



## Bioefficacy of newer insecticides against *Aproaerema modicella* and *Spodoptera litura* in groundnut (*Arachis hypogaea* L.)

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### Abstract

Two field experiments were conducted during *Kharif* 2020 and *Rabi* 2020–2021 at Ariyalur district, Tamil Nadu, to evaluate the bioefficacy of newer insecticides against major insect pests of groundnut and their safety to natural enemies. Among the treatments tested, chlorantraniliprole 18.5 SC at 100 ml ha<sup>-1</sup> was most effective against the groundnut leaf miner, *Aproaerema modicella*, recording the lowest leaf damage of 4.03 and 3.05 per cent plant<sup>-1</sup> with 66.01 and 71.92 per cent reduction over untreated check during field experiments I and II, respectively. Against tobacco leaf caterpillar, *Spodoptera litura*, flubendiamide 39.35 SC at 100 ml ha<sup>-1</sup> recorded the lowest larval population of 0.70 and 0.68 larva plant<sup>-1</sup> with 82.76 and 83.18 percent reduction over control. Higher populations of predatory coccinellids and spiders were observed in chlorantraniliprole-treated plots, indicating relative safety to natural enemies. Chlorantraniliprole 18.5 SC at 100 ml ha<sup>-1</sup> also recorded the highest pod yield (3730.30 and 3780.33 kg ha<sup>-1</sup>). The study revealed that chlorantraniliprole, flubendiamide, and pymetrozine are effective and comparatively safer options for integrated pest management in groundnut ecosystems.

**Keywords:** Groundnut, *Arachis hypogaea*, *Aproaerema modicella*, *Spodoptera litura*, newer insecticides, chlorantraniliprole, flubendiamide, pymetrozine, bioefficacy, natural enemies

### Introduction

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops cultivated worldwide and occupies a prominent position in Indian agriculture due to its economic and nutritional significance. It is popularly referred to as the “King of Oilseeds” and “poor man’s cashew nut” because of its high protein, oil, and energy content (Naidu 2019; Prasad *et al.* 2019) [1, 2]. India ranks first in area and second in production of groundnut globally, with an annual production of about 9.54 million tonnes (Anon. 2021a). In Tamil Nadu, groundnut productivity is approximately 3078 kg ha<sup>-1</sup>, and Ariyalur district contributes substantially to the state’s production (Sudhamathi, 2019 [4]; Anon. 2018). Groundnut cultivation is severely constrained by several insect pests, among which the groundnut leaf miner, *Aproaerema modicella* (Deventer), and tobacco leaf caterpillar, *Spodoptera litura* (Fabricius), are major defoliators causing substantial yield losses (Sahayaraj and Amalraj, 2005) [6]. In addition, sucking pests such as leafhopper, *Empoasca kerri* (Singh-Pruthi), and aphid, *Aphis craccivora* (Koch), significantly affect crop growth and productivity (David and Ramamurthy, 2015) [7]. Yield losses due to insect pests in groundnut have been reported up to 26.74 per cent under severe infestation (Jayewar *et al.*, 2017) [8].

Management of these pests largely depends on chemical insecticides. However, indiscriminate and repeated use of conventional insecticides, particularly organophosphates, carbamates, and synthetic pyrethroids, has resulted in adverse effects including pest resistance, resurgence, secondary pest outbreaks, environmental contamination, and reduction of natural enemy populations (Javalage *et al.* 2019) [9]. Such practices also disrupt ecological balance and pose risks to

human health and non-target organisms (Bilal and Satti 2012; Raju *et al.* 2021) [10, 11]. In recent years, new-generation insecticides with novel modes of action have emerged as promising alternatives for sustainable pest management. These molecules are effective at lower dosages, relatively safer to natural enemies, and environmentally compatible compared to conventional insecticides (Kumar *et al.* 2017) [12]. Therefore, the present study was undertaken to evaluate the bioefficacy of newer insecticides against major insect pests of groundnut and to assess their safety to natural enemies under field conditions.

### Materials and Methods

#### Field experiments

Two field experiments were conducted during *Kharif* 2020 and *Rabi* 2020–2021 at Hasthinapuram village, Ariyalur district, Tamil Nadu, India, to evaluate the efficacy of newer insecticides against major pests of groundnut. The groundnut variety GJG 9 was raised in plots of 4 × 5 m with a spacing of 30 × 10 cm under a randomized block design comprising ten treatments replicated thrice. The treatments included flubendiamide 39.35 SC (100 g ha<sup>-1</sup>), chlorantraniliprole 18.5 SC (100 ml ha<sup>-1</sup>), fipronil 5 SC (1000 ml ha<sup>-1</sup>), emamectin benzoate

5 SG (200 g ha<sup>-1</sup>), thiamethoxam 25 WG (100 g ha<sup>-1</sup>), buprofezin 25 SC (800 ml ha<sup>-1</sup>), pymetrozine 50 WG (300 g ha<sup>-1</sup>), dimethoate 30 EC (1980 ml ha<sup>-1</sup>), profenophos 50 EC (1000 ml ha<sup>-1</sup>), and an untreated control (water spray). A blanket fertilizer dose of 25:40:20:20 kg ha<sup>-1</sup> NPKS was applied as per TNAU recommendations. Foliar applications were imposed using a hand-operated knapsack sprayer at economic threshold levels. During *Kharif*, sprays were

applied at 35, 50, and 65 days after sowing (DAS), whereas in *Rabi*, applications were given at 38, 53, and 68 DAS. Observations were recorded one day before spraying and at 1, 3, 5, 7, 9, 12, and 14 days after treatment (DAT) (Nataraja *et al.*, 2014)<sup>[13]</sup>.

### Pest assessment

*A. modicella* damage was assessed on ten randomly selected plants per plot by recording damaged and total leaves. Per cent leaf damage was calculated as:

$$\text{Per cent damage} = \frac{\text{Number of leaves damaged per plant}}{\text{Total number of leaves per plant}} \times 100$$

(Naresh *et al.*, 2017a)<sup>[12]</sup> The larval population of *Spodoptera litura* was recorded from ten randomly selected plants per plot at each observation interval and expressed as larvae per plant.

### Assessment of natural enemies

Populations of predatory coccinellids and spiders were recorded from ten randomly selected plants per plot before treatment and at subsequent observation intervals. Counts were expressed as number of natural enemies per plant.

### Yield and benefit–cost ratio

Pod yield was recorded treatment-wise at harvest and extrapolated to hectare basis. Gross returns, net returns, and benefit–cost ratio (BCR) were computed based on treatment-wise yield and cost of plant protection.

### Statistical analysis

Per cent leaf damage data were subjected to angular transformation, while population data of *S. litura* and natural enemies were transformed using:  $\sqrt{x + 5}$  The transformed data were analyzed using analysis of variance (ANOVA) for randomized block design following the F-test. Treatment means were separated using Duncan's Multiple Range Test (DMRT).

## Results and Discussion

### Management of the groundnut leaf miner, *A. modicella*

The result of the field experiment I conducted during *Kharif* 2020 against the groundnut leaf miner, *A. modicella* is presented in Table 1. It was found that per cent leaf damage was low in chlorantraniliprole 18.5 SC at 100 ml/ha (4.03 %), followed by emamectin benzoate 5 SG at 200 g/ha (4.53 %) compared to untreated check (11.85 %). The result indicated that chlorantraniliprole 18.5 SC at 100 ml/ha was found to be superior among the treatments with a per cent reduction of 66.01 compared to the untreated check. The same results were confirmed in the field experiment II conducted during *Rabi* 2020-2021 (Table 1). It was observed that the highest per cent reduction of leaf damage was recorded in chlorantraniliprole 18.5 SC at 100 ml/ha (71.92 %) that was the best treatment against the groundnut leaf miner compared to the untreated check (Fig 1).

Chlorantraniliprole 20 SC at 20 ml/100 L (99.2 %), emamectin benzoate 5 SG at 30 g/100 L (92.2 %) and emamectin benzoate 0.5 EC at 150 ml/100 L (91.6 %) were effective in controlling tomato leaf miner (Moussa *et al.*,

2013)<sup>[15]</sup>. Chlorantraniliprole 18.5 SC at 0.2 ml/L reduced the leaf damage by citrus leaf miner (2.99 and 2.03 %) during first and second spray of 2014 to 2015 (Patil, 2015)<sup>[16]</sup>. Chlorantraniliprole 20 SC at 10 ml/ac was effective against pea leaf miner with reduced leaf damage of 7.28 and 8.89 per cent and a maximum per cent reduction of 75.19 and 73.03 per cent (Naeem *et al.*, 2016)<sup>[17]</sup>. Chlorantraniliprole 18.5 SC at 0.03 per cent reduced the leaf damage by tomato leaf miner (Mithra and Anitha, 2016)<sup>[18]</sup>. Chlorantraniliprole 18.4 SC at 0.24 a.i./L brought considerable lethal and sub lethal effects in vegetable leaf miner, *L. sativae* (Khorshidi *et al.*, 2017)<sup>[19]</sup>. Chlorantraniliprole 18.5 SC at 30 g/ha was effective against leaf miner in tomato with 1.77 and 1.17 leaf miner/ plant at first and second spray with a per cent reduction of 58.58 and 51.40, respectively (Selvaraj *et al.*, 2017)<sup>[20]</sup>. Chlorantraniliprole 18.5 SC at 0.20 ml/l and thiamethoxam 25 WG at 0.25 g/l reduced serpentine leaf miner damage in ridge gourd (Hirekurubar and Tatagar, 2018)<sup>[21]</sup>. Chlorantraniliprole 18.5 SC at 30 g/ha was effective against leaf miner in tomato with 1.07 and 1.59 larvae/ plant during season I and II of 2016 – 2018 (Floret and Regupathy, 2019)<sup>[5, 18, 22]</sup>. Chlorantraniliprole 18.5 SC at 0.3 ml/L and emamectin benzoate 5 SC at 2 g/L reduced the leaf damage (20.10 and 19.34; 23.18 and 28.58 %) by tomato leaf miner during first and second season (Bastola *et al.*, 2020)<sup>[23]</sup>. Chlorantraniliprole 18.5 SC at 0.08 per cent was found effective against 2<sup>nd</sup> instar larvae of tomato leaf miner of about 17 larvae compared to control 111 larvae (Khani *et al.*, 2020)<sup>[24]</sup>. Since there are no works for chlorantraniliprole 18.5 SC and flubendiamide 39.35 SC against groundnut leaf miner, the literature related to other crops of defoliators and leaf miner were discussed above which are in consonance with the present findings.

### Safety to natural enemies

The population of predatory coccinellids in field experiment I ranged from 0.47 to 3.52 per plant. The highest population was recorded in the untreated check (3.52/plant), followed by chlorantraniliprole 18.5 SC at 150 ml/ha (2.89/plant), thiamethoxam 25 WG at 100 g/ha (2.47/plant) and flubendiamide 39.35 SC at 100 ml/ha (2.01/plant), while other treatments recorded lower populations (1.69 to 0.47/plant). A similar trend was observed in field experiment II, where coccinellid population ranged from 0.49 to 3.54/plant. The untreated check recorded the highest population (3.54/plant), followed by chlorantraniliprole (2.91/plant), thiamethoxam (2.49/plant) and flubendiamide (2.03/plant) (Table 3) (Fig 3).

The population of spiders in field experiment I ranged from 0.93 to 6.54 per plant. The untreated check recorded the highest population (6.54/plant), followed by chlorantraniliprole 18.5 SC at 100 ml/ha (5.51/plant), thiamethoxam 25 WG at 100 g/ha (4.76/plant) and flubendiamide 39.35 SC at 100 ml/ha (4.13/plant), whereas other treatments recorded lower populations (3.39 to 0.93/plant). Similar observations were made in field experiment II, where spider population ranged from 0.92 to 6.51/plant (Table 4) (Fig 4).

Earlier studies also reported the safety of emamectin benzoate, chlorantraniliprole and flubendiamide to natural enemies in chickpea, okra and cucumber (Kambrekar *et al.*, 2012; Chaukikar *et al.*, 2017; Bhatt *et al.*, 2018; Mahato and Misra, 2019), which corroborates the present findings.

**Table 1:** Bioefficacy of newer insecticides against the leaf miner, *A. modicella* during *Kharif* 2020 and *Rabi* 2020 -2021 on the basis of leaf damage in the groundnut variety GJG 9 (Field experiment I and II)

Sl. No	Treatments	Conc. ml/g per ha	Per cent leaf damage <i>Kharif</i> 2020				Per cent leaf damage <i>Rabi</i> 2020 – 2021			
			I Foliar application	II Foliar application	Overall mean	Per cent reduction over control	I Foliar application	II Foliar application	Overall mean	Per cent reduction over control
1	Flubendiamide 39.35 SC	100	5.16	4.90	5.03	57.57	4.16	3.90	4.03	62.87
2	Chlorantraniliprole 18.5 SC	100	4.18	3.88	4.03	66.01	3.18	2.92	3.05	71.92
3	Fipronil 5 SC	1000	5.46	5.20	5.33	55.03	4.46	4.20	4.33	60.10
4	Emamectin benzoate 5 SG	200	4.66	4.40	4.53	61.78	3.66	3.40	3.53	67.48
5	Thiamethoxam 25 WG	100	6.56	6.30	6.43	45.75	5.56	5.30	5.43	49.97
6	Buprofezin 25 SC	800	7.76	7.50	7.63	35.63	6.76	6.50	6.63	38.91
7	Pymetrozine 50 WG	300	10.06	9.80	9.93	16.22	9.06	8.80	8.93	17.71
8	Dimethoate 30 EC	1980	8.16	7.90	8.03	32.25	7.16	6.90	7.03	35.22
9	Profenophos 50 EC	1000	5.96	5.70	5.83	50.82	4.96	4.70	4.83	55.50
10	Untreated check	-	11.72	11.98	11.85		10.72	10.98	10.85	

**Table 2:** Bioefficacy of newer insecticides against the tobacco leaf caterpillar, *S. litura* during *Kharif* 2020 and *Rabi* 2020 -2021 on the basis of larval population in the groundnut variety GJG 9 (Field experiment I and II)

Sl. No	Treatments	Conc. ml/g per ha	Mean larval population /plant <i>Kharif</i> 2020				Mean larval population /plant <i>Rabi</i> 2020 – 2021			
			II Foliar application	III Foliar application	Overall mean	Per cent reduction over control	II Foliar application	III Foliar application	Overall mean	Per cent reduction over control
1	Flubendiamide 39.35 SC	100	0.77	0.62	0.70	82.76	0.75	0.60	0.68	83.18
2	Chlorantraniliprole 18.5 SC	100	1.47	1.25	1.36	66.11	1.45	1.23	1.34	66.44
3	Fipronil 5 SC	1000	1.75	1.53	1.64	59.14	1.73	1.51	1.62	59.43
4	Emamectin benzoate 5 SG	200	1.17	0.95	1.06	73.58	1.15	0.93	1.04	73.94
5	Thiamethoxam 25 WG	100	2.39	2.17	2.28	43.31	2.37	2.18	2.28	43.18
6	Buprofezin 25 SC	800	2.81	2.65	2.73	32.10	2.74	2.63	2.69	32.81
7	Pymetrozine 50 WG	300	3.60	3.45	3.53	12.29	3.58	3.44	3.51	12.28
8	Dimethoate 30 EC	1980	3.20	3.04	3.12	22.33	3.14	3.02	3.08	22.98
9	Profenophos 50 EC	1000	2.06	1.84	1.95	51.43	2.04	1.82	1.93	51.68
10	Untreated check	-	4.06	3.98	4.02		4.04	3.96	4.00	

**Table 3:** Effect of newer insecticides on the population of predatory coccinellids in the groundnut variety GJG 9 during *Kharif* 2020 and *Rabi* 2020 – 2021 (Field experiment I and II)

Sl. No	Treatments	Conc. ml/g per ha	Mean number of predatory coccinellids/ plant <i>Kharif</i> 2020				Mean number of predatory coccinellids/ plant <i>Rabi</i> 2020 - 2021			
			I Foliar application	II Foliar application	III Foliar application	Overall mean	I Foliar application	II Foliar application	III Foliar application	Overall mean
1	Flubendiamide 39.35 SC	100	1.70	1.97	2.04	2.01	1.72	1.99	2.06	2.03
2	Chlorantraniliprole 18.5 SC	100	2.36	2.85	2.92	2.89	2.38	2.87	2.94	2.91
3	Fipronil 5 SC	1000	0.72	0.79	0.86	0.83	0.74	0.81	0.88	0.85
4	Emamectin benzoate 5 SG	200	1.43	1.65	1.72	1.69	1.45	1.67	1.74	1.71
5	Thiamethoxam 25 WG	100	2.02	2.43	2.50	2.47	2.04	2.45	2.52	2.49

6	Buprofezin 25 SC	800	1.18	1.37	1.44	1.41	1.2	1.39	1.46	1.43
7	Pymetrozine 50 WG	300	0.93	1.10	1.17	1.14	0.95	1.12	1.19	1.16
8	Dimethoate 30 EC	1980	0.52	0.59	0.66	0.63	0.54	0.61	0.68	0.65
9	Profenophos 50 EC	1000	0.34	0.42	0.52	0.47	0.36	0.44	0.54	0.49
10	Untreated check	-	2.78	3.45	3.59	3.52	2.80	3.47	3.61	3.54

**Table 4:** Effect of newer insecticides on the population of predatory spiders in the groundnut variety GJG 9 during *Kharif* 2020 and *Rabi* 2020 – 2021 (Field experiment I and II)

Sl. No	Treatments	Conc. ml/g per ha	Mean number of predatory spiders/plant <i>Kharif</i> 2020				Mean number of predatory spiders/ plant <i>Rabi</i> 2020 - 2021			
			I Foliar application	II Foliar application	III Foliar application	Overall mean	I Foliar application	II Foliar application	III Foliar application	Overall mean
1	Flubendiamide 39.35 SC	100	3.04	4.44	4.90	4.13	3.05	4.42	4.90	4.12
2	Chlorantraniliprole 18.5 SC	100	4.09	5.97	6.46	5.51	4.09	5.96	6.45	5.50
3	Fipronil 5 SC	1000	1.36	1.79	2.25	1.80	1.37	1.78	2.25	1.80
4	Emamectin benzoate 5 SG	200	2.55	3.58	4.03	3.39	2.56	3.57	4.03	3.39
5	Thiamethoxam 25 WG	100	3.52	5.15	5.60	4.76	3.51	5.14	5.58	4.74
6	Buprofezin 25 SC	800	2.13	2.99	3.45	2.86	2.14	2.98	3.45	2.86
7	Pymetrozine 50 WG	300	1.74	2.35	2.81	2.30	1.75	2.34	2.81	2.30
8	Dimethoate 30 EC	1980	1.02	1.34	1.81	1.39	1.03	1.33	1.81	1.39
9	Profenophos 50 EC	1000	0.64	0.83	1.31	0.93	0.64	0.82	1.31	0.92
10	Untreated check	-	4.91	7.04	7.68	6.54	4.82	7.03	7.68	6.51

**Table 5:** Yield and Benefit cost ratio of groundnut on the different treatments of newer insecticides in the groundnut variety GJG 9 during *Kharif* 2020 and *Rabi* 2020 – 2021 (Field experiment I and II)

Sl. NO	Treatments	Conc. ml/g per ha	Yield (kg/ha)		Benefit cost ratio (BCR)	
			Field experiment I	Field experiment II	Field experiment I	Field experiment II
1	Flubendiamide 39.35 SC	100	3553.90 <sup>c</sup>	3603.87 <sup>c</sup>	1:1.19	1:1.34
2	Chlorantraniliprole 18.5 SC	100	3730.30 <sup>a</sup>	3780.33 <sup>a</sup>	1:1.25	1:1.35
3	Fipronil 5 SC	1000	3465.60 <sup>d</sup>	3515.64 <sup>d</sup>	1:1.16	1:1.30
4	Emamectin benzoate 5 SG	200	3642.10 <sup>b</sup>	3692.10 <sup>b</sup>	1:1.22	1:1.36
5	Thiamethoxam 25 WG	100	3289.00 <sup>f</sup>	3339.18 <sup>f</sup>	1:1.10	1:1.18
6	Buprofezin 25 SC	800	3201.00 <sup>g</sup>	3250.95 <sup>g</sup>	1:1.07	1:1.14
7	Pymetrozine 50 WG	300	3024.00 <sup>i</sup>	3074.49 <sup>i</sup>	1:1.01	1:1.06
8	Dimethoate 30 EC	1980	3112.70 <sup>h</sup>	3162.72 <sup>h</sup>	1:1.04	1:1.12
9	Profenophos 50 EC	1000	3377.40 <sup>e</sup>	3427.41 <sup>e</sup>	1:1.13	1:1.20
10	Untreated check	-	999.00 <sup>j</sup>	1049.00 <sup>j</sup>	1:0.33	1:0.45
C.D. (P=0.05)			62.14*	78.64*	-	-

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

\* - Significant at P = 0.05 #-Mean of 3 replications

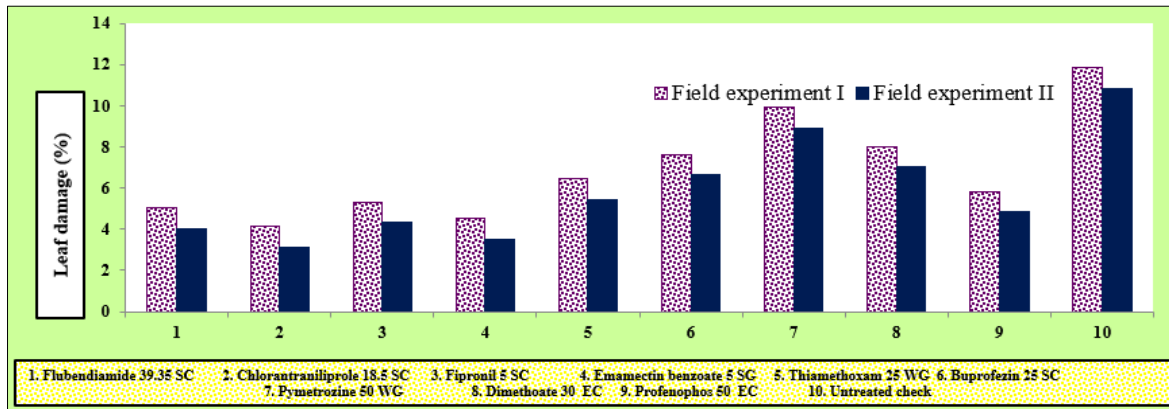


Fig 1: Bioefficacy of newer insecticides against the leaf miner, *Aproaerema modicella* (Deventor) on the basis of leaf damage in the groundnut variety, GJG 9 during *Kharif* 2020 and *Rabi* 2020 - 2021 (Field experiment I and II)

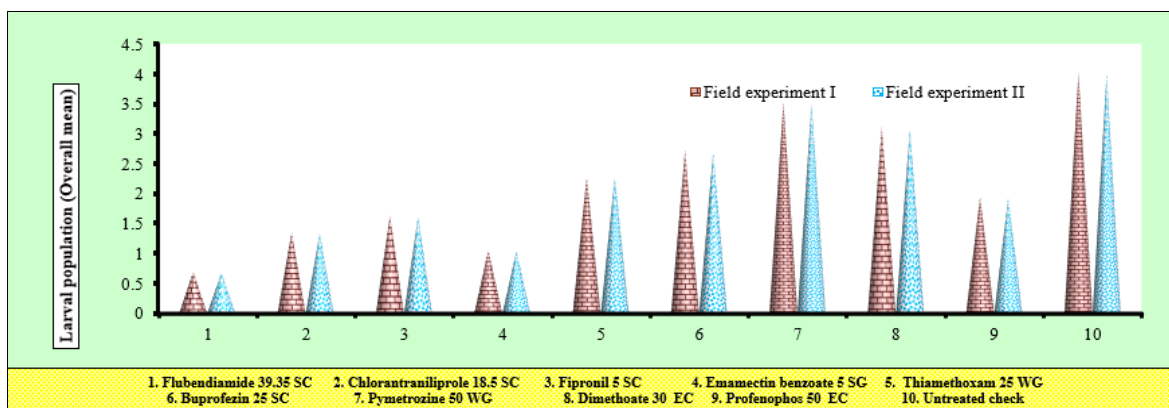


Fig 2: Bioefficacy of newer insecticides against the tobacco leaf caterpillar, *Spodoptera litura* (Fabricius) on the basis of larval population in the groundnut variety, GJG 9 during *Kharif* 2020 and *Rabi* 2020 - 2021 (Field experiment I and II)

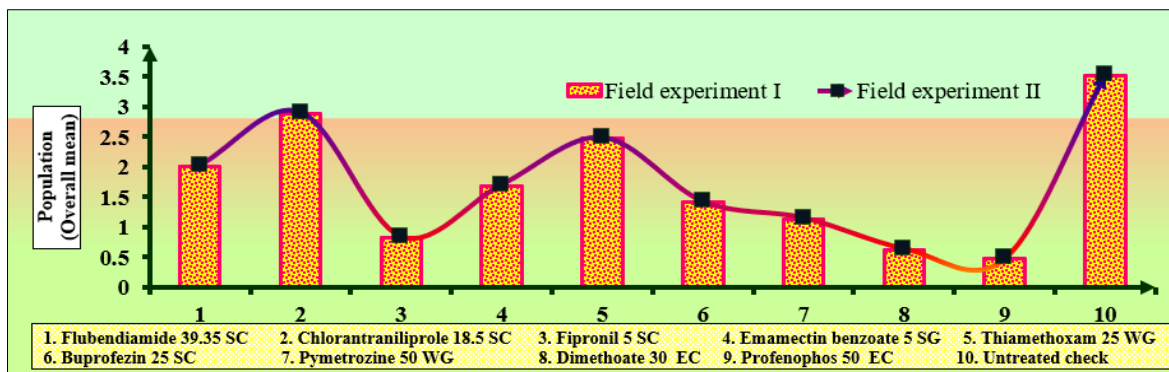


Fig 3: Effect of newer insecticides on the population of predatory coccinellids in the groundnut variety, GJG 9 during *Kharif* 2020 and *Rabi* 2020 - 2021 (Field experiment I and II)

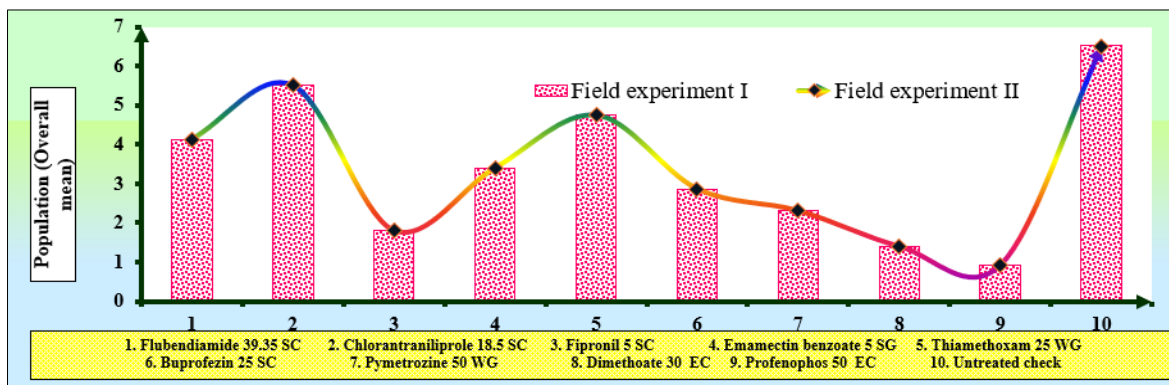


Fig 4: Effect of newer insecticides on the population of predatory spiders in the groundnut variety, GJG 9 during *Kharif* 2020 and *Rabi* 2020 - 2021 (Field experiment I and II)

### Management of the tobacco leaf caterpillar, *S. litura*

The results of the field experiment I conducted during *Kharif* 2020 against the tobacco leaf caterpillar, *S. litura* (Table 2) exhibited that flubendiamide 39.35 SC at 100 ml/ha registered the low larval population of 0.70 larva/ plant, followed by emamectin benzoate 5 SG at 200 g/ha (1.06 larvae/ plant) compared to untreated check (4.02 larvae/ plant). The results indicated that flubendiamide 39.35 SC at 100 ml/ha was found to be superior among the treatments with 82.76 per cent reduction of larval population compared to untreated check. The similar results were confirmed in the field experiment II conducted during *Rabi* 2020-2021 (Table 2). It was found that flubendiamide 39.35 SC at 100 ml/ha registered the low larval population of 0.68 larva/ plant, followed by emamectin benzoate 5 SG at 200 g/ha (1.04 larvae/ plant) compared to untreated check (4.00 larvae/ plant) (Table 4). The results expressed that flubendiamide 39.35 SC at 100 ml/ha was the best treatment among the treatments with 83.18 per cent reduction of larval population compared to untreated check (Fig 2).

Tatagar *et al.* (2009)<sup>[25]</sup> reported that flubendiamide 20 WG at 60 g a.i./ ha recorded the lowest fruit damage of 3.45 per cent, followed by emamectin benzoate 5 SG at 11 g a.i./ ha against *H. armigera* and *S. litura* in chilli. Flubendiamide 39.35 SC at 60 and 48 g a.i./ ha and emamectin benzoate 5 SG at 10 g a.i./ ha registered the maximum reduction of *S. litura* in chilli with a mean larval population (0.32, 0.41 and 3.00; 0.30, 0.43 and 0.68 larva/ plant) during first and second spray (Patil *et al.*, 2013). Patil and Mohite (2015)<sup>[26]</sup> reported that flubendiamide 480 SC at 200 ml/ha and emamectin benzoate 1.9 EC at 200 ml/ha offered excellent protection against *S. litura* with a mean larval population of 0.30 and 0.40 larva/ plant in soybean crop. Chlorantraniliprole 18.5 SC at 30 g/ha was effective against *H. armigera* in pigeon pea larval reduction (Wale *et al.*, 2017)<sup>[27]</sup>. Chlorantraniliprole 18.5 SC at 0.002 per cent and emamectin benzoate 5 SG at 0.002 per cent were effective against *L. orbonalis* in brinjal with lowest shoot infestation of 6.77 and 5.74 per cent during first and second spray and recorded 5.95 per cent lowest fruit infestation (Khanzada *et al.*, 2018)<sup>[28]</sup>. Flubendiamide 39.35 SC at 0.01 per cent, chlorantraniliprole 18.5 SC at 0.006 per cent and emamectin benzoate 5 SG at 0.02 were found effective against *H. armigera* in groundnut (Dwivedi, 2020)<sup>[29]</sup>. Chlorantraniliprole 18.5 SC at 0.3 ml/L and flubendiamide 480 SC at 0.3 ml/L gave effective protection against tomato pinworm (Kumar *et al.*, 2020). Muralikrishna *et al.* (2021)<sup>[30, 31]</sup> reported that flubendiamide 480 SC at 0.0096 per cent and emamectin benzoate 5 SG at 0.002 per cent were found effective against *S. litura* in amaranth under field condition with a mean larval population (2.10, 0.71, 0.62 and 0.96; 0.41, 0.07, 0.00 and 0.21) during four insecticidal sprays. The above reports are in agreement with the present findings.

### Yield and BC ratio

Among the insecticides tested in groundnut, chlorantraniliprole 18.5 SC at 100 ml/ha recorded the highest yield (3730.30 and 3780.33 kg/ha) and maximum benefit-cost ratio (1:1.25 and 1:1.38), followed by emamectin benzoate 5 SG at 200 g/ha. Untreated plots showed the lowest yield and B:C ratio. The effectiveness of treatments in descending order was: chlorantraniliprole > emamectin benzoate > flubendiamide > fipronil > profenophos > thiamethoxam > buprofezin > dimethoate > pymetrozine.

Previous studies also supported the superior performance of chlorantraniliprole, flubendiamide, and emamectin benzoate in improving yield and economic returns. The study concluded that chlorantraniliprole was most effective against groundnut leaf miner, flubendiamide against tobacco leaf caterpillar, and pymetrozine against sucking pests such as leafhoppers and aphids. These newer insecticides were also safe to natural enemies like coccinellids and spiders and can be effectively incorporated into IPM strategies for groundnut pest management (Table 5).

### Conclusion

The study concluded that chlorantraniliprole 18.5 SC at 100 ml ha<sup>-1</sup> was highly effective against groundnut leaf miner and significantly improved pod yield, while flubendiamide 39.35 SC at 100 ml ha<sup>-1</sup> effectively controlled tobacco leaf caterpillar. Pymetrozine also proved effective against sucking pests. These newer insecticides were comparatively safe to natural enemies such as coccinellids and spiders, indicating their suitability for integrated pest management (IPM) in groundnut cultivation.

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