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Efficacy of new molecules against aphids, a major sucking pest of green gram [*Vigna radiata* (L.) Wilczek]

Suman Kumar Panigrahi, Bhubanananda Adhikari, Priyanka Priyadarshini, Rakesh Roshan Satapathy, Bidwan Ranjan Sahoo and Rajeeb Kumar Behera

Abstract
The field experiment was conducted at Agricultural Research Station, Faculty of Agricultural Sciences, (IAS), SOADU, Binjhagiri, Chhatabar, Khordha during *Summer*, 2021 to evaluate the relative efficacy of certain new molecules of insecticides against aphid (*Aphis craccivora* Koch) in green gram and the influence of insecticides on crop yield. The effect of various treatments imposed at 20 and 40 days after sowing (DAS) on aphid revealed that all the treatments were superior than the control and among the treatments, diafenthuron 50 WP at 250 g a.i./ha was the best treatment during the period of investigation accounting for more than 75% reduction in aphid population. The other better efficacious treatments were thiamethoxam 25 WG @ 25 g a.i./ha, spiromesifen 240 SC @ 150 g a.i./ha, fipronil 5 SC @ 50 g a.i./ha and imidacloprid 17.8 SL @ 25 g a.i./ha that also accounted for nearly 75 % reduction in aphid population. Clothianidin 50 WDG @ 125 g a.i/ha was proved to be the least effective insecticide against aphid having 64-67% reduction in aphid population. In the experiment, all of the newer insecticides were found to be effective in reducing the number of sucking insect pests of green gram, and all of the newer compounds had an impact on crop yield. From all of the pesticides tested, diafenthuron 50 WP at 250 g a.i/ha was the most effective in impacting yield.

Keywords: aphid, green gram, new molecules, diafenthuron, spiromesifen

Introduction
Green gram is a high-protein staple food with a protein content of 25%, roughly three times that of cereals. It meets the protein needs of the country's vegetarian population. It is ingested in the form of split and whole pulses, and is an important addition to a cereal-based diet. Because it is a leguminous crop, it has the ability to fix nitrogen from the atmosphere (30-40 kg N/ha). It also aids in soil erosion prevention. Green gram is cultivated in all seasons. India is the primary origin of green gram (*Vigna radiata*) and the crop is cultivated in many states of India including Odisha (Sharma *et al.*, 2011) [15]. India is the major producer of green gram in the world and grown in almost all the States. It is grown in about 4.5 million hectares with the total production of 2.5 million tonnes with a productivity of 548 kg/ha and contributing 10% to the total pulse production in 2018-19. According to Government of India 3rd advance estimates, green gram production in 2020-21 is at 2.64 million tonnes (Anon., 2021) [1]. As Odisha is one of the major green gram growing states of India, farmers cultivate the particular pulse crop widely. In 2018-19 Odisha had green gram growing area 837000 hectare with production 412000 MT and yield 491 kilogram per hectare (Anon., 2020) [2]. Plenty of technical and socioeconomic barriers lie in the way of increasing mung bean production. Among the several biological restrictions, the insect pest problem is one of the most significant, accounting for a 30% yearly crop loss (Soundararajan and Chitra, 2011) [16]. The green gram is attacked by various insect pests among which the infestation of sucking pests causes maximum loss in the cropping season (Swaminathan *et al.*, 2012) [18].

Chemical control methods employing synthetic organic insecticides are commonly used by farmers to manage these pests, as chemical control is the first line of defence against insect pests in any eco-system. But the conventional insecticides are becoming ineffective against these insect pests within a short span of time as they have either lost their efficacy or become obsolete due to development of resistance in insect against them or for their residual toxicity problem. Keeping the aforesaid consideration in view, the present investigation was carried out to evaluate the efficacy of some new molecules against aphids, which is a major sucking pest of green gram and to evaluate the insecticidal effect on the crop yield.

Materials and Methods

Field trial was conducted during *Summer*, 2021 in a randomized block design (RBD) at Agricultural Research Station, Faculty of Agricultural Sciences, (IAS), SOADU, Binjhagiri, Chhatabar, Khordha, to field evaluation of new molecules against aphids of green gram [*Vigna radiata* (L.) Wilczek]. A popular green gram variety "IPM 02-14" was taken as the test variety in the present investigation. It is a short duration (60-65 days) variety and widely cultivated by farmers. The field experiment was laid out with seven treatments including six insecticidal treatments and one untreated control. The experiment was replicated thrice. Each sub-plot measured $12m^2$ (3m x 4m) and was separated from each other by bunds. Drainage and irrigation facilities were adequately provided to the plots as per the requirement. Sprayable formulations of six insecticides *viz*., each at single dose were field evaluated at recommended concentration on aphids of green gram with an untreated control. Details of the insecticidal treatments are presented in Table 1.

Table 1: Details of the treatments used in the experiment

Treatment	Chemical Composition (Available concentration)	Dose (g a.i./ha)	Chemical Group
T_1	Thiamethoxam 25WG	25	Neonicotinoid
T_2	Spiromesifen 240SC	150	Spirocyclic tetronic/tetramic acid derivatives
T_3	Fipronil 5SC	50	Phenylpyrazole
T_4	Clothianidin 50WDG	125	Neonicotinoid
T_5	Diafenthuron 50WP	250	Thio urea derivatives
T_6	Imidacloprid 17.8 SL	25	Neonicotinoid
T_7	Untreated Control	-----	

All the treatments were applied in the form of foliar sprays by means of high volume and hand compression sprayer using 500 litres of spray solution per hectare to ensure thorough coverage of plants. Sufficient care was taken to avoid drifting of insecticides while spraying. The first spray application of respective insecticides was given on the initiation of target pests i.e., 20 days after sowing (DAS) and subsequently another spray was given after 20 days of first spray i.e., 40 DAS after regaining of insect population. During the cropping season *Summer*, 2021 observations were recorded on the population of aphids on one day before and 1, 3, 7 and 15 days after spraying and then the average was calculated. For recording of observations of aphids, the population was counted from 10 cm apical shoot of each plant. Ten randomly selected plants from each treatment plots were taken into consideration for taking observation. Yield was recorded after threshing and separating of green gram seeds from each plot weighed separately and converted into quintals per hectare for further statistical analysis. The per cent increase over control was also calculated by following formula.

$$\text{percentage increase in yield} = \frac{\text{Yield of treatment} - \text{Yield of Control}}{\text{Yield of treatment}} \times 100$$

The data so obtained for various insect counts and their damage symptoms were suitably transformed following Gomez and Gomez (1984) [3], analysed statistically to arrive at meaningful conclusion. The data recorded on pest population as well as yield were also subjected to statistical analysis after suitable transformation. Treatment variations were tested for their significant F-test standard error and mean standard error i.e., SE (m) $_\pm$ and critical difference (CD) at 5% level of significance were calculated following standard procedure for RBD.

Results and Discussion

Efficacy of new insecticides on aphid population

Data of the Aphid population/10 cm apical shoot was taken one day before spraying (1 DBS), 1 day after spray (1 DAS), 3 days after spraying (3 DAS), 7 days after spraying (7 DAS) and 15 days after spraying (15 DAS). Efficacy of different insecticides against aphid population after 1st spraying is mentioned in Table 2. From Table 2, at 1 DBS all the treatments had well distributed population of insects and statistically at par with one another. At 1 DAS, all the insecticide treated plots had significantly lower insect population than untreated control. From the insecticide treatments thiamethoxam 25 WG @ 25 g a.i/ha (T1) showed lowest insect population (5.02/10 cm apical shoot), followed by fipronil 5 SC @ 50 g a.i/ha (5.05/10 cm apical shoot), diafenthuron 50 WP @ 250 g a.i/ha (5.07/10 cm apical shoot). At 1 DAS, clothianidin 50 WDG @ 125 g a.i/ha (7.12/10 cm apical shoot) was the lowest effective insecticide. At 3 DAS, the lowest insect population was observed in the plot treated with a diafenthuron 50 WDG @ 125 g a.i/ha (1.03 / 10 cm apical shoot) (T5) which was at par with thiamethaoxam 25 WG @ 25 g a.i/ha (T1) (1.55 / 10 cm apical shoot), spiromesifen 240 SC @ 150g a.i/ha (1.96 / 10 cm apical shoot), fipronil 5 SC @ 50 g a.i/ha (1.82 / 10 cm apical shoot) and imidacloprid 17.8 SL @ 25 g a.i/ha (2.02 / 10 cm apical shoot)

Table 2: Efficacy of newer insecticide against aphid after 1st spray (20 DAS) during *Summer*, 2021

Insecticides	Dose g a.i./ha	Aphid population / 10 cm apical shoot				
		1 DBS	1 DAS	3 DAS	7 DAS	15 DAS
Thiamethoxam 25% WG	25	12.70 (3.63)	5.02 (2.35)	1.55 (1.43)	2.06 (1.60)	3.22(1.93)
Spiromesifen 240% SC	150	11.98 (3.53)	5.40 (2.43)	1.96 (1.57)	2.92 (1.85)	4.09 (2.14)
Fipronil 5% SC	50	10.00 (3.24)	5.05 (2.36)	1.82 (1.52)	2.24 (1.66)	4.02 (2.13)
Clothianidin 50% WDG	125	11.75 (3.50)	7.12 (2.76)	2.33 (1.68)	3.17 (1.92)	4.27 (2.18)
Diafenthuron 50% WP	250	9.11 (3.10)	5.07 (2.36)	1.03 (1.24)	1.84 (1.53)	2.08 (1.61)
Imidacloprid 17.8% SL	25	10.17 (3.27)	6.40 (2.63)	2.02 (1.59)	3.26 (1.94)	4.01 (2.12)
Control		11.06 (3.40)	11.63 (3.48)	11.96 (3.53)	12.27 (3.57)	12.32 (3.58)
SE(m) ±		NS	0.22	0.11	0.09	0.13
CD (P=0.05)		NS	0.69	0.35	0.29	0.40

Figures in parentheses are (X + 0.5) square root transformed values DBS: Days before spraying DAS: Days after spraying NS: Non-significant

Table 3: Efficacy of newer insecticide against aphid after 2nd spray (40 DAS) during *Summer*, 2021

Tr. No.	Insecticides	Dose g a.i./ha	Aphid population / 10 cm apical shoot						Reduction over control (%)
			1 DBS	1 DAS	3 DAS	7 DAS	15 DAS	Mean population after post spray	
T_1	Thiamethoxam 25% WG	25	7.60 (2.85)	6.65 (2.67)	1.05 (1.25)	2.74 (1.80)	3.00 (1.87)	3.36	73.11
T_2	Spiromesifen 240% SC	150	9.63 (3.18)	7.06 (2.75)	2.37 (1.69)	2.78 (1.81)	3.55 (2.01)	3.94	68.47
T_3	Fipronil 5% SC	50	8.10 (2.93)	6.45 (2.64)	2.20 (1.64)	2.79 (1.81)	3.37 (1.97)	3.70	70.37
T_4	Clothianidin 50% WDG	125	9.59 (3.18)	7.57 (2.84)	2.22 (1.65)	2.64 (1.77)	3.74 (2.06)	4.04	67.65
T_5	Diafenthuron 50% WP	250	7.85 (2.89)	6.26 (2.60)	1.65 (1.47)	2.05 (1.60)	2.18 (1.64)	3.03	75.71
T_6	Imidacloprid 17.8% SL	25	6.26 (2.60)	6.68 (2.68)	1.79 (1.51)	2.24 (1.66)	3.41 (1.98)	3.53	71.75
T_7	Control		9.87 (3.22)	11.36 (3.44)	12.44 (3.60)	12.70 (3.63)	13.49 (3.74)	12.49	
	SE(m) ±		NS	0.248	0.158	0.173	0.164		
	CD (P=0.05)		NS	0.76	0.49	0.53	0.51		

Figures in parentheses are (X + 0.5) square root transformed values DBS: Days before spraying DAS: Days after spraying NS: Non-significant

At 7 DAS, the similar trend was observed in which T5 resulted the lowest insect population (1.84 /10 cm apical shoot) followed by T1 (2.06 / 10 cm apical shoot) and fipronil 5 SC @ 50 g a.i/ha(T3) (2.24 / 10 cm apical shoot). Spiromesifen 240 SC @ 150 g a.i/ha was also found to be effective having decreased insect population (2.92/10 cm apical shoot) than untreated control. At 15 DAS, overall insect population was slightly increased and diafenthuron 50 WP @ 250 g a.i/ha (2.08 / 10 cm apical shoot) treated plot (T5) showed the lowest the insect population which was only at par with Thiamethoxam 25 WG @ 25 g a.i/ha (3.22 / 10 cm apical shoot). At first spray from the Table 2, it was concluded that diafenthuron 50 WP @ 250 g a.i/ha (2.08 / 10 cm apical shoot) was found to be the best treatment with having 79.2 per cent reduction over control followed by, thiamethoxam 25 WG @ 25 g a.i/ha (75.4 per cent reduction over control).The least effective chemical was clothianidin 50 WDG @ 125 g a.i/ha (64.94 per cent reduction over control).

Efficacy of different insecticides against aphid population after 2nd spraying is mentioned in Table 3. From Table 3, at 1 DBS all the treatments had well distributed population of insects and statistically at par with one another. At 1 DAS, all the insecticide treated plants had significantly lower insect population than untreated control. From the insecticide treatments diafenthuron 50 WP @ 250 g a.i/ha (T5) showed lowest insect population (6.26/10 cm apical shoot), followed by fipronil 5 SC @ 50 g a.i/ha (6.45/10 cm apical shoot) and thiamethoxam 25 WG @ 25 g a.i/ha (6.65/10 cm apical shoot). At 3 DAS, the lowest insect population was observed in the plot treated with thiamethoxam 25 WG @ 25 g a.i/ha (T1) which was at par with diafenthuron 50 WP @ 250 g a.i./ha (1.65 / 10 cm apical shoot), imidacloprid 17.8 SL @ 25 g a.i/ha (1.79 / 10 cm apical shoot), fipronil 5 SC @ 50 g a.i/ha (2.20 / 10 cm apical shoot), clothianidin 50 WDG @ 125 g a.i/ha (2.22 / 10 cm apical shoot) and spiromesifen 240 SC @ 150 g a.i/ha (2.37 / 10 cm apical shoot). At 7 DAS, T5 resulted the lowest insect population (2.05 / 10 cm apical shoot) followed by imidacloprid 17.8 SL @ 25 g a.i/ha (T6) (2.24 / 10 cm apical shoot) and clothianidin 50 WDG @ 125 g a.i/ha (T4) (2.64 / 10 cm apical shoot). Thiamethoxam 25 WG @ 25 g a.i/ha (2.74 / 10 cm apical shoot) and spiromesifen 240 SC @ 150 g a.i/ha (2.78 / 10 cm apical shoot) were also found to be effective having decreased insect population then untreated control.

At 15 DAS, overall insect population was increased and diafenthuron 50 WP @ 250 g a.i/ha treated plot (T5) showed the lowest insect population which was at par with thiamethoxam 25 WG @ 25 g a.i/ha (3.00 / 10 cm apical shoot), fipronil 5 SC @ 50 g a.i/ha (3.37 / 10 cm apical shoot), imidacloprid 17.8 SL @ 25 g a.i/ha (3.41 / 10 cm apical shoot), spiromesifen 240 SC @ 150 g a.i/ha (3.55 / 10 cm apical shoot) and clothiandin 50 WDG @ 125 g a.i/ha (3.74 / 10 cm apical shoot). At 2nd spray from the Table 4, it was concluded that diafenthuron 50 WP @ 250 g a.i /ha was found to be the best treatment with having 75.71 per cent reduction over control followed by thiamethoxam 25 WG @ 25 g a.i/ha (73.11 per cent reduction over control). The least effective chemical was clothianidin 50 WDG @ 125 g a.i /ha with 67.65 per cent reduction over control.

Effect of new insecticides on yield of green gram

The data on yield of green gram was taken from each experimental plot and represented in Table 4. It was clear that the effect of various insecticides influenced the yield. The yield of the test variety (IPM-02-14) from different insecticide treated plots ranged from 2.03 q/hectare to 3.6 q/hectare. From the Table 4, the highest yield was observed in the plot treated with diafenthuron 50 WP @ 250 g a.i/ha (T5) followed by the yield of the plot treated with spiromesifen 240 SC @ 150 g a.i/hectare which was also at par with thiamethoxam 25 WG @ 25 g a.i/hectare and imidacloprid 17.8 SL @ 25 g a.i/hectare. Lowest yield was observed in clothianidin 50 WDG @ 125 g a.i/hectare.

Table 4: Effect of different newer insecticides on yield of green gram

Tr. No.	Insecticides	Dose g a.i./ha	Seed Yield (q/ha)	Increase over control (%)
T_1	Thiamethoxam 25 WG	25	3.31	63.45
25	Spiromesifen 240 SC	150	3.4	67.08
150	Fipronil 5 SC	50	3.03	49.26
50	Clothianidin 50 WDG	125	2.24	10.34
125	Diafenthuron 50 WP	250	3.6	77.34
250	Imidacloprid 17.8 SL	25	3.37	66.00
25	Control		2.03	
	SE(m) ±		0.176	
	CD (P=0.05)		0.54	

The present research findings regarding aphid incidence indicated that all the insecticides tested were effective in restricting aphid population till 15 DAS compared to untreated control. However, diafenthuron 50 WP at 250 g a.i/ha proved superior than other treatments. According to Sujatha and Bharpoda (2017) [17] thiamethoxam 25 WG @ 0.01% and imidacloprid 70 WG @ 0.014% were found significantly superior than rest of the insecticidal treatments and recorded lower population. They also found that diafenthiuron 50 WP @ 0.05% showed significantly lower aphid population than control. Clothianidin 50 WDG @ 0.02% was comparatively less effective by recording higher population in green gram. Justin *et al.*, (2015)[5] found seed treatment with thiamethoxam 25 WG @ 3 g/ kg of seed + spray with thiamethoxam 25 WG @ 0.4 g/ l recorded the lowest population of aphids (1.60, 1.45 no. /plant) in black gram. Kabir *et al.*, (2014) [6] recorded 32.8 and 40.96 per cent reduction over control of aphid population by application of thiamethoxam 25 WG in green gram. Khutwad *et al.*, (2002) [8] also reported higher efficacy of thiamethoxam and imidacloprid in green gram. Hence, the present finding derived ample support from the findings of the above authors.

Misra (2002) [9] found imidacloprid and thiamethoxam, both belonging to nitroguanidine group used at 25 g a.i./ha proved significantly superior in controlling aphids in cowpea which is a pulse crop and belonging to same family of green gram. From the experimental result of Khade *et al.*, (2014) [7] imidacloprid 17.8SL @ 0.005 per cent was found most effective insecticide controlling significantly aphids (76.83 per cent reduction over control). Reddy *et al.*, (2014) [14] and revealed that imidacloprid (0.005 per cent) caused 98.0 per cent mortality of cow pea aphid, *A. Craccivora*. Whereas, thiamethoxam (0.005 per cent) showed more than 80 per cent aphid mortality. Gowtham *et al.*, (2016) [4] found that imidacloprid 17.8SL (0.25 ml/l) proved to be highly effective against cow pea aphid, *A. craccivora* with mortality percentage of 86.66. In direct spray method spiromesifen (1.948) showed highest efficacy followed by thiamethoxam (1.617) against cow pea aphid which was concluded by Patil *et al.*, (2017) [13].

Thiamethoxam 25 WG @ 50g a.i./ha (51.78%) showed higher efficacy against cow pea aphid than spiromesifen 22.9 SC @ 120g a.i./ha (49.20%) which was found by Patil *et al.*, (2018) [12]. Mohamed and Aziza (2010) [10] also reported that thiamethoxam was the most effective followed by diafenthiuron (thiourea compounds) against the different field strains of *A. craccivora*. Patel (2013) [11] reported that diafenthiuron 50 SC @ 400 g a.i./ha was found to be the most effective and recorded maximum reduction in population of cotton aphid. However, thiomethoxam 25 WG 75 g a.i. /ha and imidacloprid 200 SL @ 100 g a.i. /ha were next effective chemicals. Hence the present finding is well supported by the above findings.

Conclusion

It was concluded from the above experiment that all the treatments were superior than the control. Among the treatments, diafenthuron 50 WP at 250 g a.i./ha was the best treatment during the period of investigation accounting significantly more reduction in insect population. The other better efficacious treatments were thiamethoxam 25 WG @ 25 g a.i./ha, spiromesifen 240 SC @ 150 g a.i./ha, fipronil 5 SC @ 50 g a.i./ha and imidacloprid 17.8 SL @ 25 g a.i./ha that also responsible for restricting the aphid population. From the experiment Clothianidin 50 WDG @ 125 g a.i/ha was proved to be the least effective insecticide against aphid of green gram. Effect of various insecticides on crop yield was also evaluated and it was found that diafenthuron 50 WP at 250 g a.i/ha was the most effective insecticide registering highest yield. According to a critical review of various groups of chemical insecticides, conventional insecticides, including all neuroactive chemicals, have played a major role in the management of insect pests in pulses for the past five decades, but their indiscriminate use has resulted in several issues such as resistance, residue, resurgence, and environmental safety. As a result, the attention has turned to the development of newer new chemicals with novel biochemical targets for pest control and resistance management. The novel insecticide families are highly effective at lower dosages, cause little damage to non-target creatures and the environment, and offer a wide range of administration methods.

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