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Bioefficacy of new generation insecticides against leaf miner (*Aproraema modicella* Deventer) and tobacco caterpillar (*Spodoptera litura* Fab.) on groundnut

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Abstract
Field experiments were conducted to evaluate bioefficacy of new generation insecticides against leaf miner (*Aproraema modicella* Deventer) and tobacco caterpillar (*Spodoptera litura* Fab.) on groundnut under field condition during Kharif and Rabi seasons of 2020 and 2021. The observations on number of tobacco caterpillar larvae and leaf miner larvae were recorded on top, middle and bottom leaves of five randomly selected plants from each treatment at one day before and 3, 7, 10 and 14 days after first and second application of insecticides. The results of the field experiments conducted in *Kharif* and *Rabi* seasons of 2020 and 2021 revealed that all the insecticides were found significantly superior over untreated control in reducing population of leaf miner larvae at 3, 7, 10 and 14 days after first and second application. Spinosad 45 SC @ 200 ml/ha and Emamectin Benzoate 5 SG @ 200 g/ha were found most effective for managing leaf miner larval population on ground nut. Similarly the population of tobacco caterpillar was the lowest in Spinosad 45 SC @ 200 ml/ha followed by Profenophos 50 EC @ 1lit/ha and Cartap hydrochloride 50 SP @ 500 g/ha with 0.67, 0.67 and 1.00 larva/5plants, respectively.

Keywords: Groundnut, bioefficacy, new generation insecticides, leaf miner

Introduction
Groundnut, *Arachis hypogaea* L. is the principal oilseed crop in India and also serves as a valuable cash crop for small and marginal farmers under rainfed condition. Groundnut is rich source of edible oil (43-55%), protein (25-28%) and vitamins E, K and B. The haulms and oilcakes are good source of protein and calcium, and used as feed for small ruminants and livestock, particularly during the dry season (Smith, 2002; Motaphale *et al*., 2018) [11, 6]. In India, the area under groundnut is 4.5 m ha with an average productivity of 1465 kg/ha. More than 50 insects have been reported to occur on groundnut in India and few are quite destructive and reduce the yield considerably. *Aproaerema modicell*a Deventer, *Amrasca biguttula biguttula* Ishida, *Spodoptera litura* Fabricus, *Helicoverpa armigera* Hubner, *Aphis craccivora* Koch, *Scirtothrips dorsalis* H. are considered as important destructive pests on groundnut (Amin and Mohammad, 1980; Singh and Sachan, 1992) [1, 10]. Groundnut leaf miner and tobacco caterpillar are the serious pests on groundnut both in rainy and post rainy season and severe infestation can inflict yield loss up to 76 per cent. Many new insecticide molecules with different mode of action have been developed which are having high bioefficacy, selectivity and very less mammalian toxicity. These recent molecules are used at lower rate which inturn reduces the resistance development, have less residual effect and safer to environment. The present study is carried out to evaluate efficacy of the new insecticide molecules against *A. modicella and S. litura*.

Materials and Methods
Field experiments were conducted to evaluate bioefficacy of different insecticides against leaf miner and tobacco caterpillar on groundnut during Kharif and Rabi seasons of 2020 and 2021 at farmer's holdings of Thiruvannamalai Districts, Tamil Nadu, India. The experiments

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were conducted in a randomized block design (RBD) with ten treatments including untreated control with three replications during 2020 and with seven treatments including untreated control with three replications during 2021. Groundnut VRI 8 was sown at a spacing of 30x10 cm in a plot size of 5mx5m.The crop was raised as per the package of practices recommended by Tamil Nadu Agricultural University, Coimbatore. The observations on total number of leaf miner larvae and tobacco caterpillar larave were recorded per five plant from each on top, middle and bottom leaves of five randomly selected plants from each treatment at one day before treatment and 3, 7, and 14 days after first and second application of insecticides.

Results and Discussion

Effect of new generation insecticides on leaf miner population during Kharif 2020

During Kharif 2020, at three days after first spray (3 DAS), significantly maximum population of leaf miner larvae (7.33 larvae/five plant) was recorded from the untreated control plots (T_{10}), followed by plots treated with treatment T_5 (Emamectin Benzoate 5 SG @ 200 g/ha) with 2.67 larvae/five plant. At 10 days after first spray (10 DAS), the population of leaf miner was lowest (0.00 larvae/five plant) in T_6 (Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1lit/ha), followed by T_2 (Spinosad 45 SC @ 200 ml/ha) with 0.33 larvae/five plant. Similarly, at 14 DAS, the population of leaf miner was recorded to be the minimum (5.67 larvae/five plant) in T_6 (Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1lit/ha) and T_9 (Quinalphos 25 EC @ 1 lit/ha), as against 11.00 larvae/five plant in untreated control. Thus, after first spray it can be concluded that the leaf miner population was decreased for only initial three days after first spray and thereafter the population slowly increased (Table 1).

During Kharif 2020, the population data of leaf miner after second spray revealed the similar trend as that of first spray and all the insecticides under investigation were observed to be significantly superior over untreated control in reducing the population of leaf miner on groundnut at 3, 7, 10 and 14 days after second spray. At 10 and 14 days after second spray (10 DAS and 14 DAS), the population was leaf miner was lowest (0.00 larvae/five plant) in plots treated with T_1 (Lambda-Cyhalothrin 5 EC @ 500 ml/ha), T_2 (Spinosad 45 SC @ 200 ml/ha) and T_6 (Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1lit/ha), as against untreated control with 13.00 larvae/five plant and 14.33 larvae/five plant, respectively (Table 1).

Effect of new generation insecticides on leaf miner population during Rabi 2020

During Rabi 2020, after first spray, the population of leaf miners was significantly lowest in plots treated with Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1 lit/ha (T_6) with 0.33, 0.00, 0.33 and 4.00 larvae/5 plants at 3, 7, 10 and 14 DAS respectively. However, the population was highest in untreated control plots with 8.00, 8.00, 9.33 and 11.33 larvae/5 plants at 3, 7, 10 and 14 DAS respectively (Table 3).

During Rabi 2020, after second spray, the similar trend was observed with lowest population of 0.00 larvae/5 plants was observed in T_6 (Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1 lit/ha), whereas, the population was significantly highest in untreated control with 11.67, 12.67, 13.00 and 14.33 larvae/5 plants at 3, 7, 10 and 14 DAS respectively. It has been concluded that the plots treated with Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1 lit/ha recorded significantly lowest population of leaf miner larvae on groundnut and found effective over rest of the treatments after 1st and 2nd spray (Table 3).

Effect of new generation insecticides on leaf miner population during Kharif 2021

During Kharif 2021, at 3 and 7 days after first spray (3 DAS and 7 DAS), the leaf miner population was significantly reduced with 0.00 larvae/5 plants in T_4 (Emamectin benzoate 5 SG @ 200 g/ha) plots, whereas, population was highest (7.33 and 7.67 larvae/5 plants) in untreated control. At 10 DAS and 14 DAS, the population was lowest with 0.00 and 0.67 larvae /5 plants in Spinosad 45 SC @ 200 ml/ha treated plots (T_1), followed by 0.67 and 1.33 larvae/5 plants in T_4 plots (Emamectin Benzoate 5 SG @ 200g/ha) (Table 6).

During Kharif 2021, after second spray, the population was significantly reduced (0.00 larvae/5 plant) in T_1 (Spinosad 45 SC @ 200 ml/ha), T_2 (Profenophos 50 EC @ 1lit/ha) and T_3 (Cartap hydrochloride 50 SP @ 500 g/ha), followed by T_4 (Emamectin benzoate 5 SG @ 200 g/ha) with 0.00, 0.00, 0.67 and 2.67 larvae/5 plant at 3, 7, 10 and 14 DAS at second spraying (Table 6).

Effect of new generation insecticides on leaf miner population during Rabi 2021

During Rabi 2021, at 3 days after first spray (3 DAS), the leaf miner population was 0.00 larvae/ 5 plant in T_1 (Spinosad 45 SC @ 200 ml/ha), T_3 (Cartap hydrochloride 50 SP @ 500 g/ha) and T_4 (Emamectin benzoate 5 SG @ 200 g/ha), followed by 0.33 larvae/5 plant) in T_2 (Profenophos 50 EC @ 1lit/ha) (Table 8).

During Rabi 2021, at 14 days after second spray (14 DAS), the leaf miner population was lowest (0.00 larvae/5 plant) in T_1 (Spinosad 45 SC @ 200 ml/ha), T_2 (Profenophos 50 EC @ 1lit/ha) and T_3 (Cartap hydrochloride 50 SP @ 500 g/ha), followed by 2.00 larvae/5 plant in T_4 (Emamectin benzoate 5 SG @ 200 g/ha). At 14 days after first and second spray, the population was significantly increased in untreated control (T_7) with 12.67 and 14.67 larvae/5 plant respectively (Table 8).

Effect of new generation insecticides on tobacco caterpillar population

The effect of new generation insecticides on the population of tobacco caterpillar in groundnut was recorded during Kharif 2020 and Rabi 2020. The results revealed that all the insecticides were found significantly superior over untreated control in reducing population of tobacco caterpillar at 3, 7, 10 and 14 days after both first and second spray application.

Effect of new generation insecticides on tobacco caterpillar population during Kharif 2020

During Kharif 2020, at 3 and 7 days after first spray (3 DAS and 7 DAS), the tobacco caterpillar population was significantly reduced with 0.00 larvae/5 plants in T_1 (Lambda-Cyhalothrin 5 EC @ 500 ml/ha), T_3 (Profenophos 50 EC @ 1lit/ha) and T_6 (Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1 lit/ha), followed by T_2 (Spinosad 45 SC @ 200 ml/ha) with 0.33 larvae/5 plants. Likewise, at 10 DAS and 14 DAS, the population was recorded to be the lowest with 0.00 and 5.67 larvae/5 plants in T_6 (Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1

lit/ha) (Table 2). During Kharif 2020, second spraying at 3, 7, 10 and 14 DAS resulted in significantly reduced population of tobacco caterpillar with 0.00 larvae/5 plants in plots treated with T_6 (Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1 lit/ha) as against untreated control (Table 2).

Effect of new generation insecticides on tobacco caterpillar population during Rabi 2020

During Rabi 2020, after first spray, the population of tobacco caterpillars was significantly reduced in plots treated with Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1 lit/ha (T_6) with 0.00, 0.00, 0.67 and 3.67 larvae/5 plants at 3, 7, 10 and 14 DAS respectively. However, the population was highest in untreated control plots with 9.33, 9.33, 11.67 and 11.67 larvae/5 plants at 3, 7, 10 and 14 DAS respectively (Table 4).

During Rabi 2020, after second spray, the population of tobacco caterpillars was significantly reduced in plots treated with Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1 lit/ha (T_6) with 0.00, 0.00, 0.00 and 0.67 larvae/5 plants at 3, 7, 10 and 14 DAS respectively. However, the population was highest in untreated control plots with 11.67, 12.33, 12.00 and 12.00 larvae/5 plants at 3, 7, 10 and 14 DAS respectively (Table 4).

Effect of new generation insecticides on tobacco caterpillar population during Kharif 2021

During Kharif 2021, first spraying at 3, 7 and 10 DAS indicated a significant reduction in population of tobacco caterpillar (0.00 larvae/5 plant) in T_1 (Spinosad 45 SC @ 200 ml/ha) and T_2 (Profenophos 50 EC @ 1lit/ha), followed by T_3 (Cartap hydrochloride 50 SP @ 500 g/ha) with 0.67, 0.67 and 1.00 larva/ 5plants respectively. However, at 14 DAS, the pest population was significantly reduced (6.00 larvae/5 plant) in T_4 (Emamectin benzoate 5 SG @ 200g/ha) as against 7.67 larvae/5 plant in untreated control (T_7) (Table 7).

During Kharif 2021, second spraying at 3, 7, 10 and 14 DAS resulted in significantly reduced population of tobacco caterpillar with 0.00 larvae/5 plants in plots treated with T_1 (Spinosad 45 SC @ 200 ml/ha), T_2 (Profenophos 50 EC @ 1lit/ha) and T_3 (Cartap hydrochloride 50 SP @ 500 g/ha), followed by T_6 (Quinalphos 25 EC @ 1 lit/ha) with 0.00, 0.00, 0.67 and 2.00 larvae/5 plant respectively (Table 7).

Effect of new generation insecticides on tobacco caterpillar population during Rabi 2021

During Rabi 2021, first spraying at 3, and 7 DAS indicated a significant reduction in population of tobacco caterpillar (0.00 larvae/5 plant) in T_1 (Spinosad 45 SC @ 200 ml/ha) and T_2 (Profenophos 50 EC @ 1lit/ha), followed by T_6 (Quinalphos 25 EC @ 1 lit/ha) with 0.00 and 2.00 larva/ 5plants respectively. Likewise, at 14 DAS, the pest population was significantly reduced (4.33 larvae/5 plant) in T_1 (Spinosad 45 SC @ 200 ml/ha) and T_4 (Emamectin benzoate 5 SG @ 200 g/ha) over other treatments (Table 9).

During Rabi 2021, second spraying at 3, 7, 10 and 14 DAS indicated a significant reduction in population of tobacco caterpillar with 0.00, 0.00, 0.00 and 0.33 larvae/5 plant in T_1 (Spinosad 45 SC @ 200 ml/ha) which was on par with T_2 (Profenophos 50 EC @ 1lit/ha) as against untreated control with 13.87 larvae/5 plants at 14 DAS (Table 9).

Effect of new generation insecticides on natural enemies of groundnut: The effect of new generation insecticides on the population of natural enemies in groundnut was recorded during Kharif 2020 - 21 and Rabi 2020 – 21. The results revealed that population of coccinellids and syrphids were more in untreated control than all other insecticidal treatments.

Effect of new generation insecticides on natural enemies of groundnut during 2020

During Kharif and Rabi 2020, among the insecticidal treatments, the number of coccinellids was recorded to be maximum in T_2 (Spinosad 45 SC @ 200 ml/ha) and T_6 (Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1 lit/ha) with 6.67 coccinellids/5 plants. Likewise, the syrphid population was recorded to be the highest (3.67 and 4.67 syrphids/5 plants) in T_6 (Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1 lit/ha) and T_2 (Spinosad 45 SC @ 200 ml/ha), respectively during Kharif and Rabi 2020 with was similar to T_6 (Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1 lit/ha) during Rabi 2020 (Table 5).

Effect of new generation insecticides on natural enemies of groundnut during 2021

During Kharif 2021 and Rabi 2021, among the insecticidal treatments, the number of coccinellids was recorded to be maximum in T_1 (Spinosad 45 SC @ 200 ml/ha) with 6.33 and 5.67 coccinellids / 5 plants respectively, while it was 9.33 and 7.33 coccinellids/5 plants in untreated control (T_7). Similarly, among the insecticidal treatments, the number of syrphids was also recorded to be maximum in T_1 (Spinosad 45 SC @ 200 ml/ha) with 3.33 syrphids/5 plant, while it was 4.33 and 5.33 syrphids/5 plants in untreated control (T_7) during Kharif and Rabi 2021 (Table 10).

Effect of new generation insecticides on yield and BCR of groundnut

The effect of new generation insecticides on the yield and economics of groundnut was recorded during 2020 and 2021. During Kharif2020 and Rabi 2020, the plots treated with Chlorpyriphos 50% + Cypermethrin 5% - 55 EC @ 1 lit/ha (T_6) recorded the maximum yield with 1220kg/ha and 1305 kg/ha respectively with BCR of 1:1.99 and 1:1.91 respectively (Table 5). Similarly, during Kharif and Rabi 2021, the plots treated with Spinosad 45 SC @ 200 ml/ha (T_1) recorded the maximum yield with 1220 and 1345 kg/ha respectively with BCR of 1:1.99 and 1:2.19 respectively (Table 10).

Navya *et al*. (2021) reported less incidence of *Spodoptera litura* against spinetoram @ 0.7 ml/ l and 0.5 ml/ l, Whereas, Raut *et al*. (2021) stated that, 11.7SC recoded leaf miner population. Pazhanisamy and Hariprasad reported that quinalphos (2 ml), acephate (1 g), spinosad (0.1 ml), thiodicarb (0.6 g), thiomethoxam (0.2 g) was effective against groundnut leaf miner. This was in accordance with the present study. Jayewar *et al*., (2018) reported that emamectin benzoate (5 WSG 100 g/ha) and spinosad 45 SC @175 ml/ha were showed significant control against groundnut defoliator pests.

The present study concluded that, Spinosad 45 SC @ 200 ml/ha and Emamectin Benzoate 5 SG @ 200 g/hawere found most effective for managing leaf miner larval population on ground nut. Similarly the population of tobacco caterpillar was the lowest in Spinosad 45 SC @ 200 ml/ha followed by Profenophos 50 EC @ 1lit/ha and Cartap hydrochloride 50 SP @ 500 g/ha with 0.67, 0.67 and 1.00 larva/5plants, respectively.

Table 1: Efficacy of new generation insecticides on the population of leaf miner *Aprorema modicella* in groundnut - *Kharif 2020*

Treatments	Mean number of leaf miner larvae per plant								
	PTC	I Spray				II Spray			
		3 DAS	7 DAS	10 DAS	14 DAS	3 DAS	7 DAS	10 DAS	14 DAS
T_1 Lambda-Cyhalothrin 5EC@ 500 ml/ha	5.67	0.00 (0.71)a	0.00 (0.71)a	1.00 (1.22)a	6.33 (2.61)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_2Spinosad 45SC @ 200 ml/ha	6.00	0.33 (0.91)a	0.33 (0.91)a	0.33 (0.91)a	6.67 (2.68)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_3Profenophos 50EC @ 1 lit/ha	6.00	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a	6.00 (2.55)a	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a	2.00 (1.58)b
T_4 Cartap hydrochloride 50SP@ 500 g/ha	6.33	2.33 (1.68)b	2.67 (1.78)b	4.33 (2.20)b	6.33 (2.61)a	1.67 (1.47)b	2.33 (1.68)c	4.67 (2.27)d	5.00 (2.35)d
T_5Emamectin Benzoate 5SG @ 200 g/ha	6.33	2.67 (1.78)b	2.67 (1.78)b	3.67 (2.04)b	6.67 (2.68)a	1.67 (1.47)b	2.67 (1.78)c	2.67 (1.78)c	3.67 (2.04)c
T_6Chlorpyriphos 50%+Cypermethrin 5%-55EC @ 1 lit/ha	5.33	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	5.67 (2.48)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_7Chlorpyriphos 20EC @ 1.25 lit/ha	6.00	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a	6.00 (2.55)a	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a	2.67 (1.78)b
T_8Monocrotophos 36SL @1 lit/ha	6.33	1.00 (1.22)a	1.00 (1.22)a	1.33 (1.35)a	6.33 (2.61)a	0.67 (1.08)a	1.00 (1.22)b	1.33 (1.35)ab	3.67 (2.04)c
T_9 Quinalphos 25EC @1lit/ha	5.67	1.00 (1.22)a	1.00 (1.22)a	1.67 (1.47)a	5.67 (2.48)a	0.67 (1.08)a	1.00 (1.22)b	1.67 (1.47)ab	4.00 (2.12)c
T_{10} Untreated control	6.33	7.33 (2.80)c	7.33 (2.80)c	8.67 (3.03)c	11.00 (3.39)b	11.67 (3.49)c	12.67 (3.63)d	13.00 (3.67)e	14.33 (3.85)e

*Values in parentheses are √x+0.5 transformed values

Table 2. Efficacy of new generation insecticides on the population of *Spodoptera litura* in groundnut - *Kharif 2020*

Treatments	Mean number of tobacco caterpillar larvae per plant								
	PTC	I Spray				II Spray			
		3 DAS	7 DAS	10 DAS	14 DAS	3 DAS	7 DAS	10 DAS	14 DAS
T_1 Lambda-Cyhalothrin 5EC @ 500 ml/ha	7.67	0.00 (0.71)a	0.00 (0.71)a	1.00 (1.22)a	6.33 (2.61)a	0.00 (0.71)a	0.00 (0.71)a	0.33 (0.91)a	0.00 (0.71)a
T_2Spinosad 45SC @ 200 ml/ha	7.67	0.33 (0.91)a	0.33 (0.91)a	0.33 (0.91)a	6.67 (2.68)a	0.33 (0.91)a	0.33 (0.91)a	0.33 (0.91)a	0.67 (1.08)a
T_3Profenophos 50EC @ 1 lit/ha	7.67	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a	5.67 (2.48)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a
T_4 Cartap hydrochloride 50SP @ 500 g/ha	8.33	4.00 (2.12)c	2.33 (1.68)b	2.33 (1.68)b	6.33 (2.61)a	3.33 (1.96)c	1.67 (1.47)b	2.33 (1.68)c	2.67 (1.78)b
T_5Emamectin Benzoate 5SG @ 200 g/ha	8.33	3.67 (2.04)c	2.67 (1.78)b	2.67 (1.78)b	6.67 (2.68)a	3.00 (1.87)c	1.33 (1.35)b	2.67 (1.78)c	2.00 (1.58)b
T_6Chlorpyriphos 50%+Cypermethrin 5%-55EC@ 1 lit/ha	7.67	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	5.67 (2.48)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_7Chlorpyriphos 20EC @ 1.25 lit/ha	8.00	2.33 (1.68)b	2.00 (1.58)b	0.67 (1.08)a	6.00 (2.55)a	2.00 (1.58)b	1.33 (1.35)b	0.67 (1.08)b	0.67 (1.08)a
T_8Monocrotophos 36SL @1 lit/ha	7.67	2.67 (1.78)b	2.33 (1.68)b	3.33 (1.96)c	6.33 (2.61)a	2.00 (1.58)b	1.33 (1.35)b	0.67 (1.08)b	1.00 (1.22)a
T_9 Quinalphos 25EC @1lit/ha	8.33	3.33 (1.96)c	2.67 (1.78)b	3.00 (1.87)bc	5.67 (2.48)a	2.33 (1.68)b	2.67 (1.78)c	2.33 (1.68)c	1.00 (1.22)a
T_{10} Untreated control	7.67	8.33 (2.97)d	9.00 (3.08)c	10.67 (3.34)d	11.00(3.39)b	11.00(3.39)d	11.67(3.49)d	11.33(3.44)d	11.00(3.39)c

*Values in parentheses are √x+0.5 transformed values

Table 3: Efficacy of new generation insecticides on the population of leaf miner *Aprorema modicella* in groundnut - *Rabi 2020*

Treatments	Mean number of leaf miner larvae per plant								
	PTC	I Spray				II Spray			
		3 DAS	7 DAS	10 DAS	14 DAS	3 DAS	7 DAS	10 DAS	14 DAS
T_1 Lambda-Cyhalothrin 5EC @ 500 ml/ha	7.67	0.67 (1.08)a	1.00 (1.22)ab	1.33 (1.35)b	5.67 (2.48)b	1.33 (1.35)b	1.00 (1.22)ab	0.00 (0.71)a	0.00 (0.71)a
T_2Spinosad 45SC @ 200 ml/ha	7.67	1.33 (1.35)b	1.00 (1.22)ab	0.33 (0.91)a	6.67 (2.68)c	1.00 (1.22)b	0.67 (2.68)ab	0.00 (0.71)a	0.00 (0.71)a
T_3Profenophos 50EC @ 1 lit/ha	8.33	0.67 (1.08)a	0.33 (0.91)a	3.67 (2.04)d	6.67 (2.68)c	0.67 (1.08)b	0.33 (0.91)a	0.67 (1.08)b	1.67 (1.47)b
T_4 Cartap hydrochloride 50SP @ 500 g/ha	7.67	3.67 (2.04)d	2.33 (1.68)d	1.00 (1.22)b	5.67 (2.48)b	2.67 (1.78)cd	1.00 (1.22)ab	2.33 (1.68)c	6.33 (2.61)e
T_5Emamectin Benzoate 5SG @ 200 g/ha	8.00	2.33 (1.68)bc	1.00 (1.22)ab	2.00 (1.58)c	6.33 (2.61)c	0.67 (1.08)b	1.00 (1.22)ab	2.67 (1.78)d	5.00 (2.35)d
T_6Chlorpyriphos 50%+Cypermethrin 5%-55EC@ 1 lit/ha	7.67	0.33 (0.91)a	0.00 (0.71)a	0.33 (0.91)a	4.00 (2.12)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_7Chlorpyriphos 20EC@ 1.25 lit/ha	7.67	1.33 (1.35)b	0.67 (1.08)ab	0.67 (1.08)a	5.00 (2.35)b	1.00 (1.22)b	0.67 (1.08)ab	2.00 (1.58)c	3.67 (2.04)c
T_8Monocrotophos 36SL @1 lit/ha	7.67	2.00 (1.58)bc	0.67 (1.08)ab	0.67 (1.08)a	5.67 (2.48)b	1.00 (1.22)b	1.33 (1.35)c	1.00 (1.22)b	4.00 (2.12)c
T_9 Quinalphos 25EC @1lit/ha	8.00	1.67 (1.47)bc	1.67 (1.47)bc	1.00 (1.22)b	6.33 (2.61)c	2.33 (1.68)cd	1.67 (1.47)c	3.67 (2.04)e	5.67 (2.48)d
T_{10} Untreated control	7.33	8.00 (2.92)e	8.00 (2.92)e	9.33 (3.14)e	11.33 (3.44)d	11.67 (3.49)e	12.67 (3.63)d	13.00 (3.67)f	14.33 (3.85)f

*Values in parentheses are √x+0.5 transformed values

Table 4: Efficacy of new generation insecticides on the population of *Spodoptera litura* in groundnut - *Rabi 2020*

Treatments	Mean number of tobacco caterpillar larvae per plant								
	PTC	I Spray				II Spray			
		3 DAS	7 DAS	10 DAS	14 DAS	3 DAS	7 DAS	10 DAS	14 DAS
T_1 Lambda-Cyhalothrin 5EC @ 500 ml/ha	8.67	0.00 (0.71)a	0.67 (1.08)b	2.33 (1.68)b	6.67 (2.68)c	0.00 (0.71)a	0.67 (1.08)b	0.67 (1.08)a	1.00 (1.22)a
T_2Spinosad 45SC @ 200 ml/ha	8.00	0.00 (0.71)a	1.00 (1.22)b	2.33 (1.68)b	7.00 (2.74)c	0.33 (0.91)a	0.67 (1.08)b	1.67 (1.47)b	2.00 (1.58)b
T_3Profenophos 50EC @ 1 lit/ha	8.33	0.00 (0.71)a	0.67 (1.08)b	2.67 (1.78)b	6.00 (2.55)c	0.00 (0.71)a	0.67 (1.08)b	1.33 (1.35)b	2.33 (1.68)b
T_4 Cartap hydrochloride 50SP @ 500g/ha	8.67	3.33 (1.96)d	2.00 (1.58)c	5.67 (2.48)d	6.33 (2.61)c	4.00 (2.12)d	2.33 (1.68)c	2.33 (1.68)c	3.00 (1.87)c
T_5Emamectin Benzoate 5SG @ 200g/ha	9.00	0.00 (0.71)a	2.67 (1.78)c	3.67 (2.04)c	7.33 (2.80)d	2.67 (1.78)c	1.33 (1.35) b	2.33 (1.68)c	3.33 (1.96)c
T_6Chlorpyriphos 50%+Cypermethrin 5%-55EC@ 1 lit/ha	8.00	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a	3.67 (2.04)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a
T_7Chlorpyriphos 20EC @ 1.25 lit/ha	8.67	2.67 (1.78)c	2.67 (1.78)c	2.00 (1.58)b	5.67 (2.48)b	2.33 (1.68)c	1.00 (1.22)b	1.33 (1.35)b	2.67 (1.78)b
T_8Monocrotophos 36SL @1 lit/ha	8.00	1.33 (1.35)b	1.33 (1.35)b	2.67 (1.78)b	5.00 (2.35)b	1.00 (1.22)b	1.00 (1.22)b	2.67 (1.78)c	2.33 (1.68)b
T_9 Quinalphos 25EC @1lit/ha	9.00	3.67 (2.04)d	3.00 (1.87)d	3.00 (1.87)bc	3.67 (2.04)a	2.00 (1.58)c	2.67 (1.78)c	2.33 (1.68)c	3.67 (2.04)c
T_{10} Untreated control	8.67	9.33 (3.14)e	9.33 (3.14)e	11.67 (3.49)e	11.67 (3.49)e	11.67 (3.49)e	12.33 (3.58)d	12.00 (3.54)d	12.00 (3.54)d

*Values in parentheses are √x+0.5 transformed values

Table 5: Effect of new generation insecticides on natural enemies, yield and economics of groundnut

Treatments	*Kharif 2020*		*Rabi 2020*		*Kharif 2020*		*Rabi 2020*	
	Coccinellids/5 plants	Syrphids/5 plants	Coccinellids/5 plants	Syrphids/5 plants	Yield (kg/ha)	BCR	Yield (kg/ha)	BCR
T_1 Lambda-Cyhalothrin 5EC @ 500 ml/ha	5.67	2.67	5.67	3.33	1090	1:1.80	1205	1:1.91
T_2Spinosad 45SC @ 200 ml/ha	6.67	3.00	6.00	4.67	1165	1:1.93	1250	1:1.91
T_3Profenophos 50EC @ 1 lit/ha	5.00	2.33	5.33	3.00	1105	1:1.86	1185	1:1.86
T_4 Cartap hydrochloride 50SP @ 500g/ha	4.33	2.67	5.33	1.67	1095	1:1.81	1175	1:1.83
T_5Emamectin Benzoate 5SG @ 200g/ha	1.67	1.33	2.33	2.33	1185	1:1.89	1190	1:1.90
T_6 Chlorpyriphos 50%+Cypermethrin 5%-55EC @ 1 lit/ha	3.67	3.67	6.67	4.67	1220	1:1.99	1305	1:1.91
T_7Chlorpyriphos 20EC @ 1.25 lit/ha	3.33	1.67	4.33	2.00	1050	1:1.72	1065	1:1.59
T_8Monocrotophos 36SL @1 lit/ha	2.67	0.67	1.67	1.33	1030	1:1.66	1035	1:1.51
T_9 Quinalphos 25EC @1lit/ha	3.00	1.00	2.67	1.67	1025	1:1.65	1045	1:1.54
T_{10} Untreated control	7.67	4.0	7.33	5.33	845	1:1.38	895	1:1.46

Table 6: Efficacy of new generation insecticides on the population of leaf miner *Aprorema modicella* in groundnut – Kharif 2021

Treatments	Mean number of leaf miner larvae per plant								
	PTC	I Spray				II Spray			
		3 DAS	7 DAS	10 DAS	14 DAS	3 DAS	7 DAS	10 DAS	14 DAS
T_1Spinosad 45SC @ 200 ml/ha	6.67	0.33 (0.91)a	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_2Profenophos 50EC @ 1 lit/ha	6.33	0.67 (1.08)a	0.67 (1.08)a	0.67 (1.08)b	1.33 (1.35)b	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_3 Cartap hydrochloride 50SP @ 500 g/ha	6.33	0.33 (0.91)a	0.67 (1.08)a	1.33 (1.35)c	1.67 (1.47)b	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_4 Emamectin Benzoate 5SG @ 200 g/ha	6.33	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)b	1.33 (1.35)b	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)b	2.67 (1.78)c
T_5Chlorpyriphos 20EC @ 1.25 lit/ha	6.33	0.67 (1.08)a	1.33 (1.35)ab	2.33 (1.68)d	2.67 (1.78)c	0.67 (1.08)b	1.00 (1.22)b	1.33 (1.35)c	3.67 (2.04)d
T_6Quinalphos 25EC @ 1lit/ha	6.00	1.00 (1.22)ab	1.00 (1.22)ab	1.67 (1.47)c	2.67 (1.78)c	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)b	2.00 (1.58)b
T_7 Untreated control	6.33	7.33 (2.80)c	7.67 (2.80)c	8.67 (3.03)e	10.00 (3.24)d	11.67 (3.49)c	12.67 (3.63)c	13.00 (3.67)d	14.33 (3.85)e

*Values in parentheses are √x+0.5 transformed values

Table 7: Efficacy of new generation insecticides on the population of *Spodoptera litura* in groundnut - Kharif 2021

Treatments	Mean number of tobacco caterpillar larvae per plant							
	PTC	I Spray				II Spray			
		3 DAS	7 DAS	10 DAS	14 DAS	3 DAS	7 DAS	10 DAS	14 DAS
T_1Spinosad 45SC @ 200 ml/ha	4.33	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	6.33 (2.61)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_2Profenophos 50EC @ 1 lit/ha	4.00	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	6.67 (2.68)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_3 Cartap hydrochloride 50SP @500 g/ha	4.67	0.67 (1.08)b	0.67 (1.08)b	1.00 (1.22)b	6.33 (2.61)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_4 Emamectin Benzoate 5SG @ 200 g/ha	4.33	1.00 (1.22)b	1.33 (1.35)c	1.33 (1.35)b	6.00 (2.55)a	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)b	2.67 (1.78)b
T_5Chlorpyriphos 20EC @ 1.25 lit/ha	4.67	0.67 (1.08)b	0.67 (1.08)b	1.33 (1.35)b	6.67 (2.68)a	0.67 (1.08)b	1.00 (1.22)b	1.33 (1.35)c	3.67 (2.04)c
T_6Quinalphos 25EC @1lit/ha	4.00	0.67 (1.08)b	0.67 (1.08)b	1.33 (1.35)b	6.33 (2.61)a	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)b	2.00 (1.58)b
T_7 Untreated control	4.67	5.33 (2.41)c	5.33 (2.41)d	6.33 (2.61)c	7.67 (2.80)b	8.67 (3.03)c	10.00 (3.24)c	11.67 (3.49)c	12.67(3.63)d

*Values in parentheses are √x+0.5 transformed values

Table 8: Efficacy of new generation insecticides on the population of leaf miner *Aprorema modicella* in groundnut - Rabi 2021

Treatments	Mean number of leaf miner larvae per plant							
	PTC	I Spray				II Spray			
		3 DAS	7 DAS	10 DAS	14 DAS	3 DAS	7 DAS	10 DAS	14 DAS
T_1Spinosad 45SC @ 200 ml/ha	8.33	0.00 (0.71)a	0.00 (0.71)a	1.00 (1.22)b	4.67 (2.27)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_2Profenophos 50EC @ 1 lit/ha	8.33	0.33 (0.91)a	0.00 (0.71)a	0.00 (0.71)a	5.67 (2.68)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_3 Cartap hydrochloride 50SP@ 500 g/ha	7.67	0.00 (0.71)a	0.33 (0.91)a	0.33 (0.91)a	6.00 (2.55)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a
T_4 Emamectin Benzoate 5SG @ 200 g/ha	8.00	0.00 (0.71)a	1.67 (1.47)b	2.67 (1.78)c	5.33 (2.61)a	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a	2.00 (1.58)b
T_5Chlorpyriphos 20EC @ 1.25 lit/ha	7.67	2.33 (1.68)c	2.67 (1.78)c	3.67 (2.04)d	5.67 (2.48)a	1.67 (1.47)b	2.67 (1.78)c	2.67 (1.78)c	3.67 (2.04)c
T_6Quinalphos 25EC @1lit/ha	8.33	1.67 (1.47)b	0.00 (0.71)a	0.87 (1.17)b	5.67 (2.48)a	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a	2.67 (1.78)b
T_7 Untreated control	7.67	8.67 (3.03)d	11.00 (3.39)d	11.67 (3.49)e	12.67 (3.63)b	13.00 (3.67)e	14.33 (3.85)d	14.33 (3.85)d	14.67 (3.89)b

*Values in parentheses are √x+0.5 transformed values

Table 9: Efficacy of new generation insecticides on the population of *Spodoptera litura*in groundnut - Rabi 2021

Treatments	Mean number of tobacco caterpillar larvae per plant							
	PTC	I Spray				II Spray			
		3 DAS	7 DAS	10 DAS	14 DAS	3 DAS	7 DAS	10 DAS	14 DAS
T_1Spinosad 45SC @ 200 ml/ha	6.67	0.00 (0.71)a	0.00 (0.71)a	1.00 (1.22)a	4.33 (2.20)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.33 (0.91)a
T_2Profenophos 50EC @ 1 lit/ha	6.67	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)a	4.67 (2.27)a	0.00 (0.71)a	0.00 (0.71)a	0.00 (0.71)a	0.33 (0.91)a
T_3 Cartap hydrochloride 50SP@ 500 g/ha	6.67	2.33 (1.68)c	2.67 (1.78)c	3.67 (2.04)c	4.87 (2.32)a	1.67 (1.47)c	2.00 (1.58)c	2.33 (1.68)d	2.33 (1.68)c
T_4 Emamectin Benzoate 5SG @ 200 g/ha	6.33	1.33 (1.68)b	2.00 (1.58)b	2.33 (1.68)b	4.33 (2.20)a	0.00 (0.71)a	0.00 (0.71)a	0.67 (1.08)b	2.00 (1.58)c
T_5Chlorpyriphos 20EC @ 1.25 lit/ha	8.00	1.33 (1.35)b	2.00 (1.58)b	4.00 (2.12)c	4.67 (2.27)a	0.67 (1.08)b	1.00 (1.22)b	1.33 (1.35)c	2.00 (1.58)c
T_6Quinalphos 25EC @1lit/ha	7.00	0.00 (0.71)a	2.00 (1.58)b	2.67 (1.78)b	5.67 (2.48)a	0.00 (0.71)a	0.67 (1.08)b	1.33 (1.35)c	1.33 (1.35)b
T_7 Untreated control	6.00	6.00 (2.55)d	7.67 (2.86)d	8.67 (3.03)d	11.00 (3.39)b	12.00 (3.54)d	13.33 (3.72)c	13.67 (3.76)e	13.87 (3.79)d

*Values in parentheses are √x+0.5 transformed values

Table 10: Effect of new generation insecticides on natural enemies, yield and economics of groundnut

Treatments	*Kharif 2021*		*Rabi 2021*		*Kharif 2021*		*Rabi 2021*	
	Coccinellids/5 plants	**Syrphids/5 plants**	**Coccinellids/5 plants**	**Syrphids/5 plants**	**Yield (kg/ha)**	**BCR**	**Yield (kg/ha)**	**BCR**
T_1Spinosad 45SC @ 200 ml/ha	6.33	3.33	5.67	3.33	1220	1:1.99	1345	1:2.19
T_2Profenophos 50EC @ 1 lit/ha	3.67	1.33	3.67	1.67	1105	1:1.86	1260	1:2.12
T_3 Cartap hydrochloride 50SP @ 500g/ha	4.33	2.67	5.33	2.33	1095	1:1.81	1215	1:2.01
T_4 Emamectin Benzoate 5SG @ 200 g/ha	4.33	2.33	4.33	2.67	1185	1:1.89	1185	1:1.89
T_5Chlorpyriphos 20EC @ 1.25 lit/ha	3.87	1.33	1.67	1.33	1025	1:1.65	1190	1:1.92
T_6Quinalphos 25EC @1lit/ha	3.33	1.33	3.67	2.67	1050	1:1.72	1170	1:1.92
T_7 Untreated control	9.33	4.33	7.33	5.33	895	1:1.58	1020	1:1.70

Conclusion

The study conclusively demonstrated the superior efficacy of new-generation insecticides in managing the populations of leaf miner (*Aproaerema modicella Deventer*) and tobacco caterpillar (*Spodoptera litura Fab.*) on groundnut crops during the Kharif and Rabi seasons of 2020 and 2021. Among the tested insecticides, Spinosad 45 SC (200 ml/ha) and Emamectin Benzoate 5 SG (200 g/ha) were the most effective against leaf miner larvae, significantly reducing their populations across all observation periods. Similarly, Spinosad 45 SC was also highly effective against tobacco caterpillar populations, followed by Profenophos 50 EC (1 liter/ha) and Cartap hydrochloride 50 SP (500 g/ha).

The results underscore the importance of incorporating these insecticides into integrated pest management programs to enhance groundnut yield and maintain economic sustainability. The use of these new-generation insecticides not only reduced pest populations effectively but also demonstrated a favorable benefit-cost ratio (BCR), making them economically viable for farmers. However, their impact on natural enemies suggests a need for careful planning and monitoring to minimize potential ecological disruptions. This research supports the strategic use of these insecticides for sustainable groundnut production in pest-prone regions.

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