}	2.62 (1.61)^{b}	2.90 (1.73)^{b}	3.41 (1.84)^{b}	3.41 (1.84)^{b}	2.98 (1.72)^{b}	2.41 (1.70)^{b}	2.50 (1.58)^{b}	3.40 (1.84)^{b}	3.40 (1.84)^{b}	2.90 (1.70)^{b}	2.60 (1.61)^{b}	3.50 (1.87)^{b}	3.71 (1.92)^{b}
T6	400	2.80 (1.73)	1.52 (1.34)	1.21 (1.26)^{f}	1.71 (1.48)^{f}	1.91 (1.61)^{f}	1.91 (1.61)^{f}	1.91 (1.38)^{f}	1.00 (1.22)^{f}	1.31 (1.14)^{f}	2.60 (1.61)^{f}	2.60 (1.61)^{f}	2.00 (1.41)^{f}	1.71 (1.30)^{f}	2.41 (1.55)^{f}	2.80 (1.67)^{f}
T7	750	2.80 (1.66)	1.52 (1.23)^{h}	1.21 (1.10)^{h}	1.71 (1.30)^{h}	1.91 (1.38)^{h}	1.91 (1.38)^{h}	1.30 (1.46)^{h}	0.40 (0.95)^{h}	0.80 (0.89)^{h}	2.21 (1.48)^{h}	2.21 (1.48)^{h}	1.60 (1.26)^{h}	1.30 (1.14)^{h}	1.81 (1.34)^{h}	2.30 (1.51)^{h}
T8	750	3.20 (1.78)	1.70 (1.30)^{g}	1.43 (1.19)^{g}	1.90 (1.37)^{g}	2.31 (1.51)^{g}	2.31 (1.51)^{g}	1.60 (1.26)^{g}	0.60 (1.05)^{g}	1.10 (1.05)^{g}	2.40 (1.55)^{g}	2.40 (1.55)^{g}	1.80 (1.34)^{g}	1.51 (1.23)^{g}	2.03 (1.42)^{g}	2.50 (1.58)^{g}
T9	-	2.50 (1.57)	2.90 (1.70)^{a}	2.95 (1.71)^{a}	3.00 (1.73)^{a}	3.50 (1.87)^{a}	3.50 (1.87)^{a}	3.51 (1.87)^{a}	3.59 (1.89)^{a}	3.59 (1.89)^{a}	3.60 (1.90)^{a}	3.60 (1.90)^{a}	3.60 (1.90)^{a}	3.61 (1.91)^{a}	3.62 (1.91)^{a}	3.72 (1.92)^{a}
S. Ed.		0.11	0.01	0.003	0.002	0.01	0.01	0.03	0.004	0.002	0.004	0.004	0.002	0.01	0.01	0.003
CD(P=0.05)		NS	0.01*	0.001*	0.004*	0.002*	0.002*	0.001*	0.01*	0.002*	0.01*	0.01*	0.01*	0.01*	0.01*	0.01*

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

Values in Parentheses are $\sqrt{X+0.5}$ transformed values

* - Significant at P = 0.05; #-Mean of 3 replications; PTC-Pretreatment count; DAT- Day after treatments

Table 5 Overall mean of the population of predatory coccinellids and spiders in the black gram variety VBN (Bg) 5 during *Kharif* and *Rabi* 2019 - 2020 (Field experiment I and II)

T	Conc. ml/g per ha	Overall mean of predatory coccinellids						Overall mean of predatory spiders					
		Kharif			*Rabi*			*Kharif*			*Rabi*		
		I FA	II FA	III FA	I FA	II FA	III FA	I FA	II FA	III FA	I FA	II FA	III FA
T1	100	1.60 (1.44)^{c}	1.85 (1.35)^{c}	1.79 (1.33)^{c}	1.30 (1.14)^{c}	1.21 (1.09)^{c}	1.36 (1.16)^{c}	2.20 (1.48)^{c}	2.66 (1.62)^{c}	2.85 (1.68)^{c}	2.59 (1.60)^{c}	2.68 (1.63)^{c}	2.94 (1.71)^{a}
T2	220	1.20 (1.30)^{e}	1.34 (1.15)^{e}	1.41 (1.18)^{e}	0.93 (0.96)^{e}	1.00 (1.00)^{e}	1.16 (1.07)^{e}	1.87 (1.36)^{e}	2.17 (1.47)^{e}	2.37 (1.53)^{e}	2.33 (1.52)^{e}	2.11 (1.45)^{e}	2.44 (1.56)^{e}
T3	125	1.40 (1.37)^{d}	1.60 (1.26)^{d}	1.63 (1.27)^{d}	1.11 (1.04)^{d}	1.10 (1.05)^{d}	1.26 (1.12)^{d}	2.01 (1.41)^{d}	2.41 (1.55)^{d}	2.57 (1.60)^{d}	2.49 (1.57)^{d}	2.40 (1.55)^{d}	2.69 (1.64)^{d}
T4	500	0.58 (1.03)^{i}	0.68 (0.82)^{i}	0.69 (0.83)^{i}	0.50 (0.70)^{i}	0.61 (0.78)^{i}	0.76 (0.87)^{i}	1.21 (1.10)^{i}	1.18 (1.28)^{i}	1.20 (1.09)^{i}	1.18 (1.08)^{i}	0.94 (0.96)^{i}	1.53 (1.23)^{i}
T5	2000	1.95 (1.56)^{b}	2.12 (1.45)^{b}	2.02 (1.42)^{b}	1.50 (1.22)^{b}	1.30 (1.14)^{b}	1.45 (1.20)^{b}	2.38 (1.54)^{b}	2.98 (1.72)^{i}	3.34 (1.82)^{b}	2.77 (1.66)^{b}	2.87 (1.69)^{b}	3.14 (1.77)^{b}
T6	400	1.03 (1.23)^{f}	1.04 (1.02)^{f}	1.21 (1.10)^{f}	0.80 (0.89)^{f}	0.91 (0.95)^{f}	1.06 (1.03)^{f}	1.69 (1.30)^{f}	1.93 (1.38)^{f}	2.05 (1.42)^{f}	2.14 (1.46)^{f}	1.82 (1.34)^{f}	2.22 (1.49)^{f}
T7	750	0.76 (1.12)^{h}	0.65 (0.80)^{h}	0.86 (0.92)^{h}	0.60 (0.77)^{h}	0.71 (0.84)^{h}	0.86 (0.92)^{h}	1.38 (1.77)^{h}	1.41 (1.18)^{h}	1.53 (1.23)^{h}	1.73 (1.31)^{h}	1.26 (1.12)^{h}	1.77 (1.33)^{h}
T8	750	0.87 (1.69)^{g}	0.63 (0.79)^{g}	1.02 (1.01)^{g}	0.70 (.83)^{g}	0.81 (0.89)^{g}	0.96 (0.98)^{g}	1.52 (1.23)^{g}	1.64 (1.08)^{g}	1.83 (1.35)^{g}	1.99 (1.41)^{g}	1.55 (1.24)^{g}	1.98 (1.40)^{g}
T9	-	2.13 (1.67)^{a}	2.54 (1.59)^{a}	2.86 (1.68)^{a}	1.73 (0.83)^{a}	1.83 (1.35)^{a}	1.90 (1.37)^{a}	2.64 (1.62)^{a}	3.39 (1.84)^{a}	3.96 (1.98)^{a}	2.96 (1.72)^{a}	3.55 (1.88)^{a}	3.62 (1.90)^{a}
S. Ed.		0.01	0.01	0.02	0.01	0.001	0.002	0.01	0.01	0.01	0.02	0.01	0.001
CD(P=0.05)		0.19*	0.003*	0.01*	0.01*	0.01*	0.01*	0.02*	0.02*	0.01*	0.10*	0.003*	0.01*

In a column mean followed by a common letter are not significantly different by DMRT (P=0.05)
Values in Parentheses are $\sqrt{X+0.5}$ transformed values
* - Significant at P = 0.05; #-Mean of 3 replications; PTC-Pretreatment count; DAT- Day after treatments

The present results are in consonance with the findings of [5] reported that the application of different insecticides *viz.*, novaluron 10 EC at 50, 75, 100 g a.i./ha (3.3 3.0, 3.0 spiders/ 10 plants), emamectin benzoate at 8, 9 and 10 g a.i./ha (2.0, 2.3, 1.0 spiders/ 10 plants)and spinosad at 60 g a.i./ha with 2.0 spiders/ 10 plants had no adverse effect on predators and parasitoids on chickpea crop. Flubendiamide 480 SC at 75, 100, 125 ml/ha and 48, 96, 192 g a.i./ha was found to be least toxic against beneficial arthropods and moderately safe to natural enemies on rice [6,7]. [8] stated that chlorantraniliprole 20 SC at 40 g/ha was highly safe to population of predatory coccinellids, spiders and beneficial arthropods in field. [9] observed that indoxacarb 15.8EC at 30 g a.i./ ha, chlorantraniliprole 18.5%SC at 30 g a.i./ ha, cartap hydrochloride 50%SP at 500 g a.i./ ha and fipronil 5%SC 625 ml/ ha are safer to rice natural enemies. [2] reported that natural enemies such as ladybird beetles, *Coccinella* spp. and *Scymnus* spp. and spiders were observed in all the experimental plots treated with coragen at different concentrations which had no adverse effects on the population natural enemies ranges from (1.24 to 2.11/ plant) and 1.45 to 2.10/ plant during 2008 to 2009 and 2009 to 2010. This is true in our observation that chlorantraniliprole 18.5 SC at 100 ml/ha and flubendiamide 20 WG at 125 g/ha did not have any adverse effect on the population of predatory coccinellids (1.75,129/ plant and 1.54, 1.16/ plant) and spiders (2.57, 2.73/ plant and 2.33, 2.53/ plant) in black gram in both the field experiments. [10] noticed the high safety of rynaxypyr 20 SC (0.006%) to coccinellids, spider and syrphid fly during field study. [11] stated that chlorantraniliprole 18.5 SC at 22, 26 and 30 g/ha was found more safer to spider population. [12] also express that spinosad 45 SC at 125 g a.i./ha, abamectin 1.9 EC at 3 g a.i./ha and chlorantraniliprole 18.5 SC at 30 g a.i./ha were found safer to the predatory Coccinellids. [13] and [14] reported that the plots treated with chlorantraniliprole 18.5% SC @ 25 g a.i./ha recorded the maximum population of spiders and Coccinella spp. These reports are in conformity with the present findings.

Conclusion

This is true in our observation that the newer insecticides, chlorantraniliprole 18.5 SC at 100 ml/ha and flubendiamide 20 WG at 125 g/ha can be included in IPM in black gram at Karaikal.

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